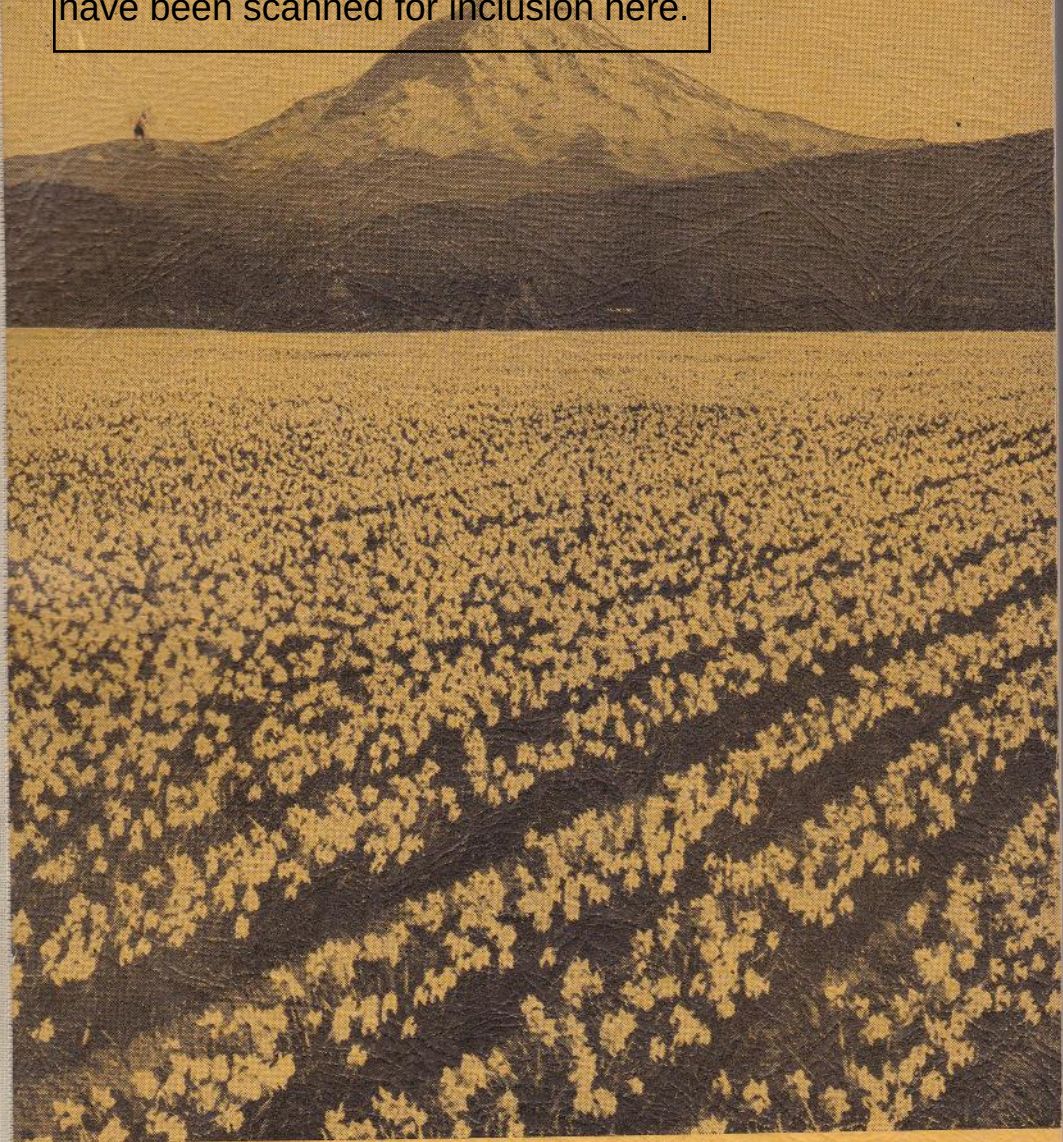
ulb Growing and Forcing

Only the pages relating to Narcissus have been scanned for inclusion here.



Bulbous Iris - Easter Lilies
Hyacinths - Narcissus - Tulips

NARCISSUS

CULTURE

J. H. Crossley

SOILS AND FIELD MANAGEMENT

TYPES OF SOIL: Fine-textured soils are preferred for the same reasons as those outlined under the Tulip section of the handbook. It is noteworthy that of the four major spring flowering bulb crops (narcissus, tulip, iris and hyacinth), narcissi are the least demanding in respect to soils. On the Pacific Northwest coast for example, they grow to perfection in practically every type of soil in which the usual cultivated crops of the area are grown. These soils include the sandy types, the silts and the clay loams. Even the heavier clay loams, that are extremely difficult to manage, produce excellent narcissi provided they are well drained. In the Pacific Northwest peaty soils feature very little in commercial bulb production although they are represented in the narcissus soils of Holland.

SOIL REACTION (pH) AND LIME: Lime to pH 6.0 to 6.5. It is preferable to apply the lime as calcium carbonate (ground limestone) to a previous crop.

Narcissi do not thrive under high alkaline soil conditions. This may explain in part why narcissi grow so well in the coast region as the soil reaction is definitely acid. For example, the pH range of Oregon narcissus soils is 5.0 - 6.0; Washington 5.0 - 6.1; British Columbia 5.0 - 6.6. It is noted that in Holland a pH of 6.0 to 7.0 is recommended.

DEPTH OF SOIL: Because narcissi have long roots,—longer than tulips —they require a deeper soil for rooting. An easily workable depth of 15 to 18 inches of soil is recommended.

SOIL PREPARATION: Prepare the soil thoroughly and deeply.

To ensure deep working, "plowing followed by a subsoiler in the furrow or a combined plow and subsoiler" is advised for narcissi in England. Also, "deep cultivation will materially help in securing the good length of flower stem that is so desirable in market crops of narcissi." In Lincolnshire, "very deep plowing,—as much as 18 to 24 inches is done with a digger plow some three weeks before planting."

The final preparation should be about 2 to 3 weeks before planting.

COVER CROP SUGGESTIONS: Same as for tulips (See appropriate section under Tulip).

ROTATIONS: Lift and rotate annually. For examples of rotations see appropriate section under Tulip.

It is the general concensus of opinion that narcissi must remain in the ground for two seasons in order to attain sufficient number of top size bulbs. While this may apply to some varieties or when large proportions of small offsets and mediocre stock are planted, it need not apply under a well managed system of bulb production when vigorous, first class stock is used.

DRAINAGE: Moisture for satisfactory growth is essential but equally true is the need for good drainage. There are few soils in the Pacific Northwest coast area that do not require some means of drainage. The methods of obtaining effective drainage are outlined under the tulip section of the handbook.

FERTILIZER AND MANURE: A great deal of experimental work on narcissus nutrition and fertilizer has been done by various workers in different countries but comparatively little of it has direct application to the grower in this region due to different soil and climatic conditions. Until further experimental work shows the necessity for change, the recommendations and suggestions outlined for Northwest grown tulips should be followed (see appropriate section under Tulip).

MULCHES: Mulches are not very practical for the same reasons as already mentioned under tulips (see appropriate section under Tulip).

IRRIGATION: Irrigation is recommended as a means of increasing the total crop weight and the quantity of top size bulbs in dry locations and seasons of marginal rainfall.

The directions and stipulations for irrigating narcissi are, in general the same as those applying to tulips (see appropriate section under Tulip).

PLANTING SYSTEMS: The single row level culture system with rows 14 to 18 inches apart in well drained soil is popular in some districts. The extent of such plantings is very limited, however. The most widely used system is the ridged furrow, 36 to 42 inches on center, with one, two or three rows of bulbs in the furrow. The size of the planting and drainage requirements usually dictate the system of planting.

TIME TO PLANT: August, September and early October is recommended. The highest yields are obtained from planting at the recommended time. The only thing gained by later planting is control of the last flush of fall germinating weeds as a result of the final ridging operation. However, where pre-emergent applications of herbicides will control fall and winter weeds there is little justification for planting later than recommended.

SIZES TO PLANT: Planting sizes usually include all except the saleable portion of the crop. As the saleable portion includes the double nosed and round bulbs, there remains the mother bulbs and slabs (offsets), the latter being the portion which separates easily from the mother. Grading planting stock into four or five convenient sizes is recommended. This is done to minimize harvesting and handling in subsequent seasons because if small sizes are planted they may require an extra year to grow. When, however, production and acreage can be maintained at a satisfactory and desired level, by planting only the larger grades of mother bulbs and slabs, this procedure should be followed because it is more economical.

DEPTH OF SOIL COVERING: Soil cover should be about 4½ inches over the top of the bulb.

One and one-half to two times the height of the bulb is the general rule in England. In Holland the average depth for planting is 3.6 to 5.6 inches.

SPACING: A spacing of approximately two diameters between bulbs is recommended.

SETTING BULBS UPRIGHT: Setting bulbs upright with spacing as above is recommended for foundation and selection blocks or wherever considerable roguing is required. In other instances **random sowing** plus proper spacing is recommended.

It is conceded that straighter rows, more uniform emergence, easier weeding and longer flower stems result from setting narcissus bulbs upright; nevertheless, with the possible exception of longer flower stems, the value of these gains remains in doubt.

Survey data for 1957 show that of 33 narcissus growers representing most of the acreage in the Pacific Northwest coast region, 27 per cent of the growers set up all their bulb stock; 36.5 per cent set up only mother bulbs and the larger sizes; the remaining 36.5 per cent do not set up any of their stock. The survey also reveals that the reason stock is not set up is that it cuts planting costs and it does not materially affect the bulb crop. This is in general agreement with results from a 3-year experiment in England reported in 1951 by Hoare as follows: "planting upside down, which with random sowing would occur only occasionally depressed yields by about 10 per cent. Planting at other angles had no effect on yield or flowering."

CULTIVATION: Cultivate to keep weeds under control but follow herbicidal directions where applicable.

DEBLOSSOMING: Remove only the flower heads just before the perianths wither in order to throw all the plant energy into bulb production.

HARVESTING AND STORAGE

WHEN TO HARVEST: Harvest when the leaves are yellowish brown and the majority of the flowering stems lie prostrate. This is usually when the foliage can be removed by gentle pulling.

The period of harvest will vary with the soil, locality, season, variety and size of bulb planted. The harvest period ranges between July 1 to July 20 for Oregon; July 5 to July 30 for Washington and July 6 to August 15 for British Columbia.

LIFTING THE BULBS: Potato diggers or bulb digging machines which are adaptations of the ordinary potato digger, are satisfactory for lifting narcissi and are the type of machines generally used for lifting the crop. (See Figs. 41 & 42).

Plowing the bulbs out is also a satisfactory method. This method is generally used where acreage and financial resources do not justify elaborate and expensive equipment. (Fig. 43).

DRYING, CLEANING AND GRADING: Just as soon as the bulbs are dug, place them in shallow, slatted bottom trays. Trays containing no more than 2 or 3 layers of bulbs should then be transferred to a cool, airy shed or open warehouse where the drying process is completed. A few days preliminary drying in trays stacked in the field is a common practice with some daffodil growers (Fig. 44). However, plenty of air circulation over and between the layers of bulbs and avoidance of direct sun and high temperatures are the chief considerations from the time the bulbs are dug until they are planted again. As soon as the bulbs are sufficiently dry, so that the dirt is easily removed and the slabs can be readily separated from the parent bulbs, the crop should be cleaned and graded.

Fig. 41. Daffodil digging machine in operation on a large bulb farm. (Photo courtesy of Lee Merrill.)

Fig. 42. Potato digger with skimmer connected to power take-off of tractor is adapted for lifting daffodil bulbs.

Fig. 43. Plowing tulip bulbs out with a tractor plow. On this farm only one of the rows in the double furrow is plowed out at a time and only sufficient bulbs to just keep ahead of the picking crew which follows. By this method tulip bulbs receive minimum exposure and gentle handling which are essential to skin preservation.

Cleaning usually consists of some system of mechanical agitation of the bulbs on a sloping screen or in a slowly revolving, cylinder screen. From the cleaner, the bulbs are generally delivered on to an endless belt for sorting and inspection before proceeding to the grading machine. A final inspection and check on the grade is recommended after the bulbs leave the grader.

For grade requirements for sale of Washington-grown narcissi consult the handbook "Washington Standards for Grading of Ornamental Evergreens and Deciduous Nursery Stock, Roses and Bulbs" and also the Nursery Inspection Supervisor, P. O. Box 518, Sumner, Washington.

For B. C. grade requirements, consult the Destructive Insect and Pest Act, SOR/54-706 P.C. 1954-2021 Canada Gazette (Part II) Jan. 12, 1955, and the Department of Agriculture, Plant Protection Division, Federal Bldg., Vancouver, B.C.

STORAGE:

(a) **Storage of Cured Bulbs for Normal Outdoor Flowering or for Propagation.** Keep cool in well ventilated shed or warehouse; temperature 55° to 60° best and 75% relative humidity. (Fig. 45).

(b) **Storage for Earliest Outdoor Flowering.** 48° for about 8 weeks beginning mid-August then planting in cool soil. **(Suggested for trial only).** Degree of success will largely depend on soil temperature following planting and spring air temperatures.)

(c) **Storage for Retarding Field Flowering.** 85° for 10 weeks. **(Suggested for trial only)**

(d) **Storage of Narcissus Bulbs Meant for the Southern Hemisphere.** 86° July - Oct. 15, then 31° Oct. 15 - Dec., then 77° January.

Fig. 44. Freshly dug daffodil bulbs in trays stacked in the field receiving a few days preliminary drying before transferring to shed to complete drying and finally cleaning and grading. Note each stack is covered with an inverted tray to ward off most of the direct sun. (Photo courtesy of Lee Merrill.)

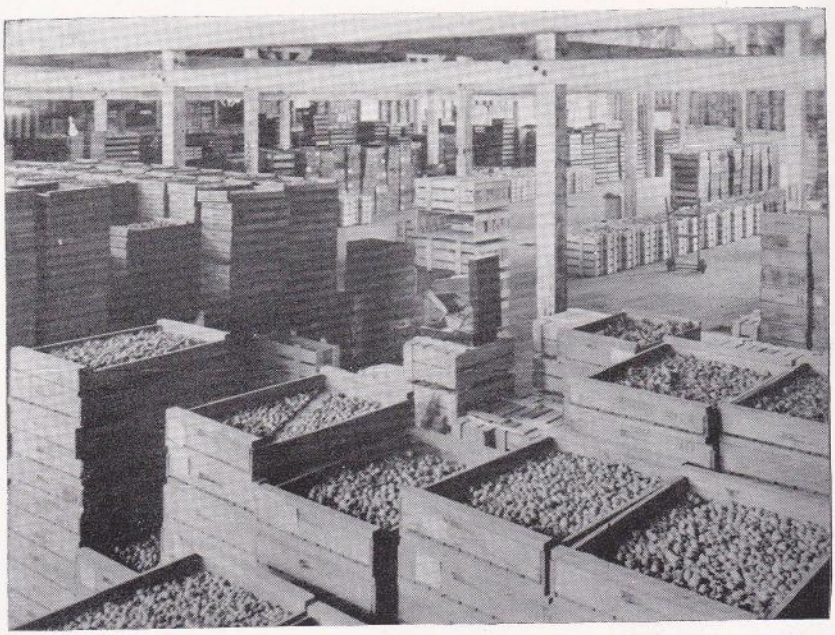


Fig. 45. Interior view of bulb storage shed and warehouse. (Photo courtesy of Lee Merrll.)

NARCISSUS

WEED CONTROL

Dwight V. Peabody, Jr.

The same recommendations for control of weeds in bulbous iris are to be used in narcissus. Although these recommended procedures have not been tested on all of the many different varieties of narcissus, enough information has been obtained to recommend the herbicidal treatments as presented previously for bulbous iris. However, in specialty narcissus, and in other species and varieties with growth habits differing from the King Alfred variety, caution is advisable. In these so-called specialty varieties, use the recommended sprays only on a limited scale so that if injury does occur, it will be restricted to a few feet of row.

A B

Fig. 46. Annual weed control in narcissus. Photo taken May 7, 1957

A. DNBP at 4½ lbs./acre plus CIPC at 4 lbs./acre applied early Nov. prior to bulb emergence.
B. Nontreated checks.

Cultivation practices vary widely from grower to grower, depending primarily on the soil and climatic conditions under which the crop is grown. As a result, it is impossible to recommend a standard cultivation program for all situations. Cultivation, either with machinery or by hand, disturbs the surface portion of the soil, and where the soil has been treated with a herbicide, tillage practices will consequently eliminate almost all of the weed-killing effects of any herbicidal treatment. Therefore, cultivation practices must be altered if herbicides are going to be utilized for weed control. When chemical weed control methods are used, hoeing and hand pulling of weeds is either eliminated or greatly reduced in ornamental bulb crops. Cultivation practices are then usually restricted to limited tractor tillage between the rows to maintain the soil in a loose, friable condition for easy and rapid movement of air, heat and water. That band of soil within the row itself is not disturbed in order to obtain the full benefits of the chemical herbicide. One objective of field management is to obtain a weed-free planting of the crop in soil of good tilth. Proper and judicious use of herbicidal chemicals, supplemented by careful cultivation practices, will increase bulb yields and lower production costs.

NARCISSUS

BULB AND STEM NEMATODES

Wilbur D. Courtney

Plantings of narcissi have often been severely damaged by bulb nematode (**Ditylenchus** spp.) infections in most of the bulb-growing areas of the world. This wide distribution is due to infected planting stock and the consequent spread of the pest from infested areas to new locations in which it became established whenever climatic and other conditions were favorable. Pacific Northwest bulb growers found this infection in many of their first narcissus plantings some 25 to 30 years ago. They immediately developed regulatory measures, administered by the State Departments of Agriculture of Oregon and Washington, and attempted to eradicate the pest through rigid application of gradually perfected control measures, including the hot-water-formalin treatment described below. This has resulted in the practical elimination of bulb nematode infections of narcissi, except as occasional contaminations in stocks purchased from other geographical sections.

Fig. 47. Narcissus planting showing damage caused by bulb and stem nematodes.

This success has been achieved because it has been the practice of growers to give their planting stocks of narcissus the prescribed hot-water-formalin treatment at regular intervals for the control of nematodes and certain other pests.

Bulb nematode infections of bulb crops in the Pacific Northwest are now under a high degree of control, but any easement of efforts to produce clean stock should not be permitted by the growers because of the potential dangers involved.

HOW NEMATODES BEHAVE

Under the microscope infected plant tissue shows nematodes as tiny worms among the plant cells. They exist as males and females and reproduce by means of eggs, from which hatch tiny larvae shaped like the adults. These grow rapidly, shed their cuticles ("skins") at intervals to form different larval stages, and finally become adult nematodes. The length of this life cycle is dependent upon several factors, such as weather conditions, and is usually completed within 25 to 30 days. When the plant dies, because of infection or final ripening, many nematodes leave the plant tissue and, if the soil is moist, migrate into the surrounding earth. Those that do not migrate become dried in plant debris and enter an inactive stage known as quiescence. In that condition they are able to withstand unfavorable conditions, and have been revived, upon moistening, after remaining more than 5 years in dry plant tissue. The same thing happens if the soil becomes dried after the nematodes migrate from the hosts, but they remain active as long as there is enough moisture. Bulb nematodes infecting narcissi have remained active in moist soil free of plant growth for 18 months. It took that much time for them to starve to death, for they existed on food stored in their bodies.

SYMPTOMS

Bulb nematodes most often enter the narcissus plant from surrounding soil through the new growth as it emerges from the bulb, if moisture and temperature conditions are optimum. This probably accounts for the variation in the location of the nematodes in different parts of the plant. If these optimum conditions prevail for only a short time before the growing tip has left the soil, or if only a limited number of nematodes are located near the growing plant during this time, the infection will be carried upward by plant growth and show later only in the upper leaf portions. Symptoms of such infections usually appear as localized leaf swellings or "spikkels", such as the bullseye type, or less conspicuous small lumps on the leaf margins. If the infection takes place later, when the foliage has nearly reached its height, the nematodes will be confined to lower parts of the leaves and will usually cause swollen areas, which may eventually become distorted and split as the nemas increase in numbers. (Figs. 47 & 48)

Bulb nematodes do not thrive in necrotic plant tissue but continue to feed and reproduce in adjacent more normal parts. Thus the dark-colored infection is spread within the plant and may continue from the upper neck region of the bulb down the scales, or portions thereof, to the bulb base. Under certain conditions, not yet fully understood, large numbers of nematodes occasionally exude to the bulb surface in nearly pure cultures at the junction of the scales and the basal plate and form dried curd-like masses known as "nematode wool". This condition rarely occurs in western Washington and then only in late season. Such bulbs are quickly destroyed by this severe infection and secondary invading organisms. Usually the nematodes remain in localized areas within infected bulbs, and reproduce less rapidly, but may infect the developing shoot before it has left the bulb. Under these conditions, foliage will be severely infected the following year if the stock is not properly hot-water-formalin treated.

In forcing, the symptoms caused by bulb nematode infection are similar to those described; however, plant injury is likely to be more pronounced.

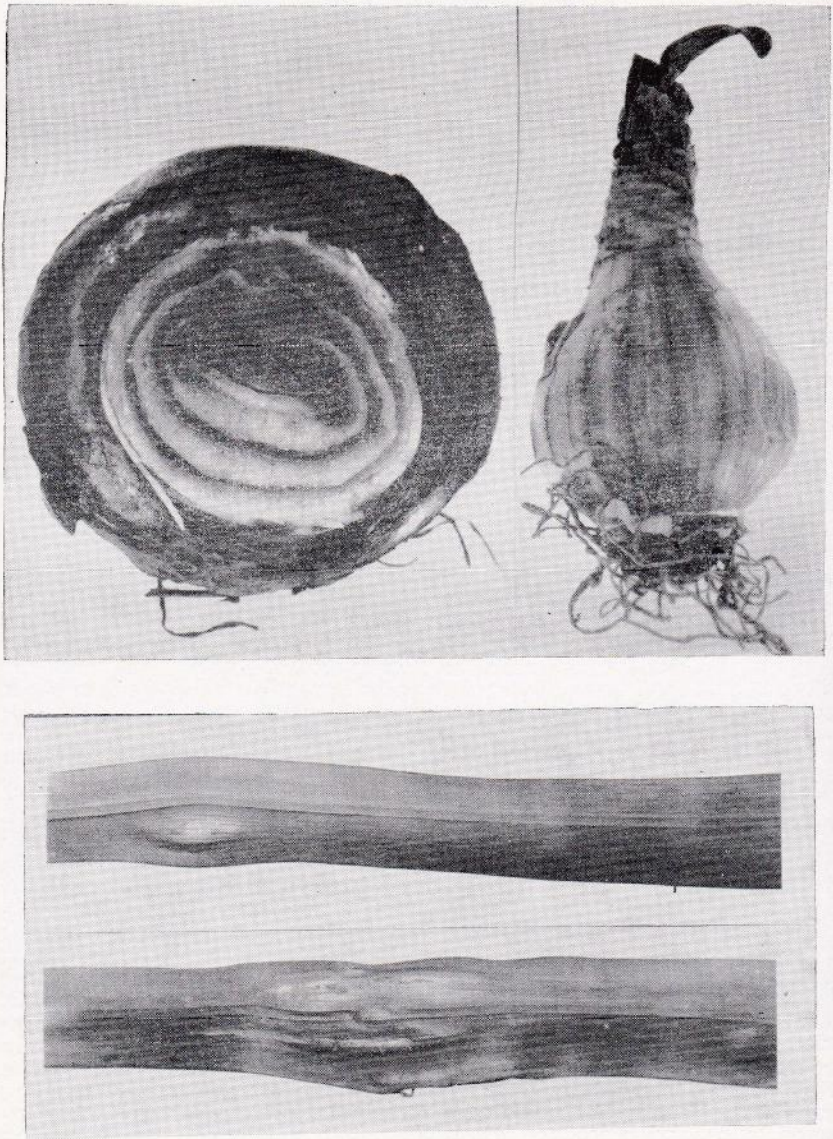


Fig. 43. Bulb nematode damage to narcissus plants.

Upper left	Cross section of infected bulb.
Upper right	Nematode "wool" at bulb base.
Middle	Characteristic bullseye leaf "spikkel".
Lower	Severe leaf distortion.

CONTROL

Control measures must include sanitation, proper soil-management, and the treatment of bulbs with hot-water-formalin.

SANITATION: Sanitary measures insure the destruction of infected plant materials and prevention of contamination by infested soil. Infected plants with adhering soil should be carefully removed from the field, placed in a deep, isolated trench, covered with quicklime, and buried with a layer of soil. Dry materials from fields and sheds may be burned. To prevent the spread of nematodes by scattering soil and debris from an infested field, adhering soil should be removed from tractors, trucks, diggers, shovels, and other tools. The implements should be washed thoroughly with water and then freely sprayed with formalin (1 part commercial formaldehyde solution U.S.P. to 9 parts of water). That solution may also be used to dip bulb trays and other equipment and to drench soil along paths to free them of the pest.

SOIL MANAGEMENT: Proper management of infested soil must destroy the nematodes by an adequate starvation program or by the use of soil fumigants. The success of the starvation method is based upon the removal of the narcissus crop, including all volunteer plants from the field in question. Infested fields must be kept free of bulbs for at least 2 years following the eradication of host plants in order to starve the pests remaining in the soil. Because rapidly decaying plant material tends to lower the number of bulb nematodes in the soil, the frequent use of fast-growing green-manure crops may be recommended during the starvation period. Corn and most grains may be used during the starvation period as cash crops.

Soil fumigants may be used to free the soil of bulb nematodes after all volunteer host plants have been removed from an infested field. Soil temperature 6 inches deep must be near the optimum for the fumigant used. In most cases, this is about 60° F. which usually does not occur in the Pacific Northwest until late summer or early autumn. No unrotted plant residue should be present in the soil, while the tilth and moisture content should be the same as if small seeds were to be planted. Best results can be expected on sandy loam soils. The heavier soil types require larger fumigant dosages. Peat soils offer little promise of success with presently available materials. Fumigation probably is most economical when used to treat infested spots or parts of fields for eradication. The materials for fumigation may cost up to 100 dollars or more per acre. A grower who is thinking of fumigating soil will do well to consult local or regional horticultural officials about the source, cost, and choice of the various fumigants and applicators.

HOT-WATER-FORMALIN TREATMENT: Hot-water-formalin treatment for narcissi, in commercial use for over 20 years, consists of immersion of bulbs in water containing formalin (1 to 200) at 110° to 111° F. for 4 hours after the bath has come to temperature. If the bulbs are severely infected with nematodes, they should first be pre-soaked in water at 75° F. for 2 hours immediately before treatment in order to revive dried or inactive nematodes, which are more difficult to kill than active ones. Wetting agents (Aerosol OT 10% clear or Triton X-100) at a dilution of ¼ pint in 100 gallons of water (1 to 3,200) in either the presoak or treating bath, assures the complete wetting of narcissus bulbs and causes no harm to resultant plant growth.

The margin of safety between effective killing of the nematodes and injury to the bulbs is so narrow that the following fundamentals must be rigidly followed if the treatment is to be fully successful.

1. **Time of Bulb Harvest**—As no maturity test has been developed for the proper harvesting of most bulbous crops, the experienced grower closely observes the plants in his fields for indications that the growth period is nearing its end, at which time harvest operations are started. If bulbs are to be successfully treated with hot-water-formalin, they must be harvested as early as the variety will allow, and treated while the bulbs are as nearly dormant as possible. All rotted and badly diseased bulbs should be removed and destroyed prior to treatment.

2. **Treating Bath**—This consists of water maintained between 110 and 111° F. with 1 pint of commercial formaldehyde solution U. S. P. added to each 25 gallons of water (1 to 200). This concentration must be maintained since it is essential for complete nematode kill and for prevention of the dispersal of rot organisms from one bulb to another during treatment. Exact amounts of formaldehyde solution must be added to any water added to the bath, either by steam or by additions, to compensate for solutions absorbed by bulbs and containers. The commercial formaldehyde solution should be clear and free of any waxy sediment or thickening. If it has long been stored in a cool place such a condition may exist and is likely to result in an unreliable concentration. In experiments, the original concentration of formalin has been maintained through repeated 4-hour runs of narcissus bulbs, when the replacement solutions contained the same percentage of formaldehyde as the solution in the tank. The bath solution should be replaced when it has an excessive amount of discoloration or sediment, usually after 6 to 8 uses or runs.

The treating bath should be maintained at the ratio (by weight) of 3 to 4 parts of bath to 1 part of bulbs. The tank (described below) must be accurately calibrated for the number of gallons required to fill it to its working level and for the amount of water necessary to raise the bath's level 1 inch. With this information the operator can accurately add the correct amount of commercial formaldehyde (1 pint to each 25 gallons of water) when the bath is first prepared and can also determine the correct number of gallons of water and amount of formaldehyde solution to add between runs. If steam is discharged into the bath as a heat source, the bath should be measured **before** the steam is turned on for initial warmup because it is necessary to know how much water is added by condensation.

3. **Treating Tanks**—Because the number of units required was too small for factory engineering and fabrication, equipment for treating bulbs in hot-water-formalin has been largely developed by growers in the States of Oregon and Washington during the past 30 years. Modern, efficient tanks incorporate the following essential items:

A. **Shape and Size**—Treating tanks are rectangular in shape and large enough to handle the stock of bulbs to be treated within a reasonable length of time. Most of the newer tanks measure (inside) 7 feet wide, 7 feet deep and 16 feet long, and with their tops at bulb shed floor level. They will hold about 5 tons of bulbs at one time in about 4,000 gallons of treating bath. Since a large quantity of water is used in the treating bath, adequate facilities must be provided for filling and draining of the tank, as well as for disposal of the used solutions.

B. **Construction and Bulb Handling**—Concrete is used in the construction of most larger tanks and metal in the small ones. In either case, the tanks are composed of two main parts—the upper, a treating chamber; and the lower, a water tunnel. This division is brought about by the use of a false bottom of heavy slats or metal rods a foot or so above the tank bottom, on which the bulb containers are placed. Small tanks have hoists to lower containers of bulbs to the false bottom

while the larger tanks use the false bottom as an elevating and lowering platform. In the latter case, an electric hoist (geared to about ½ RPM) raises the false bottom to bulb shed floor level where stacks of bulbs in trays are trucked into position. An inch or two must separate the container stacks from each other and from the tank walls. A large wire covering is then fastened into place to prevent the bulbs from floating and the entire load is lowered into the tank by the electric hoist. At the end of the treatment period, the hoist again raises the load from the water and the bulbs are trucked away. The elevating platform must be made of heavy material, or weights must be added to insure easy lowering in the bath. (Fig. 49)

C. **Bath Agitation**—Water movement within the tank is essential for the dispersal of heat and keeping the temperature even throughout the load of bulbs. Regardless of tank size, agitation is best accomplished by the use of one or more propellers, located slightly above the bottom, extending one foot or more into one end of the tank and driven by an electric motor. The bath is pushed by the propeller through the water tunnel to the opposite end of the tank and returns through the treating chamber. Baffle plates located on the under side of the false bottom can be adjusted to even the water flow to all parts of the tank. It is impossible to have too much agitation, unless the water is actually splashed from the tank, but too little agitation results in uneven heat distribution. Tests with thermocouples have shown that bath temperatures vary less than 0.5° F. between any two points throughout the treating chamber of tanks thus designed and with baffle plates properly adjusted.

D. **Sources of Heat**—Heat has been applied in the form of steam, hot-water coils, gas burners in water-tight flues and electric heaters. Most installations use steam piped into the tank, with the outlet adjacent to the propeller so as to dissipate the heat immediately when the valve is opened. When hot-water is used, it is supplied from a separate tank and is piped under pressure through coils along the bottom of the tank, with a shut-off valve near the point of entry. Gas burners have been placed in water-tight flues looped along the bottom from the propeller end of the tank and exhausted through a chamber containing a fan creating a constant outward draft of air. Electric heaters have been used only in very small tanks.

E. **Temperature Control**—The primary requirement in the operation of a hot-water tank is a good easily-read mercury-type thermometer, in a protective case, and kept within the treating bath at a point of easy access throughout the treating period. A certified thermometer is not necessary, but the one in use should be checked annually with that of the inspector to determine its correction at 110° F. A dairy or spirit-type thermometer is not reliable enough for this job because its correction point may vary from time to time. The temperature must be held between 110° F. and 111° F. throughout the treatment period. On large tanks this close control may be accomplished by careful use of hand-operated valves for the application of steam, hot-water or gas burners.

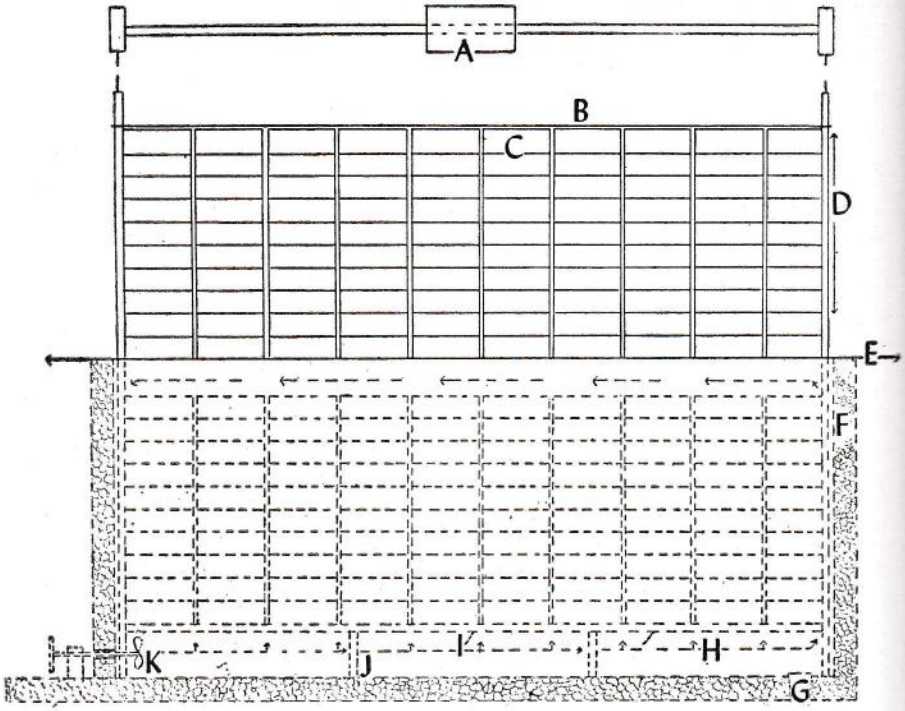


Fig. 49. Diagram of hot-water-formalin treating tank. A. Hoist Assembly; B. Wire mesh cover; C. Stack of bulb trays; D. Elevating and lowering platform; E. Shed floor level; F. Tank wall; G. Tank drain; H. Direction of bath flow; I. Baffle plate; J. Leg of platform; K. Bath agitator.

Operation of these heat control valves can be more accurately done by the use of a good thermostat connected with the desired electromagnetic valve through a relay. Some installations regularly use such equipment as well as alarm systems that give warning if the temperature drops below 110° or rises above 111° F. When thermostatic controls are used, independent manually-operated valves must also be installed to raise the temperature of the bath a few degrees between runs to compensate partly for the fall in temperature, which takes place when the cool bulbs are lowered into the bath. This drop may be anywhere from 3 to 10 degrees F., depending on the temperature of the plant material, etc., and occurs rapidly after the load is added to the bath. Treatment time is counted after the bath has come to required temperature.

Growers who do custom treating have installed recording thermometers so that a permanent record is made of each run. The mercury-type thermometer should be on hand even when a thermostat and recording thermometer are used in order to be sure the equipment is working properly.

F. **Post-treatment Care of Bulbs**— Upon removal from the treatment tank the stacks of bulbs in trays should be stored where they can cool rapidly with an abundance of air circulation to expedite rapid drying. In case the bulbs were treated in other containers they should be spread in thin layers in clean, open trays and stored as above. They should be planted as soon as possible.

NARCISSUS

ROOT LESION NEMATODE

Walter J. Apt

The importance of nematode diseases of ornamental bulbous crops has been recognized for a number of years. The bulb and stem nematodes (**Ditylenchus** sp.) on narcissus and bulbous iris, and the bud and leaf nematodes (**Aphelenchoides** sp.) on Easter lilies are well known problems to the bulb grower in the Pacific Northwest. Of more recent occurrence is a root rot of narcissus caused by the lesion, or meadow, nematode (**Pratylenchus sp.**). This disease was observed in the Northwest by Jensen et al. who first reported its occurrence in Oregon in 1951. A similar disease attributed to the lesion nematode has been observed in Holland since 1917 and was reported in British Columbia by Hastings et al. in 1932. Recent investigations have shown this disorder to be present in the bulb-growing areas of Washington as well.

Fig. 50. Premature yellowing and withering of the foliage as seen in a field of narcissus affected by root lesion nematode. (Photo courtesy Harold J. Jensen.)

SYMPTOMS

The symptoms of nematode root rot appear in late spring and early summer when normally the plants should be growing vigorously. Usually the first evidence of nematode injury observed in the field is small areas where the foliage has died down prematurely. These areas tend to reappear each time the fields are placed in production. Close examination of the affected locations reveals that premature yellowing, falling, and withering of the foliage have taken place. The yellowing and wilting of the foliage appear to progress from the older leaves to the newer ones until the entire plant wilts and dies. Bulbs produced in infested areas do not increase in size properly and in some cases are no larger than the original planting stock,. There are few roots on infected plants and these are short and stubby in contrast to the well-developed roots of a normal plant. Root tissues penetrated by lesion nematodes usually exhibit necrotic lesions or dead spots, which are frequently reddish, turning dark brown to black. (Figs. 50, 51 and 52)

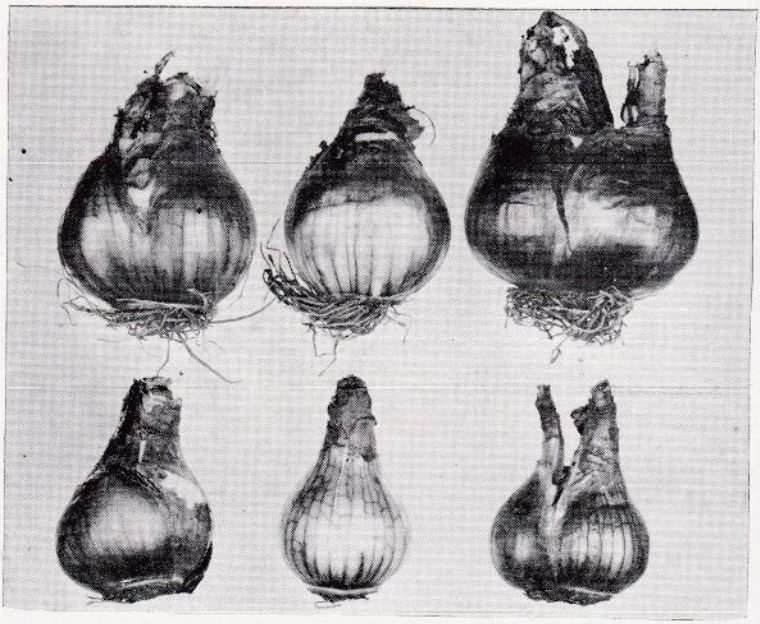


Fig. 51. Comparison of size of bulbs produced in infested soil (bottom row) and non-infested soil (top row). (Photo courtesy Harold J. Jensen.)

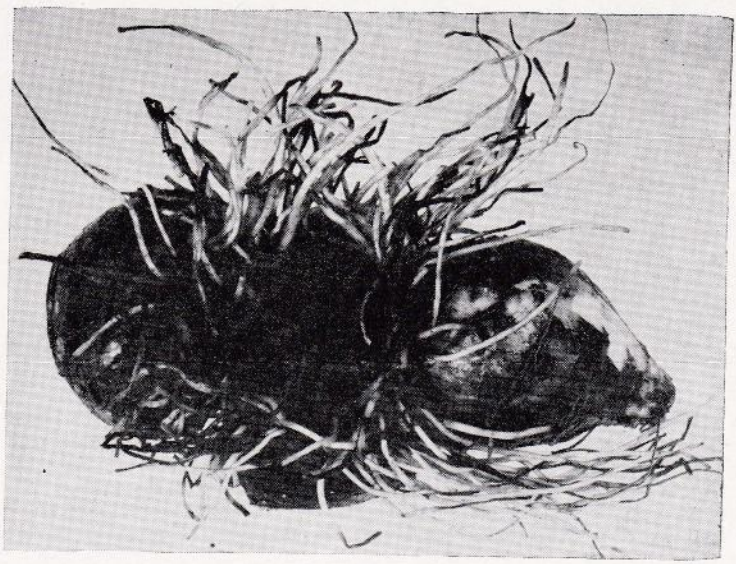


Fig. 52. A diseased mother bulb with many of remaining roots short and stubby due to a girdling or dieback condition. (Photo courtesy Harold J. Jensen.)

SUSCEPTIBLE VARIETIES OF NARCISSUS

The following varieties of narcissus have been found infected in commercial fields in Oregon.

Trumpet
King Alfred
Aerolite
Dawson City

Poeticus
Actaea
Glory of Lisse
Albus Plenus Odoratus

Jonquilla Hybrid
Lanarth
Golden Perfection

Leedsii
Silver Star
Tunis

Tazetta Hybrid
Geranium
Glorious
Klondyke
L'Innocence

Incomparabilis
Golden Pedestal

Current investigations in Washington may add additional varieties to the list.

CAUSAL AGENT

The causal agent (root lesion nematode, **Pratylenchus** sp.) is a typical nematode in that it is a minute, thread-like organism. It is approximately 1/50 inch in length and 1/2000 inch in width. 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. (Fig. 53)

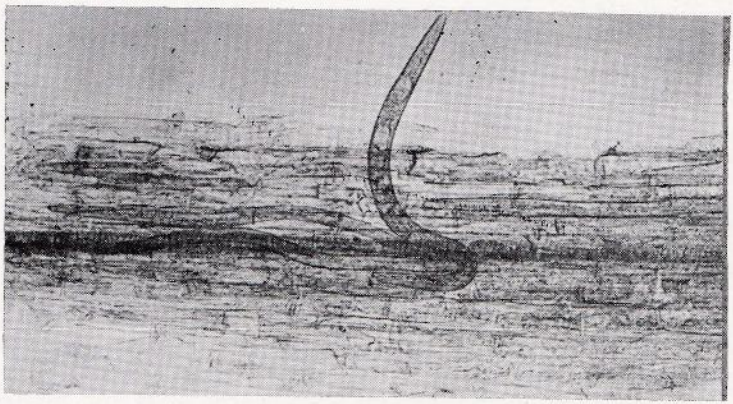


Fig. 53. Root-lesion nematodes in a section of narcissus root tissue. (Photo courtesy Harold J. Jensen.)

CONTROL

The root-lesion nematode is very susceptible to desiccation and has not been recovered alive from dried roots of bulbs held in storage. It is unlikely, therefore, that planting stock would be responsible for the spread of the nematodes into new localities. The chief concern in control of this plant pest is bulb fields already infested.

Eliminating this nematode from infested fields is difficult because it is capable of living on a wide variety of plants. Control by means of crop rotation is possible only if the alternate crop plant does not continue to build up or maintain a destructive population of nematodes in the soil.

At present a desired rotation crop which does not serve as a host to the lesion nematodes is unknown. Cultural practices such as complete summer fallow, weed control and the roguing of volunteer plants would aid in reducing the nematode population but they are not completely satisfactory. The most promising control measure at present appears to be soil fumigation. Investigations in Oregon have shown that significant increases in percentage of No. 1 bulbs were obtained by soil fumigation. The fumigants and rates used were D-D at 25 and 50 gallons per acre, and EDB (ethylene dibromide) at 5 and 10 gallons per acre. The higher dosages of those materials increased the yield of No. 1 bulbs four to five hundred percent. Soil fumigation experiments for the control of the lesion nematode are currently underway in Washington. Recommendations for the use of specific soil fumigants depend on the results of those trials.

Most of soil fumigants used on a field scale are as liquids and are applied by injection about 8 inches under the soil surface. For small areas, hand applicators capable of delivering measured amounts of the fumigant are used. For larger areas, tractor applicators are generally used. The latter are of two types. One, the most commonly used, delivers the fumigant in continuous streams behind shanks pulled through the soil. The other type places the stream of fumigant ahead of the plow which immediately turns the soil to cover it. When shanks are used, the soil is prepared in advance by plowing, disking and leveling. If the plow applicator is used, the disking and leveling follow immediately after application. Once the applicator is set up and adjusted for proper application, an acre or more can be fumigated per hour. With properly operating machines, application is neither difficult nor dangerous. In some cases, soil fumigants are becoming available as granular solids in which the granular material functions as a carrier for the fumigant which it absorbs. They are applied with certain types of fertilizer equipment.

Soil fumigation is a technical process, however, and must be done carefully. Observe the following instructions when fumigating fields for nematode control.

1. Fumigate when soil moisture is the same as it is in a good seedbed. Dry, loose soil allows much of the gas to escape; excessive moisture prevents the gas from moving through the soil.

2. Use a thermometer and do not fumigate until the soil temperature at a depth of 6 inches is between 50 and 85° F.

3. Plow to the usual depth. Do not depend 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.

4. 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.

5. Apply the soil fumigant at a depth of 8 to 10 inches, with a chisel applicator, or at the usual plowing depth with a plow applicator.

6. 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.

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

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

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

NARCISSUS

FUNGUS DISEASES

Charles J. Gould

Narcissus, or daffodils, are relatively free of disease when grown in greenhouses or in home gardens. In commercial fields, however, there may be some persistent and occasionally some very heavy losses. White Mold has flattened entire fields in southwest England and Oregon's coastal area, while Fire has done the same in Washington's Puyallup Valley. Basal Rot, a consistently serious offender, has reduced stocks of such varieties as Spring Glory and Victoria from tons to bushels in a single season in New York, Holland and other areas.

Fortunately, scientists have found ways to combat most of these plant enemies. This article describes the symptoms and control measures for the most common fungus diseases.

BASAL ROT

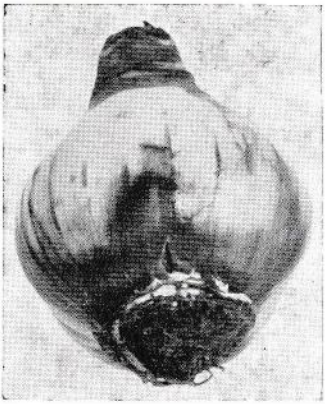


Fig. 54. Basal Rot of Narcissus. Surface view of partially rotted bulb.

Fig. 55. Basal Rot of Narcissus. Longitudinal section of a partially diseased bulb.

SYMPTOMS: Plants from infected bulbs are stunted, yellowed and often die prematurely. Roots are few or none. Such plants produce bulbs that are partially or entirely decayed with a soft, chocolate or reddish-brown rot which usually starts at the base of the bulb. A white or pinkish mold is often present between the scales and on the base. Severely diseased bulbs eventually dry into mummies. (Figs. 54 and 55)

Infection in the field usually starts in the roots and progresses into the basal plate and scales. This infection may occur late in the growing season, particularly with warm (65°—75° F.) temperatures and ample soil moisture. This combination seldom occurs in the Pacific Northwest, but often in the eastern United States. Infection also may occur during digging, cleaning and grading when healthy and diseased bulbs are mingled together. This type of infection usually starts also at the base of the bulb but may begin elsewhere, particularly at wounds, bruises,

sun-scalded areas, etc. As the harvested bulbs mature, they become increasingly resistant to infection, but as soon as root activity begins, they again become susceptible. (The disease is caused by **Fusarium oxysporum** f. **narcissi** (Cke. & Mass.) Sny. & Hans. This form is different from the one causing basal rot of tulips or iris.)

Basal rot is worldwide and serious—more so in warm climates than in cool ones, such as the Pacific Northwest. The fungus spreads rapidly in the soil at temperatures of 65° to 75° F. Temperatures below 55° retard infection. Most large trumpet varieties are susceptible, particularly the white and bicolor types. Golden Harvest is much more susceptible than the common King Alfred. The Jonquilla, Tazetta, Triandrus, and cup types are usually resistant.

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.

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. However, after freezing injury, tissues other than roots and flower buds are the first to become discolored. 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.

CONTROL: 1. Dig bulbs as early as practicable and in as dry weather as possible. Cover stacks to keep bulbs dry and protect them against sunburning. Dry as rapidly as possible with good air circulation.

2. Avoid sunburning, bruising, or otherwise injuring the 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 (55°—60°) and well ventilated conditions. Avoid overheating in transit.

5. Treat planting stock according to directions in No. 11. If the loss from basal rot exceeds 1%, treat three to seven days after digging and again just before planting. If the loss is less than 1%, treat only once, sometime after cleaning but before the root plates become swollen.

6. Remove and destroy diseased bulbs again before planting.

7. 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.

8. 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.

9. 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.

10. Disinfect used trays and cases in a solution of formaldehyde at a rate of one quart (U.S.P. type) in five gallons of water or in the mercury solutions recommended for bulbs in No. 11.

11. The fungicides generally used as dips for daffodil bulbs in the U.S. are:

Phenyl mercuric acetate (1 lb. in 500 gals. water for 5 min.)

2% Ceresan (1 lb. in 8 gal. for 5 min.)

New Improved Ceresan (1 lb. in 40 gal. for 5 min.)

Since phenyl mercuric acetate is less expensive and less apt to injure bulbs, it has become widely used in recent years. Directions for its use are:

A. PMA (Phenyl mercuric acetate) is sold in solution or as a powder. The powder is the cheaper. Make a paste of the wettable type with hot water before adding to the tank. Before treating, allow the paste to dissolve thoroughly, preferably with an agitator running.

B. Since soil and plant material may inactivate the PMA, it should be replenished at intervals. This is most accurately done by means of chemical tests. A testing procedure, suitable for grower use, is available from the Chemistry Dept. at the Western Washington Experiment Station (Puyallup, Wash.) A few tests are usually all a grower needs in order to set up a regular replenishing schedule. In the absence of chemical testing, V. L. Miller (Chemist, Western Washington Experiment Station) suggests the following schedule for trial use:

a. Treat two loads. Add water to tank to bring up to original level. Add more PMA, at a rate of 3 oz. to every 500 gals. of the original solution. (For example, add 9 oz. more of PMA to a tank holding 1,500 gals.) Treat two loads and add more PMA. Treat two more loads and discard the solution. Try to treat all six loads in one day.

b. Since peat soil removes more PMA than does sandy soil, six oz. of PMA per 500 gals. should be added after the second load of bulbs from peat soil. Discard the solution after the fourth load. The cleaner the bulbs, the more effective the solution will remain, regardless of soil type.

c. Since mercury reacts with most metals, such surfaces (of dipping tanks, for example) should be protected with a rubber or plastic base paint. Do not use lead paint.

12. If heptachlor is added for insect control, the emulsifiable form is better than the wettable powder, since it inactivates less of the mercury compound.

13. Either plant the bulbs or dry them immediately after treatment.

14. Use formaldehyde in the hot water treatment (for nematodes) to prevent spread of the basal rot fungus. After cooling the bulbs, dip basal rot-infested stocks in PMA to provide residual protection.

15. All mercury compounds are poisonous. Therefore, the operator should wear heavy-duty rubber gloves and a rubber apron. Wash off the solution immediately, (particularly the concentrated form) if it comes into contact with the skin. Warm temperatures increase the danger of injury from such materials.

16. Mercury injury (especially with Ceresan compounds) to plants may occur if: (1) Immature bulbs are treated; (2) The solution is too strong; or (3) The treated bulbs are not dried rapidly. The centers of injured bulbs die and turn black; flowers are lighter in color, smaller, and the trumpets are shrunken.

17. In large scale operations, the treating is usually done in tanks that can hold several tons of bulbs at one time, using electrical hoists. The stacks are covered and tied down to prevent shifting. The bulbs are usually left in their original trays, both for convenience and also to disinfest the trays.

SMOULDER

SYMPTOMS: As infected leaves emerge from the soil, they appear brown and more or less distorted. Dead leaf tips may be stuck together. If the rot is one-sided, the leaves develop in a sickle-shape with the rot on the inner edge appearing wet and pinkish-brown or brown. Flower stems may be rotted and flowers may develop brown spots. Masses of gray conidia and small black sclerotia often form on diseased portions, especially near ground level. Sclerotia also 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. (Figs. 56 & 57)

The fungus is widespread, although generally of minor importance. However, in the Pacific Northwest, it ranks next to basal rot in seriousness. It is more serious in cool, wet seasons; in stocks not dug every year; in 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. The early varieties are reported as being particularly susceptible, but this may be due to their exposure to more frost injury. Snowdrops are also susceptible. (The causal fungus is **Sclerotinia narcissicola** Gregory).

CONTROL: 1. Remove and destroy diseased plants as soon as they appear.

2. Promote good air movement by controlling weeds.

3. Spray every two weeks during wet weather with freshly-made Bordeaux (8-12-100) mixture, plus a compatible wetting and sticking material. (Some of the new fungicides, such as zineb, captan, and the insoluble coppers might be effective and more easily used. However, they have not been tried sufficiently to justify recommendations for other than trial use or home garden purposes). Methods of preparing Bordeaux are described at the end of this section on diseases.

4. Dig bulbs and change locations every year.

5. Discard all rotted bulbs.

6. Give infested stocks the hot-water-formalin treatment used for nematodes.

7. Plant in locations with good air movement and good soil drainage; avoid low spots and heavy soil.

LEAF DISEASES

SMOULDER: See preceding section.

SCORCH: Yellow, red or brown spots appear on the tip 2-3 inches of leaves as, or soon after, they emerge from the soil. A yellow band 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. These are small and water-soaked with yellow centers at first, later becoming elongated (up to 1/8" x 1/2" in size). Very small brown fruiting bodies of the fungus appear as raised bumps in the scabby areas. The surrounding tissue dies and turns light grayish-brown in color around the brown spots, which become raised and scabby. The leaves may die soon after the secondary lesions appear. Scorch seldom causes spotting of flowers in the North, but commonly spots them in the southern United States. The fungus survives in infested foliage and on the necks of bulbs. The disease is widespread and usually moderate, although it can be serious, especially on plants left in place for two years. It is worse in warm, moist seasons and on wet, poorly drained soils. Varieties vary in resistance. Amaryllis and certain related genera are also susceptible. (The causal fungus is **Stagonospora curtisii** (Berk.) (Sacc.) (Fig. 58)

Fig. 56. Smoulder of Narcissus. Diseased leaf tips. (Photo courtesy Frank P. McWhorter)

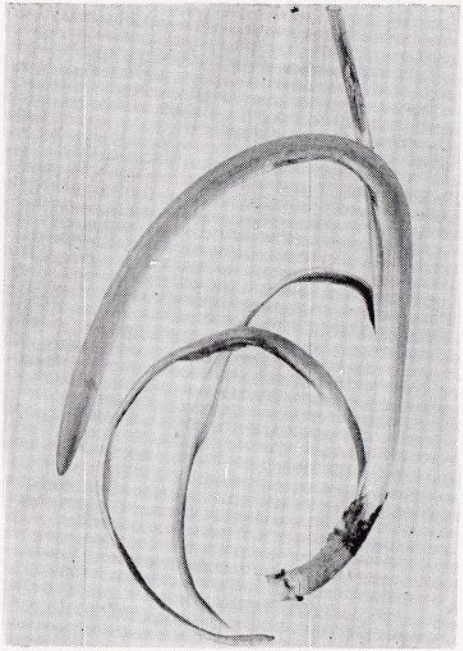


Fig. 57. Smoulder of Narcissus. Sickling, caused by fungus attack on leaf margins.

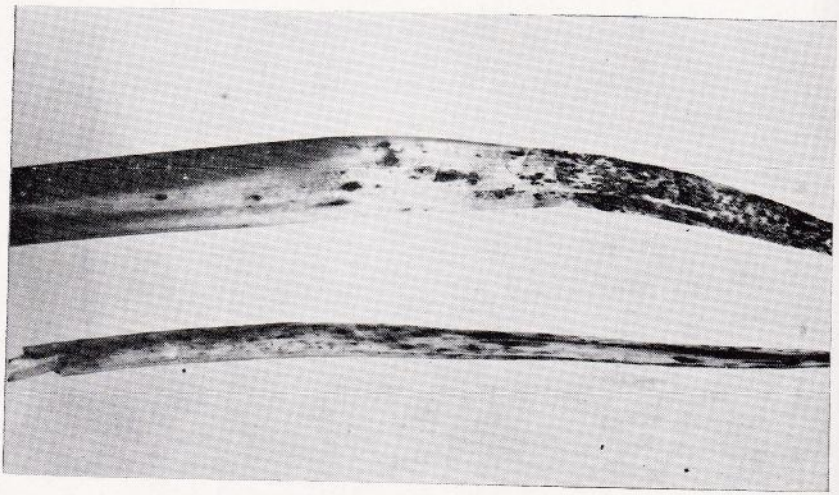


Fig. 58. Scorch on Narcissus stem and leaf.
(Photo courtesy Frank P. McWhorter.)

Fig. 59. Collapse of narcissus leaves caused by Fire.
(Photo taken by Glenn A. Huber.)

FIRE: Flowers are usually the first parts to be affected, showing small watery or light brown spots which can decay the entire flower overnite. Spores, formed in a gray mass on the flowers, infect leaves and stems, producing bright yellowish elongated spots with chocolate or reddish-brown centers. These spots may occur anywhere, but generally develop first near the tips of leaves. The part of the leaf above the spot turns yellow. Under warm moist conditions the fungus may destroy plantings within a week. Bulbs are not attacked. The fungus overwinters as smooth, plate-like elliptical sclerotia in the leaves. This disease is apparently widespread, but rather uncommon. Only occasionally has it been destructive. Because it can be disastrous, a prompt diagnosis is advisable. If in doubt, consult your nearest authority. Varieties differ in resistance. Removal of flowers before they mature aids in control. (The causal fungus is **Sclerotina polyblastis** Greg.) (Fig. 59).

WHITE MOLD: Early stages appear on leaves and flower stems as sunken yellow or gray spots or streaks, which enlarge and become yellowish-brown with a yellow margin. Leaf tips may be affected soon after emergence, somewhat resembling the scorch disease. However, the dead areas become covered with a distinctive white powdery mold during moist weather. Later very small black bodies of the fungus form in the dead tissue. These bodies germinate the next year and initiate the infection cycle. Flowers and bulbs apparently are not affected. The disease is widespread, but usually minor in importance. White mold is most serious under warm, moist conditions; in stock not dug annually and on plants weakened from other causes. Cool dry conditions retard its development. (The causal fungus is **Ramularia vallisumbrosae** Cav.) (Figs. 60 and 61).

CONTROL OF LEAF DISEASES: 1. Keep plots weeded to promote air movement.

2. Whenever practicable, remove and destroy infected leaves and flowers. Where fire is common, all flowers should be removed.

3. Spray with freshly-made Bordeaux mixture (8-12-100) plus a wetting and sticking material. The number of applications and the interval between applications will vary with local conditions. A repeated 10-14 day schedule is necessary where leaf spotting is common or expected because of extended periods of warm, wet weather. Otherwise, two applications should suffice. Make one when the plants are 6″ - 8″ tall and the other soon after flowering. (Zineb has also been recommended but should be tested on a small scale before applying to the entire acreage).

4. Dig and replant in a different location every year. When digging cannot be done, remove as many dead tops as possible and spray soon after leaves emerge the next spring.

5. Clean bulbs thoroughly and destroy trash.

6. Treat the bulbs to kill the fungi that may survive in the husks or neck. The hot water + formalin treatment (see under nematodes) has been reported effective, as well as a cold soak for one hour in formalin solution (two qts. of U.S.P. formaldehyde per 100 gals.). The PMA treatment used for basal rot control may also be beneficial.

7. Plant only in locations that have both good air and good soil drainage. Avoid crowding.

8. Avoid highly nitrogenous soils and fertilizers.

9. Leaf spots are seldom important in greenhouses. Removal of infected leaves should be sufficient. Otherwise spray with Bordeaux or try zineb.

Fig. 60. White Mold of Narcissus. Field View of diseased plants. (Photo courtesy Frank P. McWhorter)

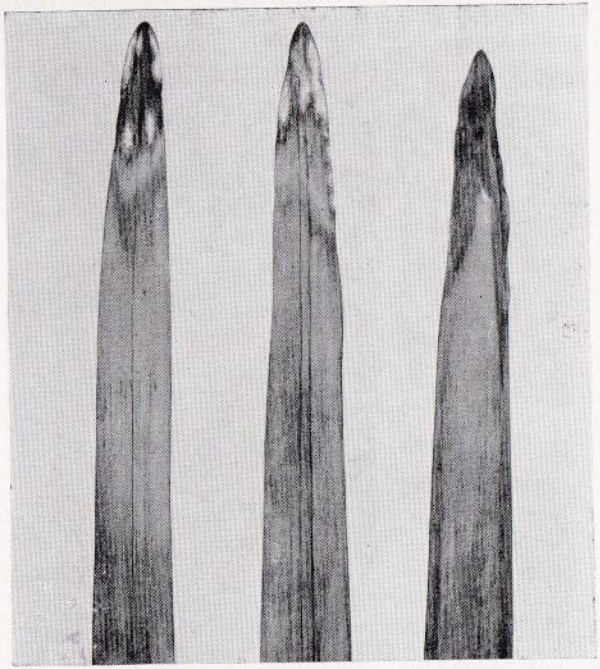


Fig. 61. White Mold of Narcissus. Diseased leaf tips, showing white masses of spores. (Photo courtesy Frank P. McWhorter.)

MISCELLANEOUS DISEASES

BACTERIAL BLIGHT: A rapid collapse of flower stems is caused by a wet basal stem rot, which progresses in color from grayish-pink to brown. Infection of leaves occurred after artificial inoculation, but natural infection of leaves has not been observed. Bacterial blight is uncommon in the Pacific Northwest. Commercial control has been achieved by digging, thoroughly cleaning the bulbs, dipping in a mercury solution and replanting in a new location.

BLACK ROT: Tops turn yellow because of a 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 more or less gray at first, later becoming a mixture of black and gray, due both to decay of the scales and development of mycelium and sclerotia of the fungus. Although daffodils are less susceptible than many other bulbs, they may carry the fungus into healthy fields. The hot water+formalin treatment used for nematodes apparently kills the fungus in lightly-infected bulbs. Also, the PCNB soil treatment would probably protect healthy bulbs planted in infested soil. See directions and discussion under iris—black rot. (The causal agent is an unnamed black sclerotial-forming fungus, perhaps a strain of **Sclerotinia sclerotiorum** (Lib.) De-Bary).

BLUE MOLD: Bulbs stored under cool, moist conditions, particularly late in the season, or bulbs that have been injured, may have their outer husks and scales rotted by the blue mold fungus (**Penicillium** spp.). Such rot also often follows disinfection of bulbs with mercury compounds. Rapid drying after treatment and early planting will help prevent such infection.

CROWN ROT (wet scale rot or 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 (1/16" - 1/4" usually) rounded reddish-brown pock-marked sclerotia on or between the scales. The odor typical 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 range of ornamental, vegetable and even weed hosts. By growing on 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+formalin treatment described under bulb or stem nematode. Healthy bulbs might be protected in infested soil by applying the PCNB soil treatment described under iris—crown rot. Although this treatment did not injure daffodils in small scale tests, it should be tried commercially only on a small scale at first to determine its safety. (The causal fungus is **Sclerotium rolfsii** Sacc.).

DRY-SCALE ROT (Black or small scale-speck): This disease is usually confined to the outer scales. It appears as a dry rot, with a sharp margin and bears many very small black fungus bodies, resembling specks. On severely-affected bulbs, the scales appear 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+formalin solution and planting on well-drained soil should clean up affected stock. (The causal agent is possibly **Stromatinia gladioli** (Dray.) Whet.).

LEAF YELLOWING: This condition may result from fungus, nematode or bacterial rot of roots, bulbs or the basal portions of leaves. However, leaf yellowing may also result from soil waterlogging and other conditions unfavorable for root growth.

MUSHROOM ROT: The honey mushroom (**Armillaria mellea** (Vahl. Fr.) sometimes causes serious losses when the bulbs are planted on recently-cleared land. Infected bulbs are covered with a coarse white mold. Under continued cultivation the fungus usually disappears.

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 under conditions of high temperature and poor ventilation. It is prevented by: (1) Avoiding injury; (2) Keeping bulbs cool and well ventilated in storage and transit; and (3) By rapid drying and cooling bulbs after the hot water treatment. (The causal fungus is **Rhizopus stolonifer** (Ehr. ex Fr.) Lind.).

OTHER DISEASES: These are either unknown in the United States or are apparently of minor importance: Green bulb rot (**Trichoderma** sp.); bulb rot (**Sclerotinia sativa** Dray. & Groves); white root rot (**Rosellinia necatrix**) Prill.; smut, rust and some miscellaneous leaf spots.

HOW TO MAKE BORDEAUX MIXTURE

(for 100 gallons)

An 8-12-100 formula refers to 8 pounds of copper sulfate, 12 pounds hydrated lime, and 100 gallons of water. Prepare as follows:

1. Prepare separate stock solutions of lime and copper sulfate, so that each gallon of the solution will contain 1 pound of these materials. Let the lime soak for 30 minutes before using. Dissolve the copper sulfate in warm water by suspending in a cheesecloth bag near the top of the water in a nonmetal container. (An "instant" grade of copper sulfate which goes into solution rapidly is now available in many stores.)

2. Fill the spray tank about two-thirds full of water. Start the agitator. Put a piece of window screen or copper wire strainer (20 mesh) over the water inlet.

3. Add 12 gallons of the lime stock solution which has been stirred thoroughly.

4. Next pour in slowly 8 gallons of the copper sulfate solution, meanwhile adding enough water through the hose to almost fill the tank.

5. Add a compatible wetting and sticking agent. Follow manufacturers' directions.

6. Use immediately or, if a delay of a few hours is unavoidable, add one heaping tablespoonful of ordinary table sugar.

(for 3 gallons)

Follow procedure as outlined above, but using only 6 ounces (23 level tablespoonsful) of hydrated lime in 6 quarts of water, and 4 ounces (7 level tablespoonsful) of copper sulfate dissolved in 6 quarts of water. Add the copper sulfate solution slowly to the lime solution, stirring continuously. Mix in a wetting and sticking agent.

NARCISSUS

VIRUS DISEASES

Frank P. McWhorter

The recent excellent investigations on virus diseases of narcissus in Prof. Dr. E. van Slogteren's laboratory at Lisse, Holland are most useful and specific for naming the viruses of daffodils and are emphasized in this discussion. In particular, modern concepts of virus diseases certainly support separation of yellow stripe, or classical "grijs" (gray) disease, from mild mosaic, as the Holland workers suggest. During our early investigations of the disease and subsequent "clean up" programs by the growers, the two were considered together. We controlled both of them!

The large literature on mosaic diseases of narcissus is confused by inconsistencies in names. In the United States the term "mosaic" has been consistently used for yellow stripe; in England "stripe" has been consistently used for yellow stripe except in a 1946 paper where that disease is called "mosaic"; in the British colonies both names have been used; in Holland the term "grijs" was originally used for both. Since Dr. van Slogteren from his recent conclusive serological investigations proposes the name "yellow stripe" for the more usual (our mosaic) disease it is proposed that the name "yellow stripe" be accepted as used in Table I. (The name yellow stripe has been proposed for the latest international list of plant viruses.)

TABLE I. VIRUS DISEASES OF NARCISSUS, 1957

The Disease	The Virus
Yellow Stripe	YELLOW STRIPE VIRUS
Mosaic	MOSAIC VIRUS
Flower Streak	?
White Streak	WHITE STREAK VIRUS
Chocolate Spot	CHOCOLATE SPOT VIRUS
—none—	NARCISSUS SYMPTOMLESS VIRUS
—?—	ONION YELLOW DWARF VIRUS

YELLOW STRIPE

Yellow stripe is the name most generally used for the common "mosaic" of daffodils that streaks or breaks the flowers. This disease is recognized by the strong yellow streaking and mottling of emerged plants at the time when roguing is most advantageous. That the malady is a transmissible virus disease was first shown in Oregon in 1931. Superb colored pictures of this disease were published in 1939 by Frank Haasis in his Cornell Memoir 224. Caldwell in England and McWhorter in Oregon independently showed that the most discriminative symptom of the disease is the roughening of the foliage; no other daffodil disease has any such symptom. This roughening and the thinning or streaking of flowers are conclusive earmarks of the disease.

The salient facts about this virus are: While spread is greatest between closely placed plants the virus does not spread root to root or leaf to leaf. When the relation of incidence of spread to closeness of plants was proved we suggested in 1932 that root transmission might occur, but none of our many experiments confirmed this hypothesis. Subsequent investigations in England and Holland also show that transmission does not take place between roots that touch. Apparently transmission by aphids, as first shown by F. S. Blanton and Frank Haasis in 1939, is the only proved means of natural spread. Subsequent investigations in England and Holland have shown that a large number of aphid species are able to transmit the virus. Aphids are so rarely seen and so transient on daffodils in the Pacific Northwest that control by aphicides has never been recommended in this area. Control by roguing and mother blocking has been successful. Since the virus is difficult to transmit mechanically precautions are unnecessary when roguing or selecting best plants or bulbs for a mother block.

MOSAIC

This disease has often been referred to as "mild mosaic" by both experienced growers and investigators. Unlike the symptoms of yellow stripe, those of mosaic are not apparent when the plants emerge. In fact, they are seldom apparent until near the time the plants bloom; then they are noticeable as mild, blue-green mottles. The flowers are not streaked and the plants show very little injury. One should select plants that do not show any mosaic-type mottle when making a mother block. We had supposed that mosaic was a form of yellow stripe due to a strain of that virus but Holland investigators have shown by serological tests that it is caused by a distinct virus. Present information indicates that plants affected with mild mosaic should be rogued only from the foundation or mother block stocks. Roguing the commercials is impractical as the virus has no effect on the appearance of the flowers when the bulbs are forced.

FLOWER STREAK

Besides yellow stripe and mosaic a third virus disease of the mosaic group has been discovered and studied in King Alfred by Charles Doucette. The distinctive symptom is a strong breaking of the flowers that appears in plants that have no other specific symptom. The flowers of such plants are streaked so strongly that they are unfit for forcing. The virus has not been investigated but Doucette has shown the condition continues bulb to bulb. Therefore plants having streaked flowers and normal foliage should be rogued from both commercial and foundation stocks. Like other bulb crops, daffodils should be rogued during early season, when in bloom, and during late season. (Fig. 62)

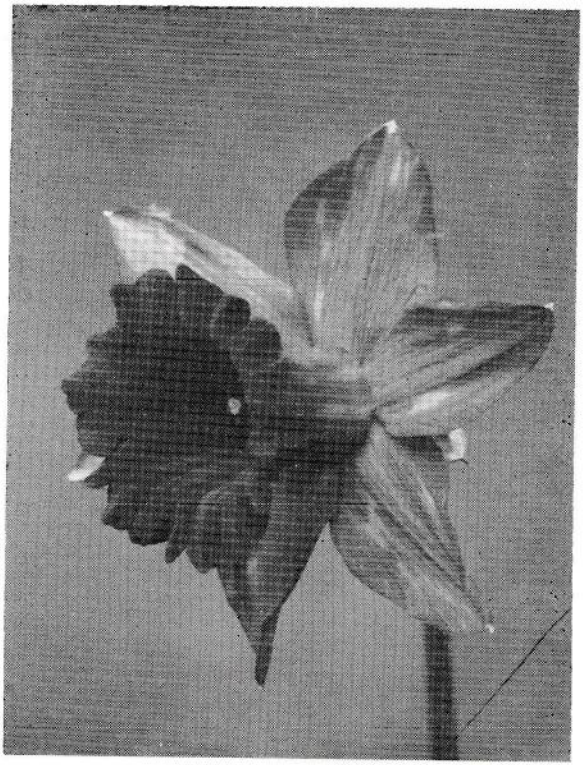


Fig. 62. Flower streak in King Alfred.
(Photo courtesy Charles F. Doucette.)

WHITE STREAK, PAPER TIP, CHOCOLATE SPOT, AND NARCISSUS DECLINE

White streak, formerly called Zilverblad in Holland, is the principal virus and symptom in the late season decline disease complex. The virus of white streak is often present in the same plant with the virus responsible for chocolate spot, purple tip, and other purple colorations. The combination, or white streak alone, produces the condition for which we prefer the general name "decline disease". "Paper tip" developed shortly after blooming seems to be a severe form of white streak. Extensive ecological and greenhouse studies of this disease proved that the appearance of symptoms is a function of the age of the plant and the temperature at which it is grown. Surveys of plantings from Watsonville, California, to British Columbia showed that the disease develops only after the plants have bloomed and is most prevalent in the climatic zones considered best for growing bulbs; it is not conspicuous in the cooler areas. This observation was followed by extensive tests on the forcing qualities of affected bulbs of known history. Thousands were tested with the cooperation of Philip Brierley at Beltsville. These tests proved that under normal forcing the bulbs produced marketable flowers. Hence our recommendation that control be practiced only in the foundation stock and not in the commercials. If the affected commercials make the required size they will force satisfactorily.

Control of white streak, regardless of whether chocolate spotting is present also, is imperative from the grower's viewpoint. While the prominent white streaking is not noticeable until a few weeks before harvest, affected plants mature so rapidly that bulbs do not attain normal growth; the stock declines. Early tests here indicated about 30% reduction in two years. Tests by Doucette during the past four years showed a 50% decrease for King Alfred. That is to say that on a weight basis a white streaked stock yielded only half as much as a healthy stock during a four year period. The grower must control this disease.

Frank Haasis in 1939 was the first to show that white streak symptoms that precede drying of tips, and the subsequent sudden wilting and falling down of foliage long before harvest, were all due to a virus. He mechanically transmitted the virus from King Alfred to Minister Talma. That same year F. S. Blanton investigating the disease on Long Island showed that the virus is transmissible by both the bean aphid and the potato aphid. More recently the Holland investigators demonstrated that the large pea aphid, the one common on our garden and field peas, was able to transmit the virus at the 100% level. In this case, the transfer was made from infected Victoria to healthy van Waveren's Giant. These observations indicate that white streak virus is spread principally by migrant aphids. White streak is more difficult to control than yellow stripe, however, because one is unable to avoid spread by early roguing since the symptoms are not apparent until after blooming. Migrant aphids after feeding a few moments on a plant infected with white streak or yellow stripe are able to fly to a healthy plant and infect it. A grower can not detect the newly infected plants until the following year unless the transfer took place shortly after the plants emerged.

MISCELLANEOUS VIRUS DISEASES

A few investigators have shown that the virus of the serious onion disease, yellow dwarf, is transmissible to narcissus and that some virus present in diseased narcissus is transmissible to onion. At least two European workers have transferred their onion yellow dwarf virus to Polyanthus types of narcissus. Brierley and Smith, using the green peach aphid, transferred a virus from King Alfred to onion. The last observation has potential commercial significance. The serious outbreak of yellow dwarf in onions in Lake Labish, Oregon, corresponded with the time that daffodils were grown in spots along the lake. While no relationship between known diseases of narcissus and those of onion has been proved, planting the two together seems inadvisable.

The Holland investigators have detected a virus in daffodils that is able to produce ring-like spots on tobacco but they have not related it to any disease in narcissus. Hence they have proposed the name "symptomless" for the virus. More and more cases of monocotyledenous plants harboring unexpected viruses are being discovered, but, as far as daffodil growers are concerned, there seems to be no reason to worry about this one that has been experimentally transmitted to tobacco.

CONTROL NOTES

Old time growers will remember how inverse-roguing—transplanting the clean plants—and mother blocking made a good stock out of even such heavily diseased varieties as Minister Talma. Once a good foundation stock is attained replanting only the largest bulbs tends to reduce the decline complex — white streak and chocolate spot — to a trace. Rogue the foundation stocks thoroughly, but rogue only the yellow stripe plants from the commercials.

NARCISSUS

INSECTS

Harry Andison

The four main economic insect pests that attack narcissi are: the narcissus bulb fly, bulb scale mite, lesser bulb fly and bulb mite. Their life history, habits, type of injury, hosts and control are briefly outlined in this article. Control of these pests is described under field and storage conditions. There are no satisfactory control methods for these species in infested bulbs growing under forcing or greenhouse conditions. It is the responsibility of the bulb grower to supply the forcer with insect-free narcissi bulbs.

NARCISSUS BULB FLY

The narcissus bulb fly (**Lampetia equestris** Fab.) is one of the most important insect pests attacking narcissus bulbs wherever they are grown in Europe and North America. (Fig. 63)

Type of Injury

The newly hatched larva or maggot enters the bulb through the root-ring of the basal plate. It tunnels in the basal plate tissue for several weeks, then upward into the scales, and finally the flower parts. Eventually the centre of the bulb becomes a cavity filled with soft, brown decayed bulb tissue containing a dirty-white or yellowish, legless maggott about ¾ of an inch long. If the bulb is not too seriously damaged, it will develop but will have fewer leaves than normally; these are small and grassy in appearance. (Fig. 64)

Under favorable weather conditions in the coastal areas of the Pacific Northwest the larvae have been observed to ruin the flower parts of 50 per cent of the infested bulbs by the end of the first week in August.

Life History and Habits

The flies, which resemble bumblebees, occur from the latter part of April to the beginning of July and are active chiefly on bright, warm days. They live for about 15 to 20 days, feeding on pollen and nectar from the blossoms of such plants as strawberry, apple, morning glory, dandelion, and many others. The flies are more likely to be found in sheltered places; consequently, narcissi planted in open, windswept fields usually have light infestations.

The female lays about 40 eggs, placed singly on the soil or foliage as near to the bulbs as possible. The eggs hatch in 10 to 15 days and the minute larva moves downward to the base of the bulb. It enters the basal plate, feeds on the interior of the bulb, and develops to mature size by late September or October. Usually one larva develops in a bulb, but occasionally two may be present and, rarely three or four. The larvae remain in the bulbs during the winter, leaving them in March or April to form puparia at the soil surface in the bulb row. It is from these puparia that the flies emerge during late April. The normal life cycle is completed in one year.

Hosts

The narcissus bulb fly is mainly a pest of narcissi. Occasionally it attacks snowdrops, amaryllis, hyacinths, lilies, tulips, and other bulbous plants.

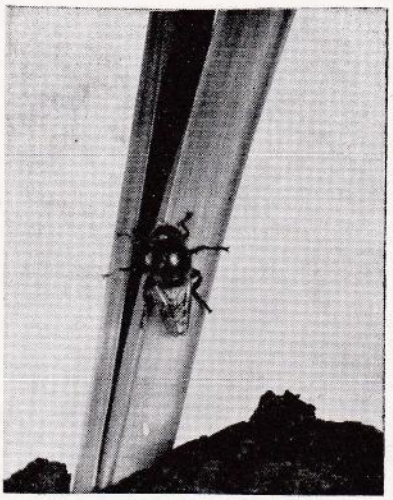


Fig. 63. Narcissus bulb fly on narcissus leaf

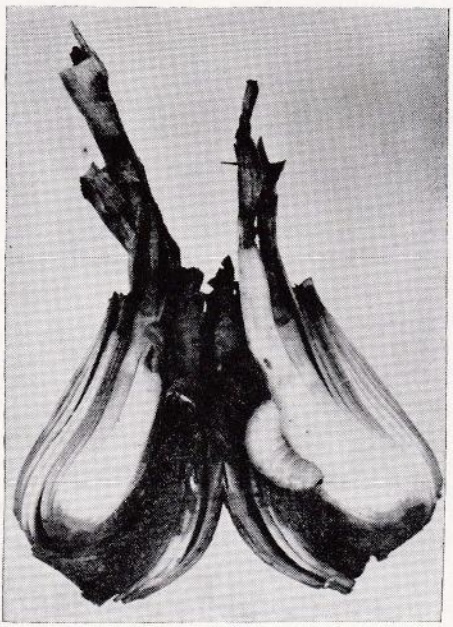


Fig. 64. Vertical section of narcissus bulb showing extensive injury in October, when the maggot is mature.

Control

Control measures are of three kinds: (A) cultural practices; (B) field treatments to prevent attack by the maggots; and (C) after-harvest treatments to kill larvae present in the bulbs.

A. CULTURAL PRACTICES

When planting, destroy unduly soft bulbs because they are likely to be infested by larvae. Most experienced growers discard such bulbs but often neglect to destroy them. Destruction is essential and can be easily and economically done by placing the bulbs in a pile, coating them with discarded crankcase or stove oil, and burning them. A fire from about one gallon of oil will reduce 500 bulbs to ashes.

B. FIELD TREATMENTS

1. Bulb Treatment at Planting

Experiments conducted by the Entomology Laboratories of the Canada Department of Agriculture, Victoria, B. C., and United States Department of Agriculture, Sumner, Washington have shown that the larvae can be prevented from entering narcissus bulbs by a treatment at planting time with either aldrin or heptachlor. You may (a) dust the bulbs in the furrow before covering them with soil, (b) spray them in the furrow before covering them with soil, or (c) soak them for ten minutes in cold water mixture or soak them in hot water (110°F. as for nematodes and mites) with the insecticide added.

(a) **Dusting Method.**—After placing the bulbs in the furrow, and before covering them with soil, thoroughly dust them with either aldrin or heptachlor (2½ per cent) dust. Apply either material by hand or with a fertilizer spreader at the rate of three pounds per 200 feet of row, or 200 pounds per acre for rows planted three feet apart. The most suitable spreader is one with holes in the bottom of the hopper, about three-eighths of an inch in diameter and one inch apart. Leave 11 holes open so that the insecticide is spread evenly over a 10-inch swath.

(b) **Spraying Method.**—After placing the bulbs in the furrow and before covering them with soil, spray them with either aldrin or heptachlor emulsifiable liquid. Apply either material with a row-crop sprayer similar to that described in the pamphlet "A Home-made sprayer for attachment to a tractor power take-off", Publication No. 1007, available from the Canada Department of Agriculture. By operating a piston pump from the tractor power take-off and adjusting the nozzles over the furrow to cover a 10-inch swath, you may obtain complete bulb and soil coverage. Use two flat-type nozzles, Tee jet 8008, directed at a 45-degree angle and about six inches above the row of bulbs. Travel at three miles per hour and operate the pump at 100 p.s.i. so that you apply about 100 gallons of spray per acre. To apply four pounds of actual aldrin or two pounds of actual heptachlor per acre, use 2 gallons of aldrin or 1 gallon of heptachlor 25 per cent liquid concentrate per 100 gallons of water per acre. It is known that these two insecticides prevent the larvae from entering bulbs left in the treated furrows for a second year after they are applied.

(c) **Soaking Method.**—

(1) **Cold water**—before planting, soak the bulbs for ten minutes in an emulsifiable liquid of either aldrin or heptachlor. Use the 25 per cent concentration of aldrin at the rate of 1 gallon or heptachlor at ½ gallon per 100 gallons of water. To prevent the spread of basal rot disease, add a fungicide to the aldrin or heptachlor mixture in the treating tank. Use phenyl mercuric acetate at three ounces, or 2 per cent ceresan at 12 pounds per 100 gallons of water.

(2) **Hot water**—add either 1 gallon of aldrin or ½ gallon of heptachlor 25 per cent emulsifiable liquid to 1,000 gallons of hot water (110°F.) and formalin when treating the narcissi bulbs for the bulb and stem nematode. (See Page 109).

Both aldrin and heptachlor may be fatal if swallowed. Avoid skin contact and excessive inhalation. Do not breathe vapor, fumes, or spray mist. Avoid contamination of feed and foodstuffs.

2. **Field Treatments After Planting**

If you do not treat at planting time, then the most satisfactory control for large plantings is an application of summer oil emulsion in combination with methoxychlor. Use one gallon of actual oil and two pounds of 50 per cent methoxychlor powder per 100 gallons of water. Apply this spray at 150 to 200 gallons per acre, or 1½ to 2 gallons of spray per 100 feet of row, at approximtely 100 pounds' pressure. Make four applications at 10- to 15-day intervals, commencing the second week of May. Commercial summer oil emulsions (Saybolt viscosity 65-80 at 100°F.; U.R. 70 per cent or over) are available in the Pacific Northwest and usually contain 65 per cent oil. This means that 1½ gallons of the emulsion are required per 100 gallons of water.

Naphthalene flakes (refined) at 200 pounds per acre, or one pound per 75 feet of row, have given satisfactory control when applied three times at 15-day intervals, commencing during the second week of May. Hilling or mounding the soil to cover the flakes after each application ensures best results. Naphthalene, costing approximately 17 cents per pound, is expensive on an acreage basis and is more suitable for home gardens or small plantings of high-priced bulbs.

Whatever material is used, apply it to the neck area of the bulb at the soil surface. It is here that the eggs are deposited and the insecticide may kill either the eggs or the newly emerged larvae.

C. AFTER-HARVEST TREATMENTS

In all bulb or storage treatments it is important that the bulbs be dug and treated as early as possible, before the larvae have caused any damage to the flower parts of the bulbs.

1. **Hot-water Treatment**—If properly used, hot water is satisfactory for treating planting stock known to be infested by the bulb fly. Dig the bulbs as early as possible and treat them after they are cured, i.e., two or three weeks after lifting. For bulb fly control, immerse the bulbs for one hour in water containing formaldehyde, two quarts (U.S.P.) per 100 gallons, and maintained at a temperature of 110-111°F. For complete details see the section on bulb and stem nematodes under Narcissus.

2. **Methyl Bromide Fumigation**—As an alternative to the hot-water treatment, fumigate the bulbs with methyl bromide in a chamber, specially constructed for the purpose, at three pounds per 1,000 cubic feet or 4½ hours at 60°. Treat the bulbs as soon as they are harvested, provided that the temperature at the centre of the bulb is 60° before fumigation. This method is particularly useful for treating infested bulbs that are to be shipped or used for the forcing trade. Methyl bromide costs approximately 75 cents per pound. It is sold in cylinders or in one-pound cans, convenient for use in a simple and economical Jiffy applicator.

LESSER BULB FLIES

Three species are recorded from the Pacific Northwest but only one is common, namely **Eumerus tuberculatus** Rond. None of them are considered to be of major economic importance.

Type of Injury

The wrinkled, grayish colored maggots usually occur in large numbers within a bulb and often cause it to rot completely. Although, occasionally the maggots may injure healthy bulbs, their presence is almost always associated with bulbs that have been damaged mechanically during careless lifting, by frost or by soil organisms such as bacteria, fungi, nematodes and narcissus bulb fly.

Life History and Habits

The two-winged fly is ⅓ of an inch long, shiny blackish-green color with several white marking on the abdomen. They appear late in April, and because there are two generations a year, some are present throughout the summer. The female lays eggs in batches of 10 or more on the soil. When the maggots hatch they enter the neck area of the bulbs, where they feed on the decayed tissue. When mature they move to the soil surface to pupate and the adults emerge late in June or in July. These lay eggs, often on stored bulbs, from which the second generation develops. Most of these second generation larvae overwinter, pupate in the spring, and develop into adults in April.

Hosts

Practically all flowering bulbs are attacked as well as some vegetable crops, including cabbage, carrot, onion, parsnip, potato, and shallot.

Control

Protect the bulbs against unnecessary bruising or other mechanical injuries. The presence of numerous mites indicates that they are or have been infested by some other organism. Carefully cull and burn infested stocks. Treat the remainder of the stock using the hot water method or methyl bromide fumigation to prevent infestation during storage.

BULB MITE

The bulb mite (**Rhizoglyphus echinopus** F. & R.) is now generally distributed throughout the world wherever bulbs are grown. It is usually considered to be a scavenger associated with decayed tissue of some form. In narcissi it has been established that the presence of this mite is secondary.

Type of Injury

Bulbs rot and fail to grow. Or infested stocks, when planted, usually produce stunted, distorted, weak and sickly leaves and no flowers. The mature mites are about the size of the head of a common pin, plump, oval, glistening bodies with reddish-brown legs and "beak" or mouth parts. They move rather sluggishly and may be found in large numbers in stored bulbs, sheltering behind or boring into the decaying basal or scale tissue.

Life History and Habits

The adult female lays about 75 eggs throughout its life of one or two months. The eggs hatch into immature six-legged mites closely resembling the adult; these become mature in an average of 70 days, depending on the temperature and humidity. Under unfavorable conditions, a traveling stage nymph is produced known as a hypopus. This very active form does not feed but readily attaches itself to mice, bulb flies or other creatures to be distributed to more favorable feeding places. They are easily transported from place to place in shipments of healthy bulbs.

Host Plants

Narcissus, lily, crocus, amaryllis, dahlia, gladiolus, hyacinth, and tulip.

Control

Look for evidence of other narcissus pests such as bulb flies, bulb scale mite, or nematodes which are probably the primary cause of the decay. Take care that narcissus bulbs are not mechanically injured during lifting, sorting, grading or other cultural practices. Apply hot water treatment or methyl bromide fumigation as described under nematodes (Narcissus) and Iris insects.

BULB SCALE MITE

The bulb scale mite (**Steneotarsonemus laticeps** Halb.) is a major pest of narcissus in the Pacific Northwest and in Europe, especially in forcing stocks.

Type of Injury

On stored bulbs the external symptoms of attack are not easily recognized. Infested bulbs become spongy and soft in the neck region because the mites feed there between the leaves and the flower stem. When cut from neck to base affected bulbs show streaks of yellow or brown tissue running longitudinally between the bulb scales. This discolored tissue is most pronounced on the edges of the growing shoot of the bulb.

The typical symptoms of bulb scale mite attack appear on growing bulbs in the field or on forced stock. When the leaves and flower stems grow upward the feeding of the mites causes them to become distorted or twisted, bright green in appearance with light brown scar-like streaks on them.

Life History and Habits

The minute (1/125 of an inch long) semi-transparent, flat, oval shaped mites cannot be seen without a high-power hand lens. They collect in numbers in longitudinal strips running from the basal plate to the neck of the bulb, feeding between the scales. There are numerous overlapping generations each year. The complete development takes place in the plant; all stages are usually present together.

During the winter months their activities in the field decrease. In the spring, or earlier with bulbs brought into the forcing house, the mites breed at a fast rate. Only during warm, dry conditions do the mite populations develop into damaging proportions. In normal storage conditions the population in infested bulbs usually increases to serious numbers by planting time. Natural spread is usually slow under field conditions and rapid during the storage season.

Control

Do not store narcissus bulbs in a warm place for long periods before replanting; otherwise the mite population will increase rapidly and the developing flowers and foliage on the bulbs will be severely injured.

Treat infested narcissus planting stocks as described under the hot water method and fumigate forcing stocks with methyl bromide. (See Page 134).

NARCISSUS

FORCING

Neil W. Stuart

CURING THE BULBS

At maturity of narcissus bulbs in July the flowers are more completely developed within the bulb than are tulip flowers at bulb harvest. For earliest flowering Dutch workers recommend storing freshly harvested bulbs about 4 days at 86° F., then 1 to 2 weeks at 63°, and afterwards at 48° until the bulbs are planted and placed outside October 1 to 15. For the next earliest blooming the bulbs are held at 63° until September 1 and then at 48° until shifted outside November 1. For later blooming 63° storage is continued until October 1; then the bulbs are held at 48° until planted outside November 1. Bulbs intended for the latest blooming are not precooled, but are held at 63° until planted November 1 to December 1.

J. H. Crossley recommends storage of British Columbia-grown narcissus bulbs at 68° for 2 or 3 weeks if the bulbs are dug in early July and for less time if they are harvested later. Termination of storage is governed by time of full development of the trumpet, visible as a short tube with serrated edges. Precooling at 48° is recommended as for tulips.

PRECOOLING THE BULBS

In the United States in recent years the sales of narcissus bulbs for garden use have increased and the sales for forcing have definitely decreased. Bulbs from the Pacific Northwest are received in the East in late August and early September. Those intended for early forcing are precooled at 48° to 50° for about 6 weeks and then shipped to forcers. Tests show that these precooled bulbs must be planted at once and placed under cool conditions or the effect of the precooling treatment will be lost to some extent. The usual practice is to flat the precooled bulbs in a well-drained field soil so that the bulbs almost touch each other. No fertilizer is needed. They are then watered thoroughly and stored at 48° to 50°, held in a bulb cellar, or buried outside well-covered with sawdust or sand and mulched with salt hay, straw, or similar material. For "rooting" and shoot development 4 to 6 weeks of such storage of precooled bulbs is necessary before forcing. Double-nose No. 1 narcissus bulbs will generally average slightly more than two flowers per bulb, while the No. 2 size will average from one and one-half to one and three-quarters flowers per bulb. Forcing time depends upon length of storage as well as greenhouse temperature.

DIRECT PLANTING

Dry narcissus bulbs can be stored for 10 to 12 weeks at 50°, flatted, and forced at once at 60° or higher. Roots develop rapidly on properly stored bulbs, and the plants bloom nearly as soon as when the precooled bulbs are flatted and held for 6 weeks at 50° before forcing. This direct planting is most useful for narcissus intended for the earliest blooming and is recommended on a trial basis. Storage for more than 12 weeks at 50° is not recommended.

Recent tests indicate that blooming is retarded and smaller flowers are produced by immature narcissus bulbs than by ones allowed to mature fully before precooling. Exposure to high temperatures (80° to 100°) after harvest and before precooling tends to accelerate blooming slightly, but at the expense of stem length and flower size. The later

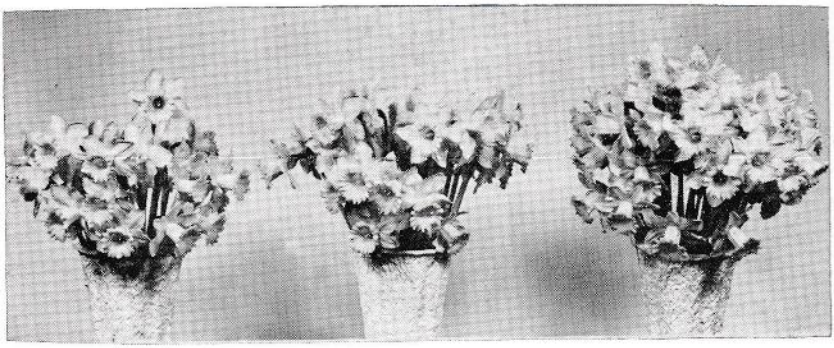


Fig. 65. Effect of time of harvest of King Alfred narcissus grown in Washington on earliness of blooming. A. Dug July 5; B. Dug July 12; C. Dug July 26. Precooled 50° Sept. 5. Flatted and returned to 50° Oct. 16. Into greenhouse Nov. 27. Photographed Jan. 11, 1957. (Total of 3 days cut from 4 flats.)

the application of the high temperature the more severe the effects. Thus the smallness of the flowers on early-forced King Alfred bulbs may be caused to some extent by overheating during shipping or storing, particularly of bulbs dug too early or ones grown in cool, wet summers as in 1955 in the Pacific Northwest. (Fig. 65)

VARIETIES

More King Alfred bulbs than other varieties are forced. Other varieties used to some extent are Golden Harvest, Helios, The First, Rembrandt, and Carlton. For midseason and late flowering of non-precooled bulbs numerous varieties of the several narcissus types can be used.

CUTTING THE FLOWERS

Narcissus are cut just before they open, placed in containers with a small amount of water, and hardened for several hours or overnight at 33° to 35°. They are bunched in lots of 12, but not wrapped in paper before shipment. Narcissus flowers have been held successfully in dry storage at 31° for 3 weeks.

FORCING NARCISSUS WITH ARTIFICIAL LIGHT

We have repeatedly forced properly precooled narcissus bulbs entirely by artificial light (50 or more foot-candles). English and Dutch workers specify 100 watts of light per square yard (preferably five 40-watt bulbs over 2 square yards). The lights are kept 6 to 8 inches above the plants for 10 to 12 hours daily. Mazda light is preferable to fluorescent light and results in earlier flowering. Because the conditions are uniform it is somewhat easier to force narcissus under artificial light than in the greenhouse. The flower colors are equally good, and usually the stems are a little longer.