Diseases of Narcissus

Extension Bulletin 709

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DISEASES OF NARCISSUS

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The major Narcissus producing areas are England, followed by the Netherlands and Washington State—all have a relatively cool and moist or maritime-type climate. Such a climate is conducive to good growth and is less favorable for some of the most serious pathogens of daffodils including basal rot, fire, white mold, scorch, root lesion nematode, and virus diseases that are spread by aphids. However, these and other diseases may still cause trouble at times. They are caused by fungi, bacteria, viruses, and nematodes.

Fungus Diseases

Many important diseases of narcissus are caused by fungi. Fungi are small and rather simple plants unable to produce their own food because they do not have the green coloring matter (chlorophyll). Rather than manufacture their own food, they feed on living or dead plants and animals resulting in disease or decay of the tissues they attack.

Fungi produce very small seed-like bodies called spores. These microscopic spores can be spread by splashing rain or wind or carried along with the movement of soil or infected plant debris. Fungi survive from one season to the next, either as dormant spores in the soil or as thread-like growths within a bulb or diseased plant tissue or as hardened lumps of fungus tissue in the soil where the bulb grew. These masses of weather-resisting fungus tissue are usually rounded, hard and are called sclerotia.

Virus Diseases

Virus particles are so small that they cannot be seen with an ordinary light microscope but require the use of an electron microscope. When they gain access to a plant, they usually penetrate into every part except the seed. Therefore, whenever a "daughter" bulb is taken from a virus-infected plant, it is usually also infected. Certain insects, such as aphids, which feed on plant sap can spread some virus diseases.

Nematode Diseases

Nematodes are very small thread-like worms. Many commonly live in the soil without doing any harm, while others attack various plants. The bulb nematode and root lesion nematodes, which affect narcissus, are too small to be seen without a microscope. Nematodes survive from season to season as eggs. They also can survive for several years in bulbs or in infected plant tissue. Any movement of soil or infected plant parts can be responsible for the spread of nematodes. Farm equipment, irrigation, flooding, and planting infected bulbs are common ways of spread.

Bacterial Diseases

Bacteria are simple, microscopic, usually single-celled plants that depend upon other plant or animal sources for their food. Most are beneficial and only occasionally do they cause trouble in narcissus. Spread and survival depend on the presence of infected plants or plant tissues since the bacteria are able to survive only a short time in soil.

Physiological Diseases

All problems that are not caused by parasitic organisms are considered in this group. Narcissus are somewhat susceptible to unfavorable weather. Frost may injure their leaves, the sun may burn the bulbs, and undesirable temperatures may prevent flowers from forming, or ruin them after they have formed.

General References

A few references are given for each specific major disease. For additional information consult the following:

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Min. of Agric. and Fisheries. Bul. No. 117. His Majesty's Stationery Office. London. Revision in press.

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ZIEKTEN, Afwijkingen bij Bolgewassen. 1978. Deel 2: Amaryllidaceae Iridaceae Laboratorium Voor Bloembollenonerzoek. Lisse, Netherlands.

General Control Recommendations

Hobbyist

Hobbyists or home gardeners should seldom face any serious narcissus disease problems if they follow these general guidelines.

1. Buy bulbs from a reliable source.
2. Plant in a well-aerated and well-drained soil.
3. Do not use excessive amounts of nitrogen, phosphorus, or organic matter.
4. Promptly remove infected plants if virus symptoms appear.
5. Spray an effective fungicide as soon as any leaf or flower disease develops.
6. Remove flowers promptly after blooming.
7. Dig and replant in a new location at least every other year.
8. Discard smaller than normal and misshapen bulbs.
9. Destroy all debris.
10. Hot water treat the stock every 3 or 4 years. This hot water treatment is the best single treatment available for bulbs since it controls insects and many fungi as well as nematodes.

Commercial

Specific pesticides are not listed in this publication because materials continuously change. Specific recommendations appear in Disease Control Recommendations for Narcissus (EM 1413, Washington State University, Pullman, WA 99164), which undergoes continuous updating. Suggestions for a general control program are:

1. If leaf diseases are commonly troublesome, begin spraying when plants are 4-5 inches high and continue at two- or three-week intervals until the foliage begins to die down. If leaf diseases are not usually serious, a single spray applied immediately after flowering should be sufficient. Add wetting agent to obtain a uniform spray deposit on the waxy daffodil leaves.

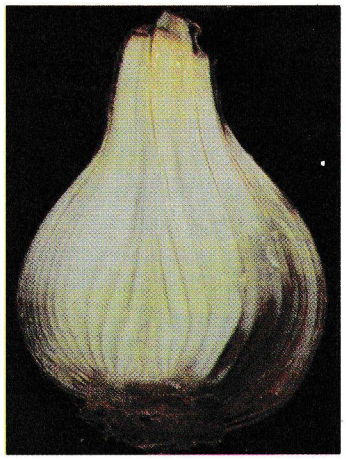
   Destroy all diseased foliage whenever possible. Change the planting site from year to year, avoid sites with poor air and soil drainage, and practice thorough weeding. If leaf diseases occur, they can markedly affect bulb size. For instance, growers estimated a 30 percent or greater reduction in bulb size caused by scorch which killed foliage 4-8 weeks earlier than normal.
2. Begin roguing (dig out and remove) for yellow stripe when the plants are 6 inches high. Try to rogue them out before blooming time. Begin roguing for white streak immediately after the plants have bloomed. Roguing of plants infected with these two major virus diseases gives best control.

   Since it is sometimes impossible to rogue the entire acreage of a commercial field, many growers have adopted a mother block or foundation system. The largest well-shaped bulbs are saved and planted in a separate mother block. The major share of attention is then given to this particular stock, and all diseased plants are carefully rogued. When this mother block has been built up to a sufficient size, all bulbs used for propagation are taken from it.
3. Rogue out nematode-infected plants before they flower. (Commercial stocks should not be rogued until inspected by staff of the State Department of Agriculture.)
4. When fire disease is anticipated, remove and destroy old blooms.
5. Dig bulbs with as little bruising as possible and store under cool, well-ventilated conditions.
6. Treat bulbs in a fungicide (see EM 4313) to control basal rot as soon as possible after digging. Careful culling is also very important to keep this disease in check.
7. If bulb and stem nematodes are present, give the bulbs a hot water formaldehyde treatment, and repeat annually until eliminated. Continue using the hot water treatment every three or four years for general clean-up purposes. Recent research indicates good control by applying a nematocide at time of planting (EM 4313).

8. Always plant well-graded stock of known disease-free ancestry.
9. Plant in cool, well-drained soil which has not had narcissus on it for at least three years. Avoid planting on soils having large amounts of nitrogen or undecomposed organic matter.
10. Alternate fungicides, whether for spraying plants or dipping bulbs, to reduce the likelihood of development of fungicide-resistant strains of the fungi—as has happened previously with *Fusarium, Botrytis*, and others.

Major Diseases

Basal Rot



Basal rot

Symptoms

LEAVES AND FLOWERS. Shoots arising from diseased bulbs may be stunted, distorted, turn yellow, and die prematurely. Intensity of these symptoms varies with time and extent of attack. Yellowed leaves and stunted plants may also be caused by other pathogens or physiological factors, including waterlogging.

ROOTS. Few or no roots at all grow from infected bulbs. Infected roots that do grow have a brown or purple decay.

BULBS. Infection usually, but not always, is through the roots or basal plate. The basal plate is partially or entirely decayed, with a soft chocolate or reddish brown color that usually progresses into the scales and eventually rots the entire bulb. Mites usually invade the rotted tissues and convert them into a dry and powdery mass. Varieties may show somewhat different symptoms, with the color varying from grayish-brown through red to violet. A white or pinkish mold usually develops between the scales and sometimes on the surface at the base. The disease is more common in double nose and mother bulbs than in rounds.

Symptoms that may be confused with basal rot are caused by heating, freezing, and methyl bromide. Overheating results in a brown decay, beginning first at the root initials and flower bud. Tissues other than roots and flower buds are the first to become discolored in bulbs subjected to freezing injury. An overdose of methyl bromide produces a grayish-brown breakdown, which progresses rather uniformly inward from the outer surface and along junctions of slabs and flower stems. In none of these cases is the white or pink mold present between scales unless the *Fusarium* has subsequently infected the bulbs.

Factors Affecting

Some infection in the soil may occur at temperatures as low as 8°C (47°F), but appreciable spread only takes place above 13°C (55°F). At temperatures up to 29°C (85°F) rapid spread occurs if sufficient moisture is present. Consequently, most infection occurs late in the growing season. This combination of hot and moist weather seldom occurs in the Pacific Northwest, but often occurs in the eastern and southern United States.

Infection also may occur during digging, cleaning, and grading when healthy and diseased bulbs come in contact. This type of infection usually starts at the base of the bulb but may begin elsewhere, particularly at wounds, bruises, sunscalded areas, etc. As the harvested bulbs mature, they become increasingly resistant to infection, but as soon as root activity begins, they again become susceptible. Infection in the field usually occurs from adjacent diseased bulbs. The fungus persists in soil in absence of hosts for several years in warm climates and less time in cool climates.

The disease is usually more severe on light sandy soils, southern slopes, or similar locations which are warmer. Weed-free fields may also have more disease than weedy fields perhaps because

the soil temperatures are higher where weeds do not shade the soil.

Animal manures, or inorganic fertilizers containing high levels of nitrogen and phosphorus, increase disease loss while potassium reduces it. The *Fusarium* and many other fungi attacking bulbs are usually stimulated by presence of undecomposed organic matter.

Basal rot usually is not serious under forcing conditions, since temperatures are often too low for optimum development. However, the rot may develop before flatting, particularly in stock shipped under high temperatures or stored in warm warehouses.

Importance

Basal rot is found throughout the world where narcissus are grown. It is more serious in warm climates than in cool ones, such as the Pacific Northwest. For example, when samples of a diseased stock were planted in Maryland and western Washington, the decay was 27 vs. 5%. The air temperature was about 4.5°C (8°F) cooler in Washington. Most large trumpet varieties are susceptible, particularly the white and bicolor types, but several of the large yellow trumpets (Division 1), such as Golden Harvest, are also very susceptible. Most of the Division 2, 3, and 8 (Tazettus) varieties are resistant. However, the fungus can mutate. King Alfred rarely became infected in western Washington until recently; now certain stocks have as much disease as the bicolors and require regular treatment.

Control

1. Dig diseased stocks as early as practicable, preferably before the soil warms to 13-15.5°C (55-60°F). Dig in as dry weather as possible. Cover stacks to keep bulbs dry and protect them against sunburning. Dry as rapidly as possible and provide good air circulation.
2. Avoid sunburning, bruising, or other injuries to bulbs. Be especially careful when digging, cleaning, and grading.
3. Remove and destroy all diseased bulbs as soon as possible. (Discard all bulbs of severely infected stocks to prevent them from contaminating healthy stocks.)
4. Store bulbs in thin layers under cool 13-15.5°C (55-60°F) and well-ventilated conditions. Avoid overheating in transit.
5. If possible, treat cleaned planting stock within 48 hours after digging with a fungicide (see EM 4313). If the loss from basal rot exceeds 1%, treat again just before planting. Under commercial conditions in the Pacific Northwest, it is usually impracticable to treat daffodils immediately after digging because of the large masses of root and soil adhering to the bulbs. Therefore, most treating is usually done prior to planting even though the control is less effective. Monitor concentrations of the fungicides in the treating tank to maintain effective strength.
6. Use a different type of fungicide each year in order to help prevent the development of fungicide-resistant strains of the fungus.
7. Do not mix fungicides, insecticides, and nematocides unless the labels state they are compatible.
8. Give bulbs a hot water plus formaldehyde treatment every 3 to 4 years (see under nematodes). This is an excellent general treatment which also partically controls *Fusarium.* Dip hot water-treated bulbs in a fungicide before planting if the stock has more than 1% basal rot.
9. Remove and again destroy diseased bulbs sometime prior to planting.
10. Plant diseased stocks in an accessible area to facilitate early digging.
11. Plant in cool, well-drained soil and as deep as practicable. If the soil temperatures are lower than those in the shed, plant as soon as possible after grading. To avoid warming the soil, the rows should not be opened until just before planting.
12. Excessive nitrogen and phosphorus increase the loss from basal rot, while high potassium helps reduce it. Either avoid organic nitrogen fertilizers or mix them thoroughly with the soil early enough to permit decomposition before planting. Some growers now fertilize the preceding cover crop instead of the bulbs. Allow the cover crop ample time to decompose before planting.
13. Do not replant bulbs on the same land more often than once every three years in cool areas such as the Pacific Northwest and less often in warmer regions.
14. Disinfect used trays and cases in a solution of formaldehyde (1 gallon of formalin (37%) to 9 gallons of water).

15. A severely diseased stock is seldom cleaned up in one year. Often, after a cool growing season, such a stock may appear healthy but contains many bulbs with dormant or latent infections that only need favorable conditions to become active. Therefore, all such stocks should receive a minimum of two consectutive annual treatments and preferably three.

Causal Agent

Fusarium oxysporum f. sp. *narcissi* Sny. and Hans. (*Fusarium bulbigenum* Cke. & Mass). In culture the microconidia are abundant, mostly non-septate, ovoid, and measure 7-10 x 3-4μ. Macroconidia are usually scarce, straight, and slightly curved, ends pointed and curved, typically 3-septate and average 30 x 4μ. Four and five septate spores present but rare. Chlamydospores are abundant, terminal or intercalary, spherical to oval, 7-10μ, smooth, and are either single or in short chains. This *Fusarium* is a strain that differs from those on iris and tulips.

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Bulb and Stem Nematode (Eelworm)

Symptoms

LEAVES. Severely diseased bulbs produce little or no foliage. Those less affected may be twisted, distorted, and exhibit 1) swollen and sometimes split corrugated leaf thickenings near bases of leaves, 2) marginal swellings and discolorations, 3) pale yellow or yellowish-brown pimples (spikkels). The pimples in the center of leaves are larger than those at the edge, but the latter are the easiest to detect in the field. Such marginal pimples appear as bulges, usually with sunken centers, and are easily felt by pulling leaves between fingers.

STEMS. Stems may have the same symptoms as leaves.

BULBS. Infected bulbs may be completely or partially rotted. In the latter case they show one or more mealy or spongy rings of brown, disorganized scales lying between healthy ones. Under certain favorable conditions large masses of nematodes collect as a whitish mass on the basal plate, and occasionally at the necks, producing what is called nematode wool. The early stage of bulb infection starts as yellowish spots on the neck region, whereas basal rot, with which it might be confused, usually begins at the base.

Factors Affecting

Nematodes enter the leaves as the leaves grow through the soil and are carried up as the leaves elongate. When the foliage begins to dry up in the summer, the nematodes tend to migrate into the bulbs or into the surrounding soil. They can survive without additional food for about 18 months in a moist soil free of vegetation. Under dry conditions, they can survive for five years or more. In actual practice it is difficult to starve them to death.

This nematode is able to survive in a wide variety of climates, occurring in hot, cold, wet, or dry areas. It is present in most soil types but populations decrease faster in light as compared to heavy soil. It has survived over 20 years in dried collections in the laboratory. The optimum temperature for reproduction and infection is between 10°C (50°F) and 15.5°C (60°F). The nematodes can migrate in the soil a few inches but most spread in a field is a result of equipment, drainage water, or by transporting diseased bulbs.

Importance

This serious disease occurs throughout the world. It is probably the one most feared by growers because of inspection restrictions on movement of infested stock and because, by the time an outbreak is discovered, the infection may have spread considerably. It can be eradicated from infested stocks as evidenced by the experience in western Washington, but this requires considerable and conscientious effort on the part of the grower as well as rigid policing by the inspection service.

Nematode damage

There are several strains of *D. dipsaci.* Unfortunately, according to research in England, the Narcissus strain can also attack and reproduce in scilla, snowdrops, onions, beans, peas, turnips, strawberries, and many other plants including such weeds as chickweed and dock. The grasses and cereals are resistant.

Control

1. Remove all infected plants and bulbs. The surrounding plants and bulbs should also be removed. Be very careful not to scatter soil while removing from field; burn plants and bulbs or bury deeply and cover with quicklime.
2. When using cultivating and other equipment, always work in healthy fields first before moving to diseased fields. Clean equipment thoroughly afterwards, preferably finishing by spraying with a formaldehyde (1:10) solution.
3. Harvest infected stocks slightly earlier than normal (before tops are completely dry) again taking care to prevent soil and plant debris from being spread either in the field or in the shed.
4. Discard (by burying or burning) all severely diseased stocks. Give lightly or moderately infested stocks the hot water treatment for two consecutive years (since disease control is seldom perfect).
5. Give diseased stock the hot water treatment as soon as the bulbs are dormant and before the root base begins to swell. There is a very narrow temperature range between avoiding injury and obtaining satisfactory control. The timing is also extremely important in order to prevent injury. The English recommend the bulbs should be treated when the flower embryo reaches the paracorolla stage. This normally occurs about 3-5 weeks after early digging but will vary with climate, time of digging, temperature of storage, and variety. Only experience will provide a suitable guide for each grower. The bulbs may be killed or may fail to grow (one year dormancy). The growth of heat-injured bulbs may be stunted, blasted or malformed flowers may be formed, and rough light spotted areas may occur on the leaf tips. This leaf spotting can be distinguished from yellow stripe by the latter not being confined to the tips.
6. After digging, stocks to be hot water treated should be stored at 15°C (61°F) or above to reduce heat injury. The injury may be reduced further by storing the bulbs for a week at 29.5°C (85°F) before treatment, but this makes the nematodes more resistant. Therefore, since the control is poorer, do not prewarm badly infested stocks. However, if nematodes are not present, the preliminary warm storage treatment is a good precaution to use to reduce leaf and flower damage.
7. The effectiveness of the hot water treatment is improved (particularly on lightly infected bulbs) by presoaking the bulbs prior to treatment for 2-3 hours at 24°C (75°F) in water with a non-ionic wetting agent added (such as Triton X-100).
8. A temperature of 43-44°C (110-111°F) for four hours is recommended in the Pacific Northwest, although slightly higher temperatures 44-46.5°C (112-116°C) are being used in England and Holland. The temperature of the bath is normally raised a few degrees above 43°C (110°F) before starting since the cooled bulbs will cause the temperature to drop. The timing should start

when the temperature reaches the 43°C (110°F) point.

9. Use a *certified mercury* thermometer, accurate to at least plus or minus 0.1°C (0.2°F), to monitor the temperature. An inaccurate thermometer can cause great losses.
10. Add formaldehyde to improve nematode kill and control fungi. Use at a rate of 0.5 gallon (37%) to 100 gallons of water. A 1% concentration is recommended in Holland but this increases the danger of injury. If the bulbs are clean, the formaldehyde concentration will remain fairly steady. The evaporation of it and water are approximately equal so replacement can be made at the same rate (0.5% solution). However, under certain conditions the loss may be excessive so the solution should be replaced every few days or the strength should be monitored with a testing kit. Steam will dilute the solution and needs to be compensated for.
11. Most commercial treating tank units have been custom made of concrete or metal, using steam or propane burners for heating. They should have automatic controls with a fail-safe alarm which rings if the temperature goes beyond a set limit. Adequate circulation is highly essential. This was formerly accomplished by propellers, but many modern types have one or two circulating pumps. The bulbs in trays are trucked onto an electrically controlled hoist, covered with a wire mesh screen to prevent floating, and then lowered for the treatment (ref. Courtney 1963, Hesling 1966). The hobbyist can construct his own without much cost. An excellent one called "A Garbage-Can Bulb Cooker" is described by Ms. Marie Zozievich (Appendix 1).
12. Use a ratio of 3 pounds bulbs per gallon of water.
13. Cool bulbs promptly. Dry or plant immediately. If planting is delayed and the stock contains considerable basal rot, sort the bulbs again and treat in a fungicide before planting.
14. Treat planting stock regularly (every two or three years) as an insurance against re-infection.
15. Disinfect used trays, cases, tools, and equipment either by a) treating with steam, b) dipping in hot water at 85°C (185°F), or c) dipping in a solution of 1 part formaldehyde (37%) to 9 parts of water.
16. Do not replant daffodils on the same ground for three years unless all volunteer bulbs are removed and the infested soil is fumigated or treated with a nematocide.
17. Remove all volunteer bulbs. Use cereals or grasses as a cover crop.
18. We consider the hot water plus formaldehyde treatment the best all-round bulb treatment available. When properly done it kills not only nematodes but also the greater bulb fly, mites, aphids, many fungi (*Sclerotium rolfsii, Botrytis* spp., *Stagonospora,* etc.) and partially controls *Fusarium* basal rot as well. Unfortunately, the use of formaldehyde may be illegal in most states according to EPA regulations. Washington has an approved state label for its use. If others are interested in obtaining a sample of the label for requested use in their state, they should contact Washington Department of Agriculture, Olympia, Washington.
19. Recent studies have shown good nematode control through applying a nematocide at time of planting (EM 4313).

Causal Agent

Ditylenchus dipsaci (Kuhn) Filip. (See Thorne for full description.) If possible, determinations concerning nematodes should be referred to a nematologist because of the highly specialized nature of the diagnosis. However, it is probable that if nematodes are found in typical leaf spikkels they belong to the species *D. dipsaci.* Most saprophytic forms found in daffodil bulbs are proportionately wider than *D. dipsaci,* which is 1.0-1.8 mm long and 0.03-0.06 mm wide.

This species has been found on over 400 species of plants in more than 40 genera. However, there appear to be populations or strains which prefer a specific host, such as narcissus.

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THORNE, GERALD. 1961. Principles of nematology. McGraw-Hill. p. 115-138.

Fire

Symptoms

LEAVES. Bright yellowish elongated spots appear generally near the tips of the leaves. At first, the center of the spots has a grayish streak that eventually turns brown. The part of the leaf above the spot turns yellow and dies. Under warm, moist conditions the fungus may destroy plantings within a week. The initial leaf infections result from spores produced on infected flowers. The fungus overwinters as smooth, plate-like elliptical sclerotia in the leaves.

FLOWERS AND STEMS. Flowers are the first part to be affected. The edges of the flower show watersoaked areas which enlarge very rapidly, turn brown, and wither.

BULBS AND ROOTS. Bulbs and roots are not attacked but early death of foliage substantially reduces the yield.

Factors Affecting

Fire is worse under mild (above 50°F), humid conditions such as in southwestern England.

Importance

Fire is a widespread disease but is not usually common in the Pacific Northwest, except during warm, humid seasons. Spore production can be rapid and prolific on the flowers, resulting in complete destruction of fields within a few days. Therefore, continued examination and prompt diagnosis are essential. Varieties vary in susceptibility; Silver Chimes is very susceptible, King Alfred rather resistant, and the jonquils highly resistant.

Control

1. Follow control recommendation as outlined for smoulder.
2. In addition to the above the following measures should be followed:
   a. Remove all flowers as soon as the disease is detected.
   b. Begin spraying immediately after the disease is detected and continue at weekly intervals (see EM 4313).
   c. Remove and destroy all plant debris.

Causal Agent

Botrytinia polyblastis (Greg.) Buchw. (*Sclerotinia polyblastis, Botrytis polyblastis*). Conidia are spherical or pear-shaped, light brown, papillate at one end, very large (30-90μ), and produce several germ tubes. Microconidia may form in culture and on sclerotia. The sclerotia are large (up to ⅓″ in length), flat rounded, black, and smooth. They form readily under moist conditions on dead leaves, sometimes preceded by the development of a few small tufts of conidia. The

Fire—general view, lower left, and closeups of infected leaves

sclerotia germinate in the spring to produce apothecia and ascospores which initiate the infection cycle.

References

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Root Lesion Nematode (Meadow Nematode)

Symptoms

FIELD. This disease is characterized by stunting, premature yellowing, and dying of plants in more or less circular spots in the field. Such diseased areas reappear in succeeding years and normally continue increasing size.

LEAVES. Leaves are often stunted and gradually turn yellow, become withered, and collapse prematurely. The older leaves are affected first. Symptom progress increases rapidly as the weather warms up.

Root lesion nematode—treated and untreated comparisons

FLOWERS AND STEMS. Flowers and stems react similarly to the leaves, resulting in poor quality flowers.

BULBS AND ROOTS. The first evidence of root lesion attack usually occurs in the fall when the new roots are infected. No noticeable symptoms appear on the foliage at this time. These initial attacks result in small necrotic lesions which are frequently reddish and later turn dark-brown or black, perhaps due to the invasion by various fungi and/or bacteria. These lesions usually continue enlarging until all or most of the root system is decayed. The few roots that may be left are stubby. The bulb itself is not infected, but is usually much reduced in size because of premature death of the foliage.

Factors Affecting

The disease is normally worse in light, sandy soils. In general, warm temperatures seem to favor nematode attacks. These nematodes are subject to dessication and are seldom transmitted with the bulbs since most daffodil roots dry and drop off before shipping.

Importance

These nematodes have worldwide distribution and are very important on narcissus in certain localities. In such areas the losses can be dramatic. In the Pacific Northwest losses are usually restricted to the light, sandy fields and fumigation once every 4-5 years usually gives adequate control. This nematode has an exceptionally wide host range, including many weeds, therefore the normal practices of rotation, fallowing, etc. are usually not effective.

Control

1. Soil fumigation, when properly done, is by far the most effective and practical control measure (EM 4313). The following should be considered to help insure an adequate fumigation. (Ref. Apt, 1957 in Handbook on Bulb Growing and Forcing.)
   a. Fumigate when soil moisture is the same as would be used for a good seedbed. Dry, loose soil allows much of the gas to escape; excessive moisture prevents the gas from moving through the soil.
   b. Use a thermometer and do not fumigate until the soil temperature at a depth of 6 inches is between 10-30° C (50 and 85°F).

c. Plow to the usual depth and subsoil if lower levels of soil are compacted. Do not depend only on disking, which rarely works the soil more than 4 or 5 inches deep and leaves a solid subsoil through which the gas cannot penetrate.

d. Fumigate soil that is in good planting condition—without large clods and unrotted organic matter. Fields in which the cover crop has just been turned under are not in suitable condition for fumigation. Allow sufficient time for the organic matter to decompose.

e. Apply the soil fumigant at a depth of 6 to 10 inches, with a chisel applicator, or at the usual plowing depth with a plow applicator.

f. Work the surface down firmly immediately after application with a harrow, leveler, drag, packer, roller, or other suitable equipment. This implement should follow immediately behind the applicator to confine the gas and get maximum benefits. A plastic cover improves efficiency of the treatment.

g. For small areas there are available hand applicators capable of delivering measured amounts of the fumigant.

h. After fumigation, delay planting 10 to 14 days at a minimum to avoid injury to the planting stock.

i. Be certain that soil fertility is high enough to insure returns for the investment in fumigation.

j. Be familiar with recommended precautions, as listed on the label of the container, for the particular fumigant that is being used.

k. Although soil fumigation will control nematodes, it may result in increased losses from fungus diseases if the planted stock is carrying any infection such as basal rot, crown rot, etc. (Apt & Gould, 1961)

The losses are most evident after use of methyl bromide and chloropicrin but also occur to a lesser extent with the other effective fumigants. This increased spread is probably due to the elimination of competitive and other beneficial soil microorganisms that normally retard spread of the pathogens from diseased to healthy bulbs. Plant stock as disease-free as possible in fumigated soil.

2. *Soil treatment* with a granular nematocide is a possibility with the recent development of a new material (see EM 4313).

3. *Summer fallow,* weed control, and roguing of volunteer plants will give some reduction but the host range of the nematode is so great that a suitable rotation program cannot be recommended.

4. *Bulb treatment* is not necessary for narcissus if all roots are removed.

5. *Rotating marigolds* (*Tagetes*) with narcissus might be useful for the hobbyist. These have been found effective in reducing root lesion nematodes in experiments in Holland and the United States. Some species of marigolds (*especially T. patula*), gave better protection than others.

Causal Agent

Pratylenchus penetrans (Cobb) Fil. and Stek (see Thorne, p. 219-220 for description). Root-lesion nematodes are often called migratory nematodes. They may enter the tissues, move through the root, and live inside it. When the tissues begin to decay they migrate to healthy roots of the same plant or of other plants. In entering and migrating through root tissues they destroy cells by breaking through cell walls and feeding on the contents. In addition, the small punctures which they make in entering the root serve as avenues of entry for decay organisms.

References

APT, WALTER J., and CHARLES J. GOULD. 1961. *Control of root-lesion nematode, Pratylenchus penetrans on Narcissus.* Plant Disease Reporter. 45(4) April 15, 1961. p. 290-295.

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MILLER, P. M., and J. F. AHRENS. 1969. Influence of Growing Marigolds, Weeds, Two Cover Crops and Fumigation on Subsequent Populations of Parasitic Nematodes and Plant Growth. Plant Disease Reporter. 53(8) p. 642-644.

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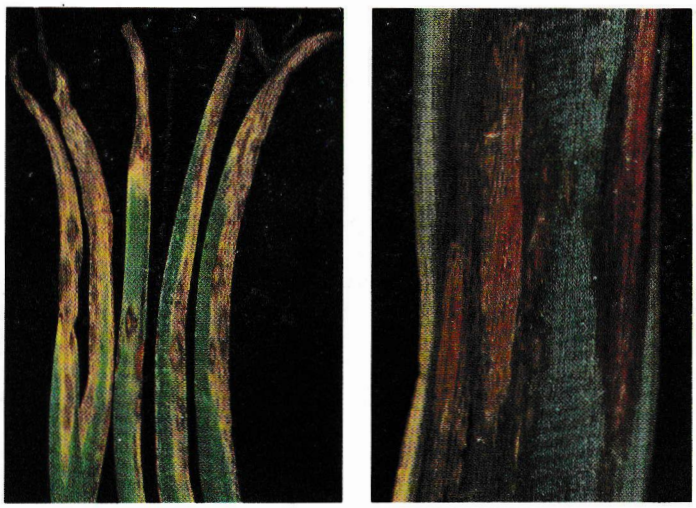


Scorch

Scorch

Symptoms

LEAVES. On the tip of the leaves, yellow, red, or brown spots appear as they emerge (or soon after) from the soil causing a scorched appearance. A yellow zone separates healthy and diseased areas. This discoloration is sometimes wrongly ascribed to frost injury. Secondary spots next appear on lower parts of the discolored leaves or on adjacent ones. At first these are small and water-soaked with yellow centers, later becoming elongated (up to ⅛″ x ½″). The spots become scabby in appearance and turn reddish brown. Very small brown fruiting bodies of the fungus appear as raised bumps in these dead areas. Eventually the tissue surrounding these spots dies and turns light grayish-brown. The leaves may die soon after the secondary lesions appear. On occasion, infections will appear as only very small rust-colored spots on the leaf bases.

FLOWERS AND STEMS. Buds may be distorted and petals spotted. The latter may be inconspicuous at picking time but enlarge and turn brown during transit.

BULBS AND ROOTS. The fungus survives in the neck of the bulb and may cause some decay.

Factors Affecting

Scorch is most serious in warm, moist climates, on wet, poorly drained soils, and in old plantings. Infection starts from diseased bulbs or debris in soils. Secondary infection is rapid during mild, showery weather. The disease is favored by high rainfall and increased by cold storage (precooling) of bulbs before planting. The optimum temperature for infection is 18-23°C (64-73°F) at a relative humidity of 90-100%.

Importance

Scorch is widespread throughout the world and is a common problem in the southern United States and southwest England, but is occasionally troublesome in the Pacific Northwest during mild, moist springs. The fungus can attack amaryllis and many other genera of the Amaryllidaceae. Varieties of narcissus vary in susceptibility, Division 8, Division 9, and Division 2 are especially susceptible. The large trumpets Division 1 are more resistant.

Control

1. In small plantings, pick off and burn infected leaf tips as soon as they emerge.
2. Begin spraying when leaves are 4-5 inches high and continue until maturity (see EM 4313).
3. Destroy mature foliage.
4. Treat infested stocks in hot water formaldehyde (see under nematodes).
5. Rotate.
6. Provide wide spacing and thorough weeding in order to achieve good aeration.

Causal Agent

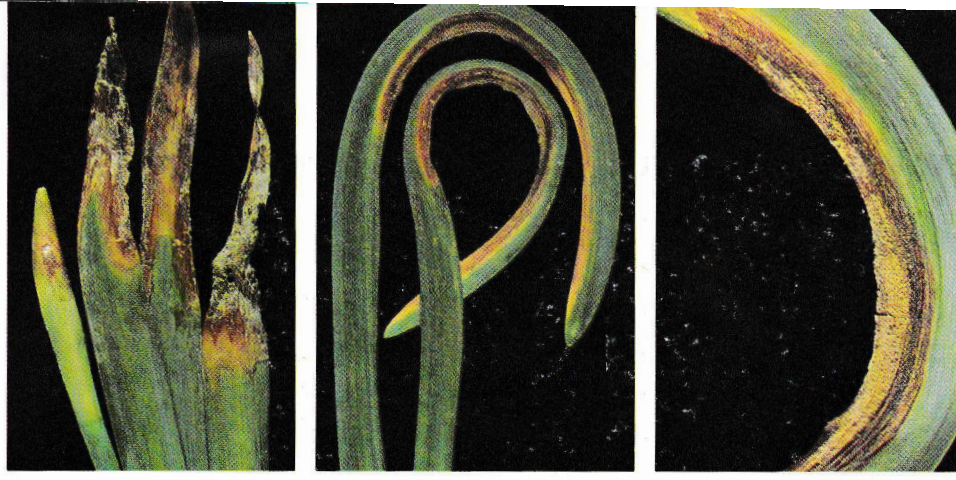
Stagonospora curtisii (Berk.) Sacc. Conidia are hyaline, elliptical to fusiform or nearly cylindrical, constricted at the septa, rounded at the ends, 1-3 septate, and 19-27μ x 6-8μ in size. They are produced in large numbers in brown to dark brown globose pycnidia (110-275μ) formed in the dead leaf spots. They are spread by raindrops or irrigation. The fungus is carried on the nose of the bulb where over-wintered mycelium or spores infect the new, emerging shoot.

References

BERGMAN, B. H. H., and C. E. I. NOORDERMEER. 1974. 2nd International Bulb Symposium. Leaf scorch and neck rot in narcissus. Acta Horticulturae 47. p. 131-32.

CREAGER, DON B. Leaf scorch of narcissus. Phytopathology. Vol. 23 (10) p. 770-786. October 1933.

Smoulder



Symptoms

LEAVES. As infected leaves emerge from the soil, they appear brown and more or less distorted. Dead leaf tips may be stuck together. When the rot is one-sided, the leaves are sickle-shaped with the rot on the inner edge appearing wet and pinkish-brown or brown. Masses of gray spores and small black sclerotia often form on the diseased tissues, especially near ground level.

FLOWERS AND STEMS. Stems may be rotted and the flowers may develop brown spots.

BULBS AND ROOTS. The fungus is able to grow down the leaf bases and into the neck of the bulb. Sclerotia develop on the nose of the bulb and on or between the husks. Infected bulbs may occasionally develop a yellowish-brown rot if subjected to prolonged storage. Sclerotia are formed between the scales of the rotted bulb. Yield is reduced.

Factors Affecting

Smoulder is more serious in multiple bulbs; cool, wet seasons; stocks not dug every year; plants weakened by waterlogging; and on leaf tips injured by wind, frost, or some other condition. Infection may come from diseased bulbs or infested debris left in the soil. Spores may be blown by wind or scattered by rain.

Importance

The fungus is widespread, although it generally is considered to be of minor importance. In the Pacific Northwest, however, it ranks next to basal rot and yellow stripe in seriousness. Both bulb and flower yield may be reduced. The Division 9 and early varieties are reported as being particularly susceptible, but this may be due to their exposure to more frost injury. Snowdrops are also susceptible.

Control

1. Remove and destroy diseased plants as soon as they appear.
2. Promote good air movement by controlling weeds.
3. Spraying has not appreciably increased yield in England and Scotland. However, it would seem to be good insurance to apply a fungicide every two weeks during wet weather (see EM 4313).
4. Dig bulbs early, dry them quickly, and remove all loose husks.
5. Discard all rotted bulbs and infested debris.
6. Give infested stocks the hot water-formalin treatment used for nematodes or dip in a fungicide (see EM 4313).
7. Plant in locations with good air movement and good soil drainage; avoid low spots and heavy soil. Rotate plantings.

Causal Agent

Botrytinia narcissicola (Greg.) Buchw. (*Sclerotinia narcissicola* or *Botrytis narcissicola*). Conidia are oval, somewhat pointed at the lower end, pale brown, and measure 8-16 x 7.5-12μ; small (1-2 mm), black, flattened sclerotia may develop under or on the surface of the outer papery scales, or on the young blighted shoots. Sclerotia may germinate to produce apothecia.

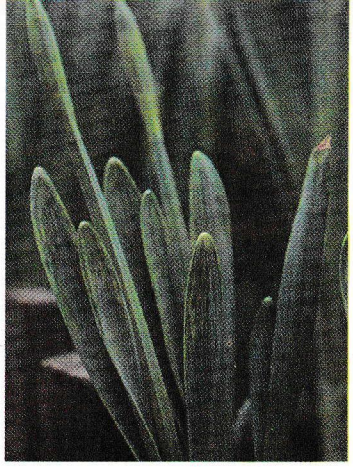
References

GREGORY, P. H. 1961. Botrytis diseases of narcissus. Daffodil and Tulip Yearbook. p. 1-5.

GRAY, E. G., and R. S. Shiel. 1974. A study of smoulder (*Sclerotinia narcissicola* Greg.) of narcissus in northern Scotland. Second International Symposium on Flower Bulbs. Acta Horticulturae 47: p. 125-29.

Virus Diseases (General)

Eighteen viruses are known to infect narcissus. Symptoms vary depending on the virus and the variety of narcissus infected. Some cause no symp-



Mosaic

toms, while others range up to severe discoloration and stunting as with yellow stripe and white streak. Some viruses are confined to one variety (as Grand Soleil d'Or) while others (as yellow stripe) attack many varieties. Most of the aphid-transmitted viruses are confined to narcissus, but the nematode-transmitted viruses are also found on many other genera, including weeds (such as chickweed). There are no known vectors for narcissus mosaic or narcissus tip necrosis; and these are possibly spread by picking flowers.

Yellow stripe (American "mosaic") and white streak are the most troublesome in the Pacific Northwest (and probably worldwide also). Probably the next most destructive is tobacco rattle; however, there has not been enough research in the United States to determine the distribution and importance of this and many of the other viruses, particularly those transmitted by nematodes. As greater research effort has been directed at these diseases, more virsues are found, as evidenced by the excellent work done recently in England, Scotland, Holland, and Japan. We have no doubt that similar diligent research would uncover most of these viruses in the United States.

The viruses, or suspected viruses, are listed in the table outlining their major characteristics. This information was obtained mostly from Brunt's publication and supplemented by information from Asjes, Mowat, Chambers, and Harrison. Some viruses have only recently been discovered so information on symptoms, host range, etc., is lacking. The common chocolate spot disease has not yet been proven to be caused by a virus, although it has many virus-like characteristics. It is described in the miscellaneous disease section.

Most commercial narcissus stocks are probably infected by at least one, and more likely by several viruses—in other words, a complex of viruses. Unfortunately, the same virus can cause different symptoms on different varieties, and sometimes similar symptoms can be caused by different viruses. When more than one virus is present the symptom picture becomes very complicated. Therefore, in general, we believe that it is good insurance to remove any plant with a persistent abnormal appearance.

Injury from frost, waterlogging, and improper herbicide application may sometimes be thought to be from viruses. However, in most of these cases, all plants in an area will exhibit similar symptoms—in contrast to the scattered nature of most virus diseases.

Control

1. Production of virus-free stock.

SEEDS. Some narcissus viruses (ringspot) are seed and/or pollen-borne, but generally seeds are considered to be virus-free. Narcissus breeders should use sterilized soil and protect seedlings with aphid-proof netting. Unfortunately, many new cultivars have a high incidence of viruses because of exposure to commercial stocks.

HEAT THERAPY OF BULBS. Heat therapy has worked for some plants but not for narcissus.

MERISTEM-TIP CULTURING. This technique has produced virus-free stocks in England, Scotland, and Holland. Some virus-free bulbs have also been found by indexing or testing. Sometimes the improvement in flower quality and bulb yield from virus-free stocks has been dramatic. In England the variety Grand Soleil d'Or, as an example, is being increased for commercial planting on the Isles of Scilly. Two practical problems emerge: (1) economically producing enough planting stock and (2) maintaining the field-planted stock free of virus. The technique of twin-scaling appears to have solved the first problem. Isolation from other Narcissus and possible weed hosts coupled with the use of soil fumigants in areas where soil-borne viruses are a problem will help in maintaining the "virus-free" field stocks.

COMMERCIAL SELECTION FROM EXISTING STOCKS. Until sufficient quantities of virus-free bulbs become available from meristem-tip culturing, it will be necessary for growers to rely upon marking and selecting superior plants for establishing a foundation block. Planting stock can then be obtained from these foundation plantings. Unfortunately, since this is a time-consuming process, it is seldom practiced. The next best solution is bulb selection. This procedure is based upon the principle that the most serious viruses (yellow stripe and white streak) reduce bulb size and the amount of reduction depends upon the severity of

Table 1. Known and Suspected Virus Diseases of Narcissus*

Virus	Natural Transmission by: Aphids	Nematodes	Mechanical	Susceptibility of Narcissus: Pseudo-narcissus	Tazetta	Jonquilla	Symptoms	Importance	Other Hosts Known
Arabis Mosaic	–	+	–	+	+	–	Inconspicuous	Common	Many
Cucumber Mosaic	+	–	–	+	+	–	Symptomless or mosaic	Prevalent in Soleil d'Or. Rare in trumpets.	Many
Jonquil Mild Mosaic	+	–	–	–	–	+	Mild mosaic	Prevalent. Of slight importance.	——
Narcissus Latent	+	–	–	+	–	–	Symptomless or very mild chlorotic areas on leaves.	Prevalent. Rather unimportant.	Nerine and Bulbous Iris
Narcissus Mosaic	–	–	+	+	–	–	Usually symptomless or mild mottling at base of leaves. Appears late.	Prevalent especially in trumpets. Probably unimportant.	Nerine
Narcissus White Streak	+	–	–	+	–	–	Purple, longitudinal streaks which later turn white, often coalesce, become necrotic and leaves die prematurely. Appears after strong sun and high temperature.	Present occasionally, very damaging. Heavy reduction in yield.	——
Narcissus Yellow Stripe	+	–	–	+	–	+	Light green to yellow or chlorotic stripes on leaves and stems which may be stunted and distorted. Flowers show white streak or blotches. Appears early in growing season.	Prevalent. Very damaging. Heavy reduction in yield.	——
Raspberry Ringspot	–	+	–	+	–	–	?	Sporadic	Many
Soleil d'Or Virus	+	–	–	–	+	–	Yellow stripes, general chlorosis and early death in Soleil d'Or.	Prevalent, may be very damaging in this variety.	——
Strawberry Latent Ringspot	–	+	–	+	+	–	Inconspicuous	Common	Many
Tobacco Rattle	–	+	–	+	–	–	Symptomless, slight to severe mottling, or streaking of lower leaves and stems; before flowering.	Sporadic	Many
Tobacco Ringspot Virus	–	+	–	?	?	?	?	Sporadic	Many
Tomato Black Ring	–	+	–	+	+	–	Inconspicuous	Sporadic	Many
Chocolate Spot	?	?	?	+	?	?	Chocolate brown to purple spots on tips of leaves. Increases after strong sunshine and high temperature. (Not proved to be virus.)	Prevalent. Apparently not harmful. Varies from year to year.	?
Narcissus Tip Necrosis	?	?	?	+	+	?	Symptomless, or chlorotic tips, or elongated chlorotic areas later turning brown and dying prematurely.	Probably widespread	——

*Most of this information is obtained from references by Brunt, Asjes, Harrison, Mowat, and Chambers.

infection. Therefore, by saving the largest, properly shaped, heaviest bulbs, a good foundation stock can be built up more rapidly than by plant selection. When this is coupled with good roguing, it is the fastest method for the commercial grower. If a high number of plants have visible infections, it is probable that most of the plants are infected. In such a case, it is best to discard the stock and obtain a healthier stock elsewhere.

2. Roguing

Roguing is essential for both commercial producers and the hobbyist. Dig and destroy all off-types. Check plantings every two weeks after emergence to catch symptoms at the best time (e.g., yellow stripe before flowering and white streak after flowering). Recently growers have had success with chemical roguing in which individual plants are treated.

3. Spraying for aphids.

Insecticide applications for aphid control are of debatable benefit. Populations are largest toward the end of the growing season as the weather warms up. Aphids pick up the virus quickly after feeding on a diseased plant. They don't particularly like daffodils so they tend to move from plant to plant. It only takes a few seconds for them to infect a healthy plant; therefore, it is possible for them to infect a number of plants in a short period. Spraying has not been of much benefit in small plots, nor has its value been definitely established in large fields although it is often recommended. Some recent reports indicate light mineral oils may be more effective than insecticides for spraying. Aphid transmission of viruses during storage is unlikely.

4. Dig stocks as early as possible.

Since aphids increase most rapidly as the weather warms, the earlier the daffodils are dug, the less opportunity there is for infection. This, plus careful roguing and planting of only large bulbs, appears to be the most practical control measure for the commercial grower.

5. Nematode control

Soil treatment for nematodes should be done in those areas where soil-borne (nematode-transmitted) viruses are known to be a problem.

6. Isolate virus-free stocks.

Plant virus-free stocks as far as possible from diseased stocks and also newly purchased stocks until the status of the latter has been determined.

7. Late planting

Planting as late as possible, within reason, will help reduce infection by certain viruses transmitted by nematodes (such as tobacco rattle by *Paratrichodorus*).

8. Precautions during flower picking

Transfer of virus during flower picking has not been conclusively proven. Narcissus mosaic would seem to be the most likely to be transmitted in this way, but this disease is relatively unimportant. Hobbyists and others who want to take all precautions should disinfect knives and other equipment as well as hands (if rubber gloves are used).

A more detailed description follows of the two most important viruses in the Pacific Northwest—yellow stripe and white streak.

References

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MOWAT, W. P., C. J. ASJES, and A. A. BRUNT. 1976. Narcissus tip necrosis virus. C.M.I./A.A.B. Descriptions of Plant Viruses. Eastern Press Ltd. London. 116:4 p.

STONE, O. M. 1975. The production and propagation of virus free narcissus, Daffodils. The Royal Hort. Soc. London, p. 30-36.

White Streak (Silver Leaf, Silver Streak, Early Maturity, or Decline)

Symptoms

LEAVES. First symptoms appear about flowering time on leaves and flower stems. The narrow (1/16" or less) dark green or purple streaks vary in length, later become white, yellowish-white, or gray, and may coalesce. Within a few days the streaks become necrotic, sunken, and the leaves soon die.

FLOWERS AND STEMS. Symptoms on the flower stems are similar to those on leaves.

BULBS AND ROOTS. Affected plants ripen prematurely so total yield and bulb size are reduced.

Factors Affecting

This virus is spread by several species of aphids. High temperatures (above 18°C, 65°F) and prolonged sunlight hasten symptoms so the disease is most apparent after flowering.

Importance

The disease is widespread and serious in some stocks. It is very harmful when present. The virus is only known to attack narcissus.

Control

See preceding section under Viruses—General.

Causal Agent

The narcissus white streak virus is filamentous (see Brunt) and measures 750 x 12 mm.

References

HAASIS, FRANK A. 1939. White streak, a virus disease of narcissus. Phytopath:29. p. 890-895.

BRUNT, A. A. 1971. Virus diseases of narcissus. The Daffodil and Tulip Year Book. p. 18-37.

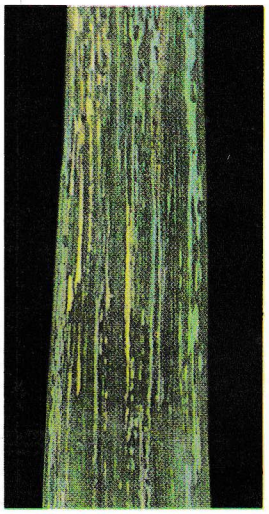
Yellow Stripe (American Mosaic or Gray Disease)

Symptoms

LEAVES. Leaves may be stunted, twisted, distorted, and curled. At emergence leaves may exhibit light green, grayish-green, dull to bright yellow, or chlorotic stripes or mottles that are mostly confined to the upper two-thirds of the leaf. One of the best diagnostic features is a roughening of the surface in the discolored areas, although some varieties show little of this.

FLOWERS AND STEMS. Stems may exhibit the same symptoms as leaves. White streaks or blotches may appear on the flowers, which are reduced in size.

BULBS AND ROOTS. Severely infected plants mature earlier than normal and consequently the bulbs are reduced in size. The yield is often one-fourth less than for comparable healthy stock. Varieties vary in severity of symptoms. Discoloration from hot water treatment also results in a mottled condition but it is confined to the leaf tips.



White streak

Yellow stripe

Factors Affecting

This virus is spread by several species of aphids but probably not by handling or flower cutting. Symptoms appear early in spring and may become masked after flowering. Normally spread is rather slow in the field. Infection increases as digging is delayed because of increased exposure to aphids.

Importance

This virus disease is serious and widespread. It only attacks narcissus and nerine. Varieties vary in their tolerance.

Control

See preceding section under Viruses—General.

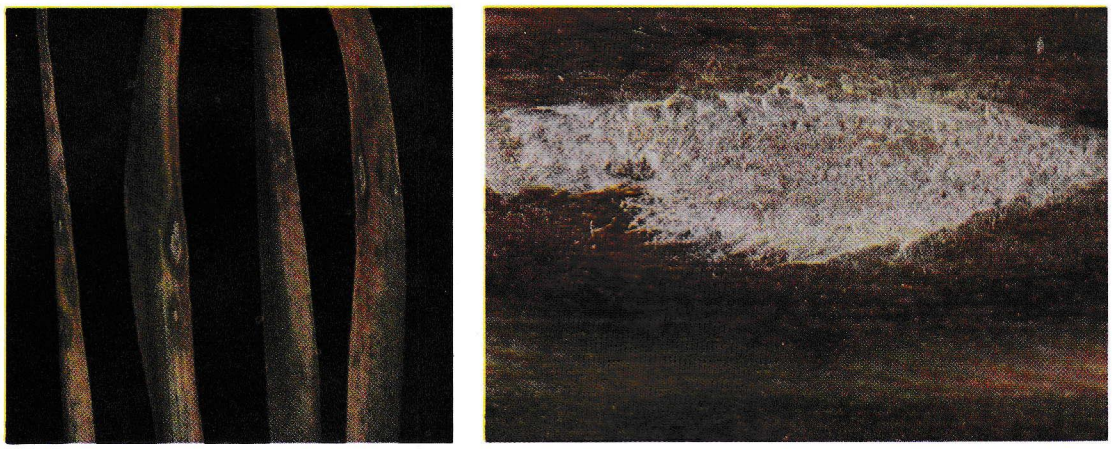
Causal Agent

The narcissus yellow stripe virus is a filamentous type (see Brunt) measuring 755 x 12 mm.

References

HAASIS, FRANK A. 1939. Studies on narcissus mosaic. Cornell University Agricultural Experiment Station. Memoir 224.

BRUNT, A. A. 1971. Virus diseases of narcissus. The Daffodil and Tulip Year Book 1971. p. 18-37.



White mold

White Mold

Symptoms

LEAVES. Early stages appear on leaves and flower stems as sunken, dark green, yellow, or gray spots, or streaks, which enlarge and become yellowish-brown with a yellow margin. Leaf tips may be affected soon after emergence and thereby somewhat resemble scorch disease. However, the dead areas become covered with a distinctive white powdery mold during moist weather. Later very small black bodies (sclerotia) of the fungus form in the dead tissue. These bodies germinate the next year and initiate the infection cycle.

FLOWERS AND STEMS. Petals are not infected, but stems are often spotted severely enough to eliminate marketability.

BULBS AND ROOTS. At the neck of the bulb the leaf bases may be infected, whereby the fungus is carried to the following crop. Severe infection will result in reduction of bulb size.

Factors Affecting

White mold is most serious in warm, moist weather, in stocks not dug annually, and on plants weakened from other causes. Cool, dry conditions retard its development. In severe attacks the foliage dies prematurely (within 3-4 weeks) so bulb yield and subsequent flower production are affected. The fungus does not survive long in the soil.

Importance

This disease is widespread but is usually only serious in southern United States, southern Europe, and southwestern England. Occasionally it is a problem in the Pacific Northwest during warm, humid springs. Varieties vary in susceptibility; the late-flowering varieties generally are most susceptible.

Control

1. Remove and burn infected leaves and flower stems.
2. Begin spraying when leaves are 4-5 inches high and continue until maturity.
3. Dig every year. Clean bulbs before replanting.
4. Rotate.
5. Plow deeply to bury debris.
6. Provide good air circulation by wide spacing and weeding.

Causal Agent

Ramularia vallisumbrosae Cav. Conidia, which are formed in white powdery masses on leaves, are hyaline, cylindrical, one to many celled, and 2.5-4 x 40-95μ in size. Very small black sclerotia-like bodies are formed in the dying leaves. They are roughly spherical with a short neck and measure 75-150μ. These sclerotia carry the fungus over the winter. The next spring they will produce spores that are blown by the wind or splashed by raindrops to infect new leaves.

References

GREGORY, P. H. 1939. The life history of *Ramularia vallisumbrosae* Cav. of narcissus. Trans. Brit. Mycol. Soc. Vol. 23. p. 24-54.

JENKINS, J. E. E. 1969. The control of narcissus white mold. Plant Pathology. Volume 18. p. 122-129.

Minor Diseases and Miscellaneous Problems

Bacterial Streak

A bacterium (*Pseudomonas* spp.) has occasionally caused disease problems in the Pacific Northwest. In the field, flower stems rapidly collapse due to a streak-like infection at their base. The infection rapidly progresses upward changing in color from an indistinct grayish-pink to pink and finally brown. The stem above the streak turns yellow. Leaves are not affected, but an occasional bulb has discolored vascular tissue.

A bacterial decay of flower stems in cold storage has been a more serious problem with occasional losses as high as 75 percent. A greenish-black or brownish-black soft decay occurs usually near or at the area where the rubber band surrounds the bunch of 10 or 12 flowers. Sometimes a few healthy stems may be present but usually the entire bunch will be diseased. Inoculation tests indicated a *Pseudomonas* bacterium was responsible. In addition, it caused a streak decay on iris leaves. The disease is progressively severe as cold storage of the picked flowers is extended beyond two weeks. Dipping stems in a mixture of streptomycin plus terramycin is effective but very expensive. The most practical solution is to drop storage temperatures from 4-7°C (40-45°F) to 2°C (33°F) and avoid holding flowers in storage beyond two to three weeks.

GOULD, C. J. 1954. Bacterial streak, a new disease of narcissus. Phytopath, Vol. 44(9) p. 489.

Bacterial stem decay

Black Slime (Black Rot)

The leaves of diseased plants turn yellow because of bulb rot. This rot appears early in the spring in contrast to crown rot, which does not show up until the weather becomes warm. Affected bulb scales are at first more or less gray, later becoming a mixture of black and gray, due both to decay of the scales and development of mycelia and sclerotia of the fungus. Although daffodils are less susceptible than many other bulbs such as iris, tulips, and hyacinths, daffodil bulbs may carry the fungus into healthy fields. The fungus is probably found worldwide. The hot water plus formalin treatment used for nematodes apparently kills the fungus in lightly infected bulbs. Repeated treatments have essentially eliminated it from plantings in western Washington. Refer to Black Slime Disease in EB 710.

(*Sclerotinia bulborum* (WAKK) Rehm.) Sclerotia white at first, later black, smooth and rounded (⅛-¼″) or flattened if between scales, and often fused into irregular masses ½ inch or more wide. Apothecia light brown with asci 140 x 9μ and ascospores 16 x 8μ.

Blue Mold

The outer husks, scales, and tips of bulbs may show a dark rot often covered with a blue mold. Severe infection may cause a reduction in roots and a blasting or rotting of leaf tips. It is usually considered to be a weak parasite, generally attacking bulbs that have been injured and stored under cool, moist conditions, or bulbs not dried quickly after the hot water treatment. Rapid drying, storing under cool but dry conditions, and reasonably early planting are recommended. Blue mold is caused by *Penicillium* spp. (PLATE, H. P., and R. SCHNEIDER. 1967. *Penicillium-zwiebelfaule auche an narzissen.* Gartenwelt 67: p. 229-230).

Bacterial streak

Crown Rot (Southern Wilt)

Plants turn yellow because of a bulb rot. The underground parts and outer bulb scales are affected with a wet, brown, or reddish-brown decay and later become dry and rather woody. The rot is usually confined to the husks and outer fleshy scales. The fungus appears as white threads, a white mat, or as small (usually 1/16″-3/16″), rounded, reddish-brown, pock-marked sclerotia on or between the scales. An odor typical of mushrooms or that of rotting wood accompanies this disease.

Although crown rot is most serious in warm climates and on other hosts, it has occasionally caused trouble in daffodils in the Pacific Northwest. However, of more importance is the fact that lightly infected stocks of daffodils have apparently served as a means of contaminating fields with the fungus, followed by a subsequent heavy loss in more susceptible crops such as iris and tulips.

The fungus has a wide host range of ornamentals, vegetables, and even weeds. By attacking these plants, especially weeds, it can persist many years in fields. The fungus can be eliminated in diseased stocks by giving the bulbs the hot water plus formalin treatment described under bulb and stem nematode. Rotate with grasses or cereals. The disease is caused by (*Corticium rolfsii* Sacc.) (See Anon. *Corticium rolfsii.* CMI Description #410). See the information on crown rot in Diseases of Bulbous Iris, Washington State University Extension Bulletin 710.

Cylindrocarpon Root Rot

This fungus has been found often in rotted roots of many different types of bulbs, including daffodils. However, it is usually considered to be a secondary invader on daffodils, following attacks by the root lesion nematode. Therefore, a control of the latter should prevent attack by the *Cylindrocarpon radicicola* Wr.

Daffodil Slime

The slime which exudes from the cut ends of daffodil flowers may injure other flowers if they are placed in containers with the slime present. For example, tulips exhibit reduced keeping quality, curled and dried-up leaf tips, and wilted stems and leaves.

Dry-Scale Rot

Leaf tips turn yellow prematurely and finally die. On bulbs the disease is usually confined to the outer scales, but repeated attacks will destroy the bulb. It appears as a dry rot, having a sharp margin in which many very small black fungus bodies resembling specks appear. On severely affected bulbs, the scales are quite rough.

The disease is widespread and sometimes very common on bulbs grown in heavy wet soils. Whether it is a strong or weak parasite has not yet been definitely determined. Treatment of bulbs in the hot water plus formalin solution and planting on well-drained soil should clean up affected stock. (*Stromatinia gladioli* (Dray). Whet.) (SAKAGUCHI, M. 1941. *A sclerotial disease of narcissus.* Phytopathological Soc. of Japan. Volume 11(3). p. 114-153.

Fluorine

Fluorine causes an ivory colored leaf tip that later becomes necrotic and is accompanied by an enlarged yellow zone. Fluorine is an air pollutant produced by aluminum plants, steel mills, pottery plants, etc. Even high quantities of superphosphate may contain enough fluorine to cause injury in gladiolus but they are much more susceptible than are narcissus. SPIERINGS, F. H. F. G. 1969. A special type of leaf injury caused by hydrogen fluoride fumigation of Narcissus and Nerine. Proc. 1st Eur. Congr. on Influence Air Pollution on Plants & Animals, Wageningen (1968). R. R. 50:20, #709, p. 87-89).

Grassiness (Horse-Teeth)

Daffodil bulbs occasionally produce large numbers of slender leaves and only a few slender flowers. The bulb splits into small daughter bulbs. A number of factors may cause this condition, but the most likely are the killing of the main shoot by insects or by too severe hot water treatment. Such bulbs should revert to a normal condition in subsequent years but if the condition persists, it may be a genetic abnormality and the bulbs should be discarded.

Gray Bulb Rot (Kwadegrond)

This fungus disease has been reported occasionally on narcissus in Europe but details on

symptoms are lacking. They probably resemble those on tulip but are most likely less intense. The problem becomes important when diseased bulbs contaminate healthy fields which are subsequently planted to a more susceptible crop. The bulbs can be cleaned up with the hot water plus formaldehyde treatment. (*Rhizoctonia tuliparum* Whet. and Arth). (FAES, H. 1935. Lands. Jb. Schweiz XLIX, 6 p. 619-664 and Anon. *Rhizoctonia tuliparum.* CMI Description #407).

Gray Mold (Botrytis)

The common gray mold (*Botrytis cinerea* Pers.) sometimes attacks leaves and flowers injured by frost, hail, or by mechanical operations.

Herbicide Injury

The improper herbicide, or the correct one used improperly, may produce distorted and/or chlorotic plants. Residues of herbicides, such as amino triazole, applied to previous crops may affect daffodils planted afterwards. The possibility of herbicide injury should be considered with any unusual chlorosis or similar abnormality.

Large Scale-Speck Fungus

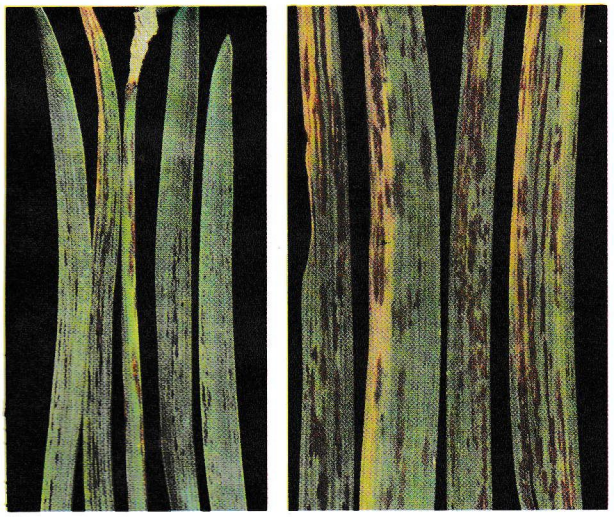
Relatively large (0.5-1.0 mm), black, flattened sclerotia are often found on the outer husks of narcissus bulbs, but inoculation tests indicate that the fungus is probably a saprophyte. (*Stromatinia narcissi* Drayton and Groves). (See DRAYTON, F. L., and J. W. GROVES. 1952. *Stromatinia narcissi*, a new sexually dimorphic discomycete. Mycologia, 44(1) p. 119-140.

Leaf-Banding

Young leaves that are exposed to very cold weather may develop one or more chlorotic bands. Alternating periods of slow and rapid growth may also result in some horizontal banding.

Mushroom Bulb Rot

The honey mushroom (*Armillaria mellea* (Vahl ex Fr.) Kumm.) sometimes causes serious losses when bulbs are planted on newly cleared ground. Affected bulbs are covered with a coarse white mold. Soil fumigation may be effective but expensive. Under continued cultivation the fungus usually disappears.



Chocolate spot

Ceratocystis Bulb Rot

The infected tissue is dark brown, rather firm, usually confined to one side of the bulb, and seldom penetrates beyond the second or third scale. The fungus appears as small, rounded, black specks with long slender beaks (perithecia) among the inner rotting tissues and on the dry outer scales. It is usually present only in wounded bulbs or those attacked by other diseases. It is found in Europe and America. (*Ceratocystis narcissi* (Limber) Hunt or *Ophiostoma narcissi* (Limber, Donald P. 1950. *Ophiostoma on Narcissus Bulbs.* Phytopathology, Vol. 40 (5). p. 493-496.)

Chocolate Spot

This condition appears late in the growing season following exposure to strong sunshine and high temperatures. The symptoms are chocolate brown to purple spots and/or streaks near the tips of leaves. They vary from year to year in intensity. Sometimes only a single leaf may show spots and at other times all leaves may exhibit them. The color is caused by death of the epidermal cells, but no fungus, bacterium, or virus has been associated with the disorder. The condition is found worldwide and is common but apparently not harmful. Bulbs from affected plants produce normal flowers. At this time we therefore assume that chocolate spot is a physiological disease and do not recommend removing affected plants.

Phyllosticta Leaf Spot

Leaves are occasionally attacked by this fungus which causes brown spots with small black fruit-

ing bodies of the fungus. The latter black "pimples" help distinguish this disease from similar colored spots caused by scorch, fire, and chocolate spot.

Rhizopus Soft Rot

Bulbs are affected with a wet, soggy rot. The basal plate appears dark and the scales a dull, grayish brown. The surface may be covered with a coarse gray mold and intermingled black specks. This disease develops primarily on bulbs with mechanical or sunburn injuries, particularly under conditions of high temperatures (above 30°C or 85°F) and poor ventilation. It is prevented by 1) avoiding injury, 2) keeping bulbs cool and well ventilated in storage and transit, 3) by rapid drying and cooling bulbs after the hot water treatment. (The causal fungus is *Rhizopus stolonifer* (Ehr. ex Fr.) Lind.)

Rosellinia White Root Rot

Infected areas in fields are scattered. Affected bulbs have few roots and show a black rot of the outer scales. White strands of the fungus appear in or near the basal plate. The fungus (*Rosellinia necatrix* (Hart.) Berl.) can infect a wide range of fleshy and woody plants and is reported from many countries. It appears to be primarily a problem on narcissus only in the Scilly Isles. Clean bulbs thoroughly, replant in a new location, and either fumigate the soil or keep it fallow. (See MANTELL, S. H., and B. E. J. WHEELER. 1973. Rosellinia and white root rot of narcissus in the Scilly Isles. Transactions of the British Mycological Soc. Vol. 60 (1). p. 23-35.

Rusts

Rusts (*Puccinia* and *Accidium* spp.) have occasionally been reported on leaves but they are apparently neither common nor serious.

Sclerotinia Rot

The symptoms resemble those of the black slime. They appear early in the spring resulting in a rotting of bulbs and development of numerous large black sclerotia between the scales. Roots are few or lacking. The disease was described in Canada and occurred mostly on tulips. Its distribution is unknown. (*Sclerotinia sativa* Drayton and Groves). DRAYTON, F. L., and J. W. GROVES. 1943. A new Sclerotinia causing a destructive disease of bulbs and legumes. Mycologia. Volume 35(4) p. 517-528.

Heat damage

Appendix

A Garbage-Can Bulb Cooker*

By Marie Bozievich, Bethesda, Maryland

The basic parts of my cooker are as follows:

(1) Themostatic control: This instrument has a heat sensor which measures the temperature of the water and a control switch which turns the heating element (2) on and off. It is vitally important to purchase one with a narrow temperature range, preferably 100-120° F (38-49°C). The narrower the temperature range, the more accurate the control will be. We used Dayton Model 2E146 which is made for hot water heaters and can be purchased at a plumbing supply house.

(2) Heating element: This is an immersible electric element made for hot water heaters. We used a Cromalox TGA water heater element purchased at a plumbing supply house.

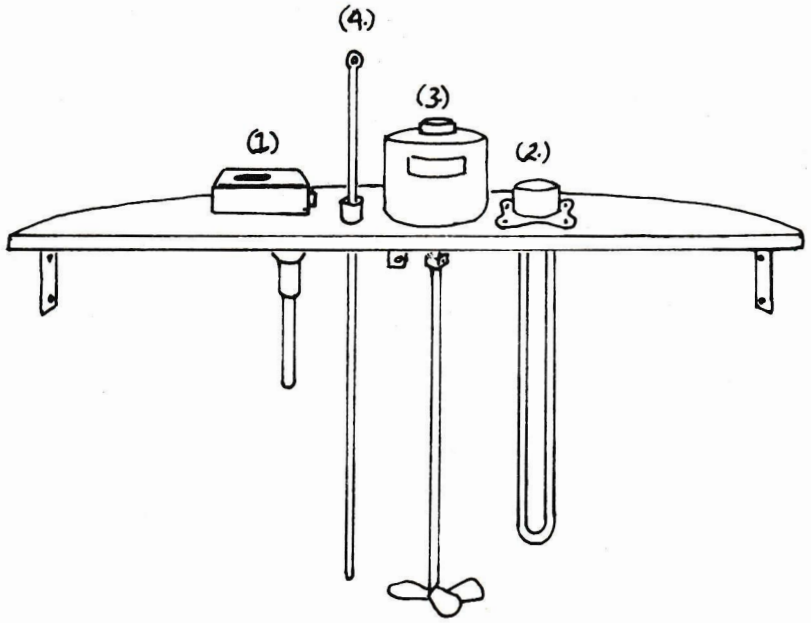
(3) Stirrer: This is needed to keep the water mixed to a uniform temperature. We used a laboratory stirrer with a small electric motor, purchased at a laboratory supply house. However, an electric drill could be used with a paint-stirrer inserted. (Use at low speed.)

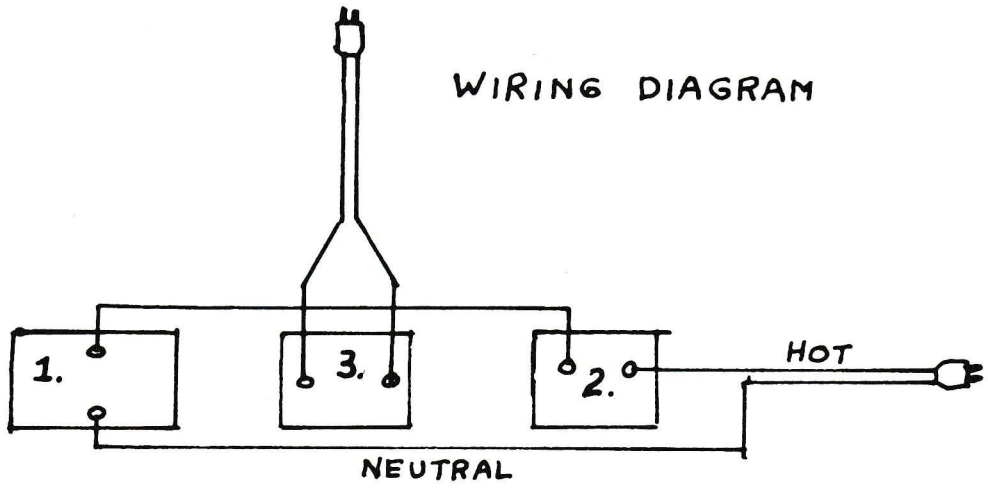
(4) Thermometer: This is needed to check the water temperature while the bulbs are being processed. It must be very accurate in the 100-120°F (38-48°C) range. A narrow range laboratory thermometer can be purchased at a laboratory supply house. (Ed.—Use only a mercury type.)

My husband has assembled these parts on a semi-circular piece of plywood which fits on top of a heavy plastic garbage can. (The size of the can would depend on how many bulbs are to be handled.) The plywood was drilled with holes to receive the various parts and given two coats of spar varnish. The working parts which are to be immersed in water are enclosed in a cage made of hardware cloth which separates them from any contact with the bulbs. The dials, motor, etc. are on top of the plywood piece. Three brackets attached underneath fit snugly within the garbage can and keep everything firmly in place.

I fill the garbage can with warm water, using a garden hose attached to the laundry mixing faucet. It is tested for correct temperature and adjusted by adding either hot or cold water. It is essential to fill the can to the top so that the heat sensor of the thermostat will be immersed. Formalin is added and mixed thoroughly.

The bulbs are treated while in the same net bags in which they received their Benlate dip at digging time and in which they have spent the summer hanging in the air-conditioned basement. Small net bags are put together in larger ones for ease in handling. The temperature of the water can be about 114°F when they are immersed because they will cool the water somewhat. From that point on the temperature should be maintained at 112°F. Keep a frequent watch on the

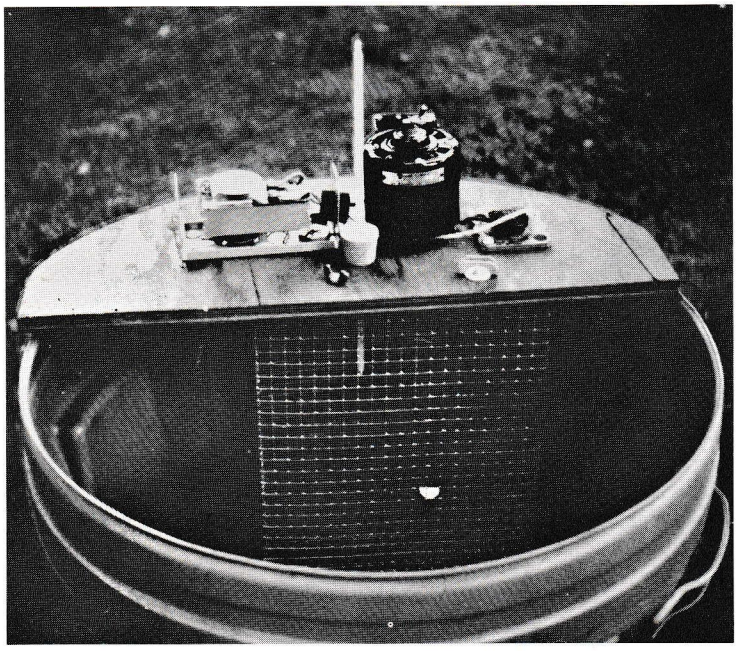




thermometer to be sure everything is all right—it will fluctuate slightly, but should not go below 111°F if you are treating for nematodes, or above 113°F lest the bulbs be damaged.

When the scheduled time has elapsed the bulbs should be removed and then cooled as rapidly as possible.

*Used with permission of the author and the editor (Mrs. George D. Watrous, Jr.) of the Daffodil Journal 12:(1) Sept. 1975, pp. 26-28 (condensed).



Many of the recommendations in this bulletin are based upon cooperative research with colleagues, particularly Mr. Vern Miller and Dr. Neil Stuart whose help we gratefully acknowledge. We also express our grateful appreciation to Mr. Worth Vassey and Mrs. Evelyn Morris for their research assistance; to Drs. Tom Allen, Alan Brunt, Gary Chastagner, William Haglund, J. J. Hesling, David Price, Alen Rees, and Willis Wheeler for reviewing the manuscript; and to the Washington State Bulb Commission and the Northwest Bulb Growers Association for their support in the research and publication of this bulletin.

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Key to Major Narcissus Diseases

1. Leaves yellowed and stunted.
   a. Bulbs with a soft, chocolate brown rot ..... BASAL ROT
   b. Bulbs not rotted but roots few or stunted ..... ROOT LESION NEMATODE

2. Leaves brown and "crumpled" or sickle-shaped as they emerge from the ground; dead areas sometimes covered with a velvety-gray mass of spores ..... SMOULDER

3. Leaves with definite dead tips or spots.
   a. Spots reddish-brown, most frequent near tips and center of leaves, appearing after flowering and sometimes causing leaves to collapse; flowers spotted ..... FIRE
   b. Leaf tips dead and brown, sometimes covered with a white mildew-like layer; flowers not spotted ..... WHITE MOLD
   c. Leaf tips dead early in season, yellow, red, or brown and bearing numerous small dark brown pimples (pycnidia); reddish-brown scab-like spots often present below tips; flowers not spotted ..... SCORCH

4. Leaves mottled in color ..... VIRUSES IN GENERAL
   a. Yellow-green mottles or streaks scattered on leaves early in spring ..... YELLOW STRIPE
   b. Yellow, purple, or white narrow streaks on leaves mostly after flowering WHITE STREAK

5. Leaves distorted and exhibiting yellow-green pimples (spikkels); rings of brown scales in bulbs ..... BULB AND STEM NEMATODE

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