

# Diseases of Narcissus



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## SUMMARY OF CONTROL PRACTICES FOR NARCISSUS DISEASES

The particular disease-control practices which a narcissus grower should employ depend on the types of diseases present. The grower must know (A) whether nematodes are present, (B) whether basal rot and other bulb rots have affected the stands and storage, (C) whether leaf spots are present and serious, and (D) whether mosaic is present. The following summarizes the treatment of each of these conditions:

### *A. For nematodes*

1. When nematodes are present hot-water treatment must be given, followed by a careful program of fallow and crop rotation.
2. When bulbs are hot-water treated to destroy nematodes, formaldehyde or other disinfectant should be included in the hot-water bath. The purpose of this is (a) to increase the efficiency of the treatment, and (b) to prevent the spread of basal rot and other fungous diseases.

### *B. For basal rot and other bulb rots*

1. Every two or three years, planting stock should receive hot-water treatment regardless of whether or not nematodes are known to be present. After such treatments the bulbs should be dipped or soaked for a short time in some chemical to prevent the spread of basal rot and improve the general condition of the root plates.
2. Cold chemical dips and short soaks applied to bulbs at planting time will favorably affect the basal plates and thereby improve stands and subsequent keeping and shipping qualities of the bulbs.

### *C. For leaf spots*

For the control of leaf spots the general recommendation is to try to effect control by chemical dips of the bulbs and subsequent rotation of the crop rather than by spray measures on the leaves during the growing season.

### *D. For mosaic*

Narcissus mosaic can be controlled only by roguing—that is, digging out and discarding the diseased plants. Hot-water, chemical, and spray treatments are useless against mosaic.

# Diseases of Narcissus

By

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## INTRODUCTION

COMMERCIAL narcissus bulb production in the United States is a young industry. Its development depends on preventing, in part by quarantine regulations, the introduction and spread of insect pests and plant diseases. The movement of planting stocks from Europe to America introduced some of the European troubles as well as new problems of propagation and disease control. These have been met to a large extent and American bulb stocks have now attained vast proportions. Special machinery for planting, cultivating, and harvesting has been devised for the purpose of reducing production costs and competing with the labor advantages held by foreign competition. The permanency of the industry is assured not alone by the mass production as achieved by American mechanical efficiency but in a large part by the recognition of the more important bulb diseases and pests, and concerted action toward their complete control. Through adequate disease control, especially of those insidious types known as mosaics, a quality product superior to the former imported stocks is being produced. Such products create their own demand. It is the purpose of this bulletin (1) to describe the more important narcissus diseases known to occur in the Pacific Northwest; (2) to discuss their relationships to diseases of other bulbs; and (3) to point out general principles of control. As certain features of each of these diseases, and especially their control, are still under investigation by the writers and their coworkers, this bulletin will be followed from time to time by circulars of information presenting later findings and recommendations.

Narcissus diseases on a basis of their causes may be classified into three main groups: VIRUS, FUNGUS, and NEMATODE. A brief general discussion of each of these groups is given before presenting the details concerning the specific narcissus diseases which are later presented under each of these headings. The general relationship of narcissus diseases to other bulb diseases is discussed in this first section.

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## DISEASE TYPES WHICH AFFECT NARCISSUS AND OTHER BULBS

**Virus diseases.** By virus diseases are meant those having for causal agent a filterable substance or "virus", the individual particles of which are too small to be discernible even with the highest powers of the microscope. These viruses develop in and permeate the living substance of the plant cells. The diseases they produce are evidenced by symptom complexes variously referred to as "mosaic", "curly top", "leaf-roll", "rosette", etc., according to the response of the affected plant. There are several known to affect lilaceous bulbs. For example, it has been recently shown that the disease which almost stopped the propagation of the Easter Lily in Bermuda is a virus disease now known as "yellow flat". This lily disease is spread by the cotton aphid, a sucking insect typical of the kinds that usually carry viruses from plant to plant. Had the virus nature of the disease and its dependence on the cotton aphid for distribution been recognized in former times, Bermuda might have continued to be the chief producing center of the Easter Lily. Most of the virus diseases of our more important bulb crops may be referred to as "mosaics". These mosaic diseases weaken some bulb kinds, spoil the appearance of others, and some they kill outright. Their control must be emphasized in every "better bulb" propagation program. Moreover, the superiority of selected bulbs will lead experienced forcers to demand mosaic-free stock. The virus disease of narcissus herein discussed is a mosaic.

**Fungous diseases.** There are numerous fungous diseases of narcissus and other bulbs, which fact is another way of saying that many kinds of fungi attack bulbs. There are four groups of these fungi; namely, those which attack the bulbs themselves, those which attack the roots; those which attack the foliage; and those which attack both bulb and foliage. All of these fungi, whether bulb-attacking or foliage-attacking, appear to be in some manner associated with the bulb during storage. It is this fact that accounts for the wide distribution of the fungous diseases, for the distribution of the diseases has accompanied that of the bulbs. Although the distribution of these diseases is wide their severity varies according to climatic conditions prevailing at the place of culture. For example, in eastern narcissus plantings basal rot has been the factor limiting production but in the sections of the west coast where the summers are cool and dry, basal rot has been of relatively little local importance. From storage experiments conducted in the east we know that this difference is directly attributable to the climatic differences. On the other hand, in certain localities of the west coast where the growing seasons are extremely wet, the *Ramularia* leaf-spot or blight occurs—a disease even more destructive than basal rot and in turn more narrowly limited in distribution by its climatic requirements. It is evident, therefore, that the fungous-disease control problems vary from place to place. One should not, however, attempt to control merely the diseases prevalent in a given locality. *On the contrary, each grower should take steps to utilize the climatic conditions available in his locality to suppress completely even those diseases that with him are of little consequence, so that his product when shipped to a new locality will be free from latent troubles which in the new locality may become a menace.*

**Nematode diseases.** The nematodes or nemas are tiny thread-like worms. Many are non-parasitic, free living inhabitants of soil, water, or decaying vegetation, but certain genera—for example *Tylenchus*, *Aphelenchoides*, *Aphelenchus* and *Caconema*—include species requiring living plant tissues for the development of their normal life cycles. In the culture of narcissus we are chiefly concerned with the stem-nematode, *Tylenchus dipsaci* Kühn, but from a standpoint of possible future developments one must realize that other parasitic nemas occasionally occur in narcissus and that these may later require specific control practices. For example, *Aphelenchoides subterraneus* appears to be truly parasitic in narcissus bulbs, and certain species of *Cephalobus* also deserve consideration in this connection. Moreover, it has been pointed out by nematologists that various saprophytic nema species are often in small numbers associated with normally growing plants without inducing disease. Yet when the plant is weakened or injured by other organisms or circumstances these nemas multiply rapidly and may become effective parasites.

There are occasional reports of parasitic nematodes on iris and tulip bulbs, but we have few records of serious economic damage to these plants in this country. From a narcissus grower's point of view, however, such findings are important since they may affect the choice of plants in crop rotation.

The stem-nematode, *Tylenchus dipsaci*, attacks many kinds of plants in a number of plant families. Among these are several cereals, solanaceous plants including potatoes, leguminous plants including clover and alfalfa, several weed hosts, strawberries wild and cultivated, and several kinds of flowering bulbs. There is no significant difference in the appearance of this nematode in the different host plants it attacks, yet within many plants it forms strains or populations so specifically adapted to that particular kind of host that it will starve rather than feed upon another host. For example, the *Tylenchus dipsaci* population of hyacinth is said to be unable to attack narcissus effectively, and that of narcissus to be unable to attack hyacinth. In some cases where attempts have been made to induce a stem-nematode population to leave a normal host and take a second host, the nematode has been able to attack the second host for a time but has failed to reproduce there and, therefore, soon dies out. Recent work in Holland indicates that the Irish potato nematode population is able to migrate and thrive in some fifty non-potato hosts but fortunately the narcissus population appears to be somewhat "fixed"—that is, specifically adapted to its particular bulb host. A few exceptions are known and these are of great importance in bulb culture. There are several cases on record indicating that narcissus nematode populations occasionally infest onion and iris. Hodson\* has recently demonstrated that under English conditions the *maritima* plantain is a possible and probable host for the narcissus nematode. This plantain occurs in Oregon and occasionally contains *Tylenchus dipsaci* but its preference for salt marshes and open rocky beaches minimizes its possible economic importance as a harbinger of narcissus nematode populations. On the west coast important non-bulb hosts of this nematode are alfalfa, clover, and rarely strawberry among cultivated plants, and false dandelion (*Hypochaeris radicata*),

\*Hodson, W. E. H. The Stem and Bulb Eelworm, *Tylenchus dipsaci* (Kuhn) Bastian. A Further Contribution to our Knowledge of the Biologic Strains of the Nematode. The Annals of Applied Biology 18:83-97, 1931.

plaintain (*Plantago lanceolata*), Crepis, and wild strawberry among wild or weed hosts. Infestations of *Hypochaeris* are extremely common and severe. Attempts to make the populations of these wild hosts attack narcissus have not as yet been successful, but the work is not considered entirely conclusive. For practical purposes, however, we may conclude that the populations of these hosts are not likely to attack narcissus.

**Relationship of narcissus bulb diseases to other bulb diseases.** The commercially important bulb crops of the Pacific Northwest—narcissus, tulip, lily, and iris—represent three plant families—namely, the Amaryllidaceae, Liliaceae, and the Iridaceae. They are botanically distinct. It is not surprising therefore that the diseases of each are for the most part distinct and attributable to different kinds of causal organisms. For example, the leaf-spots of iris differ from those of narcissus; tulip-fire occurs only on tulip; the basal-rot fungus of narcissus does not attack iris. Recent studies at the Oregon Experiment Station indicate that the mosaic diseases of members of these families are distinct and unable to pass from one to the other. To this general rule, however, there are exceptions—for example, "Sclerotium rots" and "blue-mold rots." The same species of Sclerotium-forming fungus may attack any one of the three. Likewise the same *Penicillium*, or blue mold, may attack the bulbs when storage conditions permit, especially if the bulbs have been submitted to rough handling prior to storage. The economic significance of the fact that diseases of different bulb families are largely distinct is obvious and fortunate, for it greatly simplifies the handling of crop rotation where more than one kind of bulb is grown. This is especially true where the soil fertility is sufficient to permit the growing of one bulb kind after another.

## THE NARCISSUS NEMATODE DISEASE

The stem and leaf nematode, *Tylenchus dipsaci*, was first recognized to be a serious pest of bulbs about 1910. At that time it threatened the destruction of the narcissus and hyacinth plantings in Holland and the narcissus plantings in England. The damage this pest is capable of cannot be overestimated. The feeding of the nemas in the bulbs is accompanied by activities of decay-producing organisms and these in turn by mites, lesser fly and other pests. Attacked bulbs eventually rot. In short, nematodes, if left unchecked, can destroy a narcissus planting in two or three years. Absolute nematode control must be attained. The hot-water control methods described below must be applied to planting stocks at regular periods as a preventive. The danger of any cessation in the continuous application of control measures is illustrated by what happened comparatively recently in Holland. In former years nematode was considered under control, but in 1929 and 1930, according to van Slogteren\* the nematode again became a serious menace, ruined extensive plantings, and was literally out of control. This he attributes to the extensive importation of infested bulbs from countries outside of Holland and lack of care on the part of the growers in handling such bulbs after they arrived, together with, in some cases, an attitude more or less of indifference toward the suppression of eelworm infestations on growers' own premises. Control practices must be continued from year to year with the purpose of complete eradication of narcissus nematode.

\*Van Slogteren: Warm-waterbehandeling van Narcissen. Med. no. 37. Lab. voor Bloemb. Onderzoek Lisse. 1930.

**Symptoms.** The presence of nematodes is evidenced by brown "rings" in the bulbs, by the formation of yellowish raised areas in the leaf blades, and in severely diseased plants by prominent deformation of the leaves. The sequence and interpretation of these symptoms are discussed in the following paragraph; the general appearance of diseased bulbs and plants is shown in Figures 1, 2, and 4.

If narcissus bulbs, some of which contain nematodes evidenced by "rings," are planted untreated, the spring growth of these will show the presence of nemas by two kinds of symptoms. These represent old and new infestations. The bulbs which have well developed nematode rings in them when planted may be expected to produce weak, dwarfed plants with strongly yellowed or yellow-striped leaves. These yellowed leaves may be twisted or curled and contain several raised areas or "spikkles." The nemas do not all remain in the primarily infested bulbs but during early plant growth, especially when the shoots of neighboring plants are at or near the ground level, wander through adjacent soil areas and eventually enter the shoots of healthy bulbs, therein producing a second kind of symptom. This form of attack accounts for the spread of the disease in a planting. The movement of nemas in a planting is aided by surface water and splashing rains. It is the symptoms in the newly affected plants that are so difficult to detect. The leaves are of normal length and shape but may be a shade lighter in color. The nemas center their activities (feeding, egg-laying, etc.) in certain restricted portions of the leaves and these portions thicken and harden, forming the irregular swellings often referred to as "spikkles." This spikkle formation can often be more easily detected by feeling of a leaf than by merely looking at it. These new infestations are more readily discernible in the shade or on a cloudy day and it is for this reason that the Holland bulb workers carry umbrellas when roguing. During the early stages of foliage ripening the nemas wander into the bulb necks. At this time, moreover, nemas migrate from bulbs that have been killed and to plants previously healthy having mature foliage. In these they produce no foliage symptoms. The diseased areas of the newly infested bulbs are later evidenced as "rings" since the nemas reach these areas by passing down within the tissues of the leaf blade and are then at first confined to the bulb scales connected with the spikkle-bearing leaves. This restriction to certain scale leaves gives the rings their concentric appearance. Hence, too, the nematode bulb lesions always develop from the neck down, just the reverse of basal rot.

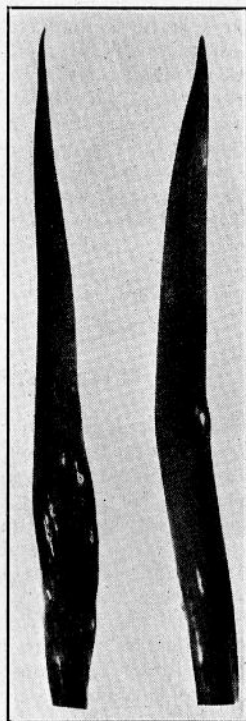


Figure 1. Nematode spikkles on King Alfred leaves. These are noticeably raised and are straw-colored.



**Diagnosis and detection of nematodes.** For positive diagnosis and warranted statement that parasitic nematodes are present in a planting one must find all symptoms in both bulb and leaf, or else base the diagnosis on the *finding* and *identification* of the nemas themselves by adequate microscopic test. The firm, yellowish, slightly raised areas (spikkles) which can be felt to be *within* the leaf, by gently stroking both sides of the leaf, are very characteristic. If bits of the spikkles are placed in a few drops of water for four or five minutes and then examined with a good hand-lens,\* and nemas are seen

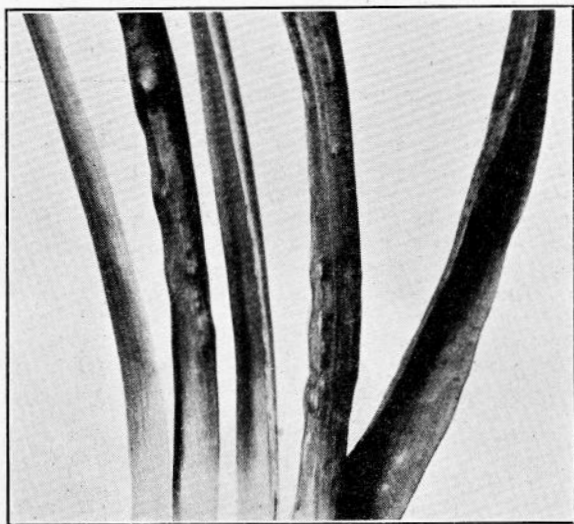


Figure 2. Nematode spikkles or galls on Campenellii-type narcissus. Note the distorted condition of the leaves.

threshing around in the water, the conclusion that parasitic nematodes are present is justified. On the other hand, if the leaves have aged and the spikkles have "cracked," the nemas may have wandered into other portions of the leaf or even along the outside of the leaf into the soil, making hand-lens confirmation difficult or even impossible. Different varieties of narcissus show different leaf responses to nematode attack. The thick-leaved forms are prone to develop prominent spikkles and to show strong leaf malformations when severely attacked. On these thick-leaved forms, especially those with dark-green leaves, the yellowed areas about the spikkles can be readily seen. The thin or "grass-leaved" types develop spikkles which cannot easily be detected even when the leaves are rubbed between thumb and finger. There is a slight graying or fading of the green in attacked leaves and the noting of this discoloration is of material aid in field inspection of the grass-leaved forms. The age of the plant affects the

\*A hand-lens magnifying 10 to 15 times is desirable for bulb work. Such lenses may be bought for from \$2 to \$10, the price ranging according to their optical corrections.



prominence of the symptoms but in most varieties they are seen best shortly after the blooming period.

The prominent hyalin mottle or coarse flecking which appears near the tips of the leaf blades as a result of hot-water treatment has no connection with nematodes and is not an indication of their presence. Certain narcissus varieties often develop elongated, gall-like, raised areas along the vascular bundles; these are generally of normal leaf-color and appear as though lying on the leaf rather than *within* the leaf; they originate from various causes but have no connection with nematode activities.

Diagnosis of nematode infestation from bulb symptoms must be made with great care. It is customary to cut consecutive descending slices of the bulb, beginning at the upper neck region. If these reveal the neck tissue to be white and clean throughout, one may conclude that nematode is not present,\* but, on the contrary, the presence of brown discolorations in the neck is by no means proof that *Tylenchus dipsaci* is present. Typical nematode "rings" are brown, not black. When a nema-infested bulb is cut lengthwise the discolorations are seen to extend down toward the base, not up. The lower edges of the lesions (rings) are irregular and do not have prominent margins. Basal-rot lesions arise from the base of the bulb and extend up; this fact and the presence in basal-rot lesions of white fungous mats between chocolate-colored scales enables one to differentiate the two. Certain other fungous rots enter from the neck region and extend downward. The decay produced by these soon blackens and may assume a parchment-like appearance. The margins of these lesions (as seen by longitudinal cuts or by peeling down the scales) are raised, even, and distinct. Still another kind of brown discoloration and incipient rot is

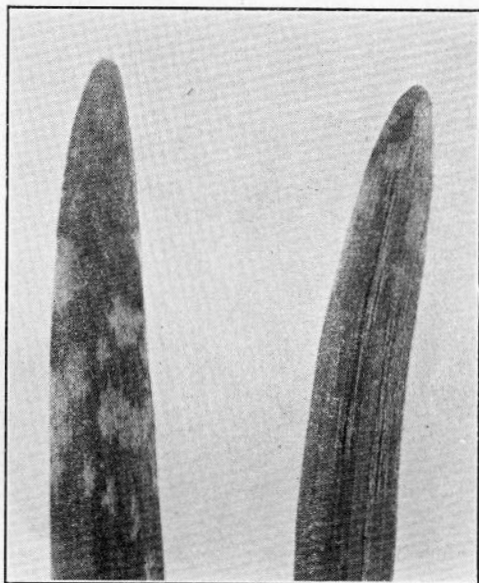


Figure 3. Chlorotic flecks and roughening on narcissus leaves caused by the hot-water treatment. Late treatment, temperature above 110° F., and dirty water increase this sort of injury.

\*In dealing with bulb stocks where many infested bulbs are found, apparently clean-necked ones may contain nemas in such incipient stages that they cannot be detected by this cutting test; hence it is necessary to treat all the bulbs of such a lot regardless of whether they appear clean or discolored.

produced in the upper part of the bulb necks by the chewing of *Tarsonemus* mites.

With practice one can recognize typical nematode rings but in doubtful cases one must identify *Tylenchus dipsaci* in the rings. This can be done only with a good compound microscope and by one who has accurate knowledge of the generic characteristics of *Tylenchus*. Diagnosis here differs from the leaf spikkle situation since the ring tissue becomes decayed tissue and is likely to contain harmless saprophytic nematodes commonly associated with normal processes of decay. An inexperienced person may easily mistake these saprophytic nemas for the *expected* stem nematode.



Figure 4. Rings in the neck portion of a nematode-diseased bulb. As a matter of fact, this bulb had both nematode and small scale-fleck fungus. When both occur in the same lot of bulbs careful microscopic tests are necessary to determine the positive presence of nematode, since either can produce rings in the bulb neck.

**Control of nematode.** Nematode control can be effected by a combination of (1) hot-water sterilization; (2) proper crop rotation; and (3) the use of common-sense sanitary methods in the handling of infested stock. Fortunately it is possible to heat the bulbs in water at such a temperature that most of the nematodes in all stages (eggs, young worms, and adults) are killed without at the same time materially injuring the bulb. In fact, the hot-water treatment, if applied at the *proper* time after digging, will cause no injury to the bulbs and usually none to the foliage. In the past, before basal rot was understood, the hot-water treatment sometimes induced severe secondary

injury by spreading basal rot, but this danger can be eliminated by the use of antiseptics within the hot-water bath, or by cold disinfectant dips shortly after hot-water treatment. Crop-rotation methods should eliminate the nematodes from the soil if care is taken in avoiding intervening crops susceptible to infestation by the narcissus strain of *Tylenchus dipsaci*. These points and suggestions for sanitation are elaborated in paragraphs below.\*

\*The details of control are discussed in circulars issued at intervals, Circular 55 of the Oregon Experiment Station being the most recent issue (up to 1932). Some of the points affecting the theory of control are discussed above.

**Advisability of roguing for nema-infested bulbs.** In American plantings where the row-method is preferred, cultivation tends to carry the nemas down the rows in the field and hence to spread the disease. This points to the desirability of early roguing—for example, when the leaves are about six inches high—the time field symptoms are first evident. Another reason for roguing is the fact that as maturity approaches the nemas migrate from obviously infested plants and infest previously healthy ones. In roguing nema-infested bulbs extreme precautions must be taken to prevent this operation from actually spreading the disease by scattering soil and debris likely to harbor the nemas. If the roguing is to be a success, not only the infested bulb but the two adjacent bulbs and the soil around them should be removed. So essential is this that the Hollanders have devised a special roguing tool fashioned like a section of stovepipe, which removes a cylinder of soil in which the bulb is included. For best results a disinfectant should be applied in the opening left by the removal of the bulb. Strong formalin (1 part formalin to 7 parts water) or kerosene may be used for the disinfectant. Some growers are considering the use of a powerful blow-torch designed for soil sterilization. This would permit "in place roguing" and eliminate danger of contaminating other localities by the removed soil. Under American conditions where land is plentiful and long-time rotations are feasible, field roguing is not so imperative as in Europe. For us the important roguing must be done in the storage house; there the infested bulbs should be sorted out both *before* and *after* treatment.

**Time of digging and time of treating.** Narcissus plantings where nemas occur should be dug early—that is, at the beginning of the ripening period rather than at the end. This is to minimize soil infestation and to reduce the amount of rotten bulbs that may be left in the field. The soft bulbs should be sorted out and destroyed as soon as possible after digging. In all stages of the handling of nema-infested stock one should take all possible sanitary measures to prevent infestation of healthy stock. This applies to both field and storage-house procedures. Kerosene washes are very effective for tools, crates, and sorting tables. To prevent the hot water from injuring the bulbs the time of treatment must be intelligently correlated with the time of digging. Two or three rules appear applicable. These are:

(1) Treatment should always be made before swelling of the basal-plate or other evidences of root growth become apparent. The earlier the variety, the sooner the treatment after digging. For example, Golden Spur should be treated before Emperor. Hot-water injury also correlates to some extent with the development of the flower.

(2) The treatments should therefore not be given before the flower bud has made visible growth.

(3) The earlier the bulbs are dug the longer the time that should elapse between digging and treating. But in early varieties such as Golden Spur this interval should be shorter than in late varieties. In the case of early bulbs three to five weeks should elapse; those dug in mid-digging season should be treated in three to four weeks; and those dug late may be treated within two or three weeks.

These statements are based on extensive (unpublished) work carried out at Oregon State College and other places.

**Hot-water treatment.** By hot-water treatment is meant the soaking of bulbs for three to four hours in water (or water plus an antiseptic) heated to 110° to 111.5° F. and mechanically circulated to insure even distribution of the heat.\* This treatment will usually kill the nemas in the bulbs without reducing the subsequent yield. In fact, when properly performed, hot-water treatment should increase the yield. The benefits accruing from the treatment are partly due to the destruction of mites and bulb-flies.

To insure success in hot-water manipulations certain precautions should be observed. These are: (1) Adequate circulation of water (and heat) should be provided by use of a propeller in the tank. (2) Care should be taken that the containers are not crowded. (3) Large bulbs should be treated for at least four hours and small planting stock for at least three hours at the specified temperature. (4) Since placing the bulbs in the bath lowers the temperature of the water, timing of the treatment must not begin until the water has reached 110° F. (5) The bulbs should be kept covered with water during the treatment. (6) The water should be changed frequently. It should be heated 20° or more after each bulb-load to sterilize the water before the next treatment. Narrow wire baskets designed to fit the tank make ideal containers, but these are expensive. Wooden bulb-crates are good. If sacks are used they must be open-mesh sacks, such as "onion-sacks" and *not* close-mesh sacks or "burlap sacks." Sacks should never be "packed full" but should be only partly filled. No matter what containers are used the bulbs should be entirely covered with hot water at all times during treatment. The inspection requirements state that a certified thermometer must be used. All such requirements emphasize the fact that the temperature must be 110° to 111.5° F. and that the bulbs must be kept at this temperature for the required time. Successful treatment requires strict attention to details.

There is some evidence that nemas associated with certain lots of bulbs that have received partly successful hot-water treatments may have developed a definite resistance to heat. When such cases as this are encountered it will be necessary to maintain a treating temperature of 114° to 115° F. In fact, certain lots of nematode-infested bulbs have been tested for which it was found that a three-hour treatment at a temperature close to 115° F. was necessary in order to insure complete disinfestation.

For best results, especially if the nema infestation is more than a trace, a disinfectant should be added to the water. There are two objects in this: (1) to prevent the spread of basal rot and (2) to increase the effectiveness of the hot water in killing the nemas. When first applied to American conditions, the hot-water treatment indirectly caused serious damage in the form of basal rot. Water heated to 111.5° F. is harmless to the basal-rot organism and instead of reducing basal rot acts as an excellent

\*The question of the proper temperature at which to treat bulbs in order to insure adequate nematode control is still under investigation. The recommendation given above is the accepted one, but as a result of the present season's work (1931-32) it may be necessary to recommend a higher temperature. Much research is likewise in progress on the selection of a proper chemical that will facilitate the killing of the nematodes and at the same time protect the bulbs from basal rot. At present we are recommending the use of formaldehyde for this specific purpose. Van Slogteren is likewise recommending formaldehyde. The present authors realize that formaldehyde is by no means ideal for the purpose since if the bulbs are not in the proper stage of ripening serious injury may result from its use. When a more fitting chemical or trade compound has been found and proved bulb growers will be at once advised.



medium for its spread. The adding of a proper disinfectant to the hot water not only will prevent spread of basal rot but will have a decided curative effect on those bulbs where incipient basal-rot lesions have begun. If the bulbs are supposedly free from nematodes and the treatment is given as a precaution and for fly and mite destruction, it is best to give the bulbs a chemical disinfection within a few hours after removal from the hot-water bath. Where the disinfectant is included in the hot-water bath, and this should be done if the nematodes are at all abundant, commercial formaldehyde (Formalin) at the rate of one pint to 25 gallons of water is the most suitable.\* Organic mercuries may be included in the bath or given as dips after the hot-water treatment. As stated above, any decayed bulbs that may be present should be sorted out both before and after the hot-water treatment. They should be removed before treatment to prevent unnecessary contamination of the hot water with both nemas and fungi. The hot water softens the bulbs and renders conspicuous those bulbs that were in a state of partial decay. These are worthless for planting purposes and should be removed. The disposal of culls, rotting bulbs, etc., often becomes a serious problem. If an efficient incinerator is available they should be burned. Burying the bulbs deeply and then covering them with waste oil is a good method of disposal. The throwing of the bulbs into a "bonfire" is an entirely unsatisfactory procedure and results in the accumulation of scorched debris which will furnish a favorable breeding ground for mites and flies.

The bulbs may be planted as soon after treatment as feasible. If more than a day or so must elapse before planting, the bulbs should be thoroughly dried. This drying must be carried out where there is no danger of contamination from infested stock. They should be spread out so that they will dry rapidly.

**Crop rotation in nema-infested fields.** It is important that treated bulbs be planted in uninfested fields and that the nematode be eradicated from those fields where it has occurred. This eradication can be accomplished by starving the pest out, utilizing the fact that there are many plants in which the narcissus strain cannot survive. Three years should elapse after *all* narcissus plants, including volunteers, have been removed from the infested area before narcissi are again planted. It is highly desirable that the area be fallowed the first year. This is important since it increases the chances of starving the nemas and permits ready removal of all volunteer narcissi. During the fallow period the land may be cultivated to good advantage. The choice of a crop to succeed the fallow period will depend on local conditions. With our present knowledge of the intricate problem of nematode hosts and fixed populations we advise against the planting of oats, onions, and bulbous iris as a second crop after the narcissus. Three years after *all* the narcissus bulbs have been removed from the infested area the land may be considered safe enough to risk planting narcissus again.

\*These recommendations are under constant investigation. When better methods are found they will be published in trade journals and circularized by various institutions. A more detailed discussion of our present recommendations is given on page 34 of this bulletin.



## NARCISSUS MOSAIC OR GRAY DISEASE

*Virus*  
Plant pathologists and experienced growers in both Europe and America have surmised for some time that the narcissus gray disease is a virus disease of the mosaic type. This opinion has been strengthened yearly by the recognition and investigation of similar mosaics in other plants, including *Hippeastrum*, a closely related member of the Amaryllidaceae, the family to which narcissus belongs.

Recent experiments\* at the Oregon Experiment Station have shown that the narcissus gray disease may be transmitted from diseased to healthy plants by "leaf mutilation"† and other mechanical methods generally applicable to mosaic diseases. In short, observations and experiments indicate that the gray disease is a true mosaic. The appellation Narcissus Mosaic, being descriptive, is therefore the preferred name for the disease.

Certain narcissus varieties, which when first developed produced desirable plants and flowers, have since deteriorated or run out. We now know that the mosaic disease became associated with many of these varieties early in the history of their development and that the weakening effects of the disease have been largely responsible for their subsequent decline. A conspicuous example of this is Sir Watkin, an old English production, for which the gardeners originally recorded consistently fine flowers. Present-day stocks of this variety exhibit irregularities of growth and flower quality, and these are in direct proportion to the percentage and severity of mosaic in the stock.

Mosaic occurs in all the major species groups of narcissus but is much more plentiful in some varieties than in others; in fact, there are some in which it is very difficult to find a single plant free from the mosaic taint. Examples of varieties in which mosaic is prevalent in the average commercial stock are Minister Talma, Cervantes, Weardale Perfection, Lucifer, Princeps, and Orange Phoenix. On the other hand, van Waveren's Giant, Tresserve, and a few others usually show a very low percentage. There is great variation in the amount of mosaic present in different growers' stocks of King Alfred, Emperor, Victoria, Golden Spur, and other well established varieties. An interesting point in the varietal distribution of the disease is the fact that certain comparatively new ones still in the novelty class show very high mosaic percentages. For example, we have seen stocks of Giraffe (1910), Venus (1907), and Jolyon‡ (1928) in which 100 percent of the plants were infected with mosaic. No satisfactory explanation has been given of the prevalence of the disease in some varieties and the comparative cleanliness of others. That the disease is seed-borne and thereby directly transferable during hybridization is not probable. A narcissus variety is technically a clone—the vegetative descendants from a single bulb. Since narcissus mosaic is bulb-perpetuated (see discussion below) it is obvious that the earlier in the development of the clone the infection is initiated the

\*McWhorter, Frank P. Narcissus "Gray Disease" is a Transmissible Mosaic, Florists Exchange 79: page 11, 1932.

†By leaf mutilation is meant the extraction of juice from a diseased plant and the subsequent rubbing of it into slightly scratched or otherwise mutilated leaf surfaces of a healthy plant. In many mosaics this procedure will transfer the disease successfully in up to 100% of the trials.

‡Jolyon was a very promising variety from a floristic point of view, but it has been discarded in this country since every plant was mosaic-diseased.

greater the proportion of diseased to healthy plants in the ensuing stock, provided adequate roguing has not accompanied the development of the stock. We have no proof as yet that the mosaic content of different varieties varies because of differences in susceptibility. Sufficient data are not yet available, moreover, to indicate whether narcissus mosaic results from only one virus. The variations in symptoms exhibited by individuals of the same variety are sufficient to suggest that the mosaic disease may result from a combination of viruses. This latter hypothesis further complicates attempts to explain the varietal distribution.

**Symptoms.** Narcissus mosaic affects all parts of the plant but produces symptoms sufficiently distinctive for identification purposes only on the leaves and flowers. These effects may be summarized as (1) loss of vigor, (2) changes in leaf color and shape, and (3) thinning and streaking of flowers. These effects are elaborated in the following paragraphs.

Mosaic-diseased plants in comparison with healthy plants show a decided lack of vigor. This is an important general symptom. Such plants as they approach blooming size begin to flatten out as though the diseased leaves lacked strength. The flower-stems and flowers are likewise weakened. Hence the poor keeping qualities of mosaic-diseased flowers. Conspicuously striped plants are noticeably dwarfed, but performance tests indicate that the shoots of even mildly diseased ones are reduced. A further evidence of weakness is the fact that when leaf-spotting fungi become active in a planting the mosaic-diseased plants are usually the first to succumb.

The virus affects the size and yield rather than the shape of bulbs. The yield of mosaic stock averages less than 75 percent of that of comparable healthy stock. Diseased bulbs and splits average smaller, a fact of great importance to the commercial grower who has to propagate a stock in which mosaic is present, since if he sells his best bulbs and plants only "splits" he will tend to increase the percentage of mosaic in his stock. The shape of diseased bulbs is not sufficiently characteristic to be of any practical use in roguing. For example, in recent tests at the Oregon Experiment Station it has been shown for the variety Sir Watkin that a

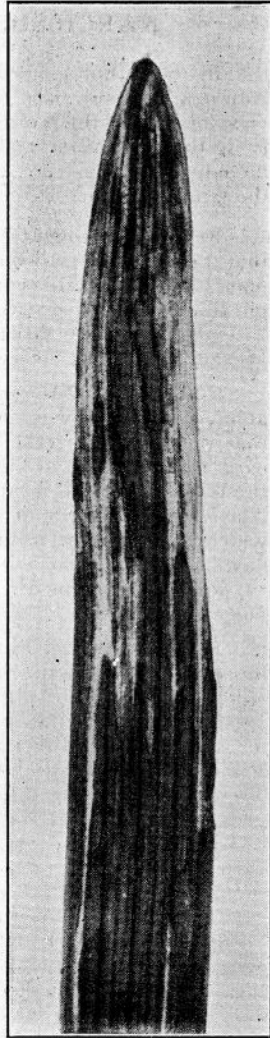


Figure 5. Mottled leaf typical of mosaic-diseased Minister Talma. In this figure the black areas are the normal green and the whitened areas are the yellow-green. The pattern or arrangement of these is characteristic of mosaic in this variety.

large percentage of the small, slender, long-necked bulbs from a known mosaic stock produce very severely diseased plants, but it does not follow that all small, long-necked bulbs are mosaic-diseased. The foregoing remarks on the effect of the mosaic disease on the vigor of narcissus plants emphasize the desirability of eliminating the disease from commercial plantings.

**Effect on leaf color and leaf shape.** The virus prevents the formation of the green coloring matter (chlorophyll) in portions of the leaves as they develop; therefore, the expanded leaves exhibit various mottles or stripes, produced by the resulting variations in the distribution of the chlorophyll. The unaffected, deeply pigmented areas remaining suggest irregularly shaped, blue-green islands surrounded by lighter-colored, faded areas. After the blooming period these primary leaf-color symptoms become less distinct and the green color of the leaf appears more evenly distributed. Such a decrease in green color contrasts is termed "masking" and is a common phenomenon in mosaic diseases. When thick-leaved varieties are severely diseased the contrast between the blue-green, island-like, pigment patches and the irregular or elongated diseased areas produces a conspicuous mottling or striping. In the thin-leaved forms contrasts are less marked and the disease is evidenced as a general graying and marbling effect usually without prominent mottle. Those varieties whose leaves are normally pale green offer weak contrast in the expression of leaf-color symptoms. As the plants age, the leaf-color discrepancies are accompanied by bronzing of the severely diseased areas in some instances and by a yellowing of these areas in others. This yellowing is often very prominent and is especially so in leaves where the faded areas are in the form of stripes. Because of the prominence of this yellowing the name "yellow stripe" has sometimes been given to this disease. Accompanying these leaf-color symptoms are effects on leaf surface and leaf shape. Diseased leaves frequently are conspicuously roughened and may develop gall-like, raised, elongated areas associated with the veins. A peculiar and characteristic twist of the leaves is a prominent mosaic symptom in certain varieties. For example, King Alfred and its hybrids, which usually

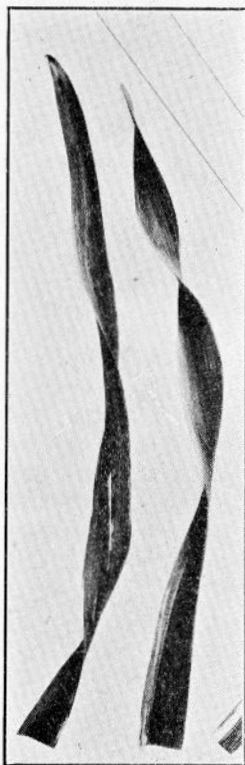


Figure 6. Leaves of mosaic-diseased King Alfred. Note the extreme curling and the few elongated white blotches.

show a marbled leaf mottle, although at times they exhibit prominent streaks, may throw their diseased leaves into a corkscrew-like position. Other varieties, as Sir Watkin, tend to bend in the plane of the leaf blade rather than to twist. This effect is more noticeable in the fleshy but relatively short-leaved forms. There is considerable variation in the kind and intensity of these color irregularities and leaf-shape effects, but the leaf

symptoms are as a rule sufficiently marked to permit diagnosis of the disease in a planting and to serve as a guide for roguing.

#### Effect on flowers.

Even more conspicuous than the leaf symptoms are the flower symptoms. Diseased bulbs continue to produce flowers, and may be forced, but the flowers are noticeably reduced in size and are of poor texture, the flower tissues being thinner. The stems of mosaic flowers average shorter. The mosaic-diseased flowers of most varieties, especially the strong yellow ones, develop very prominent hyalin streaks or translucent, cleared areas in the tubes and perianth segments. White-flowered forms are also streaked, but the effect is much less noticeable. The effects on the flower can be well seen in the varieties Weardale Perfection and Sir Watkin. This translucent streaking or clearing of flower parts is really the most distinctive symptom of narcissus mosaic.

#### Narcissus troubles confused with mosaic.

There are certain other markings and leaf disturbances that are sometimes mistaken for mosaic. Injury from hot-water treatment is evidenced by pale, more or less circular blotches accompanied by varying degrees of roughening of the leaf surfaces. This injury differs from mosaic mottle in that the latter is composed of smaller, more translucent blotches more or less evenly distributed throughout the entire leaf surface, while the hot-water injury tends to form bands across

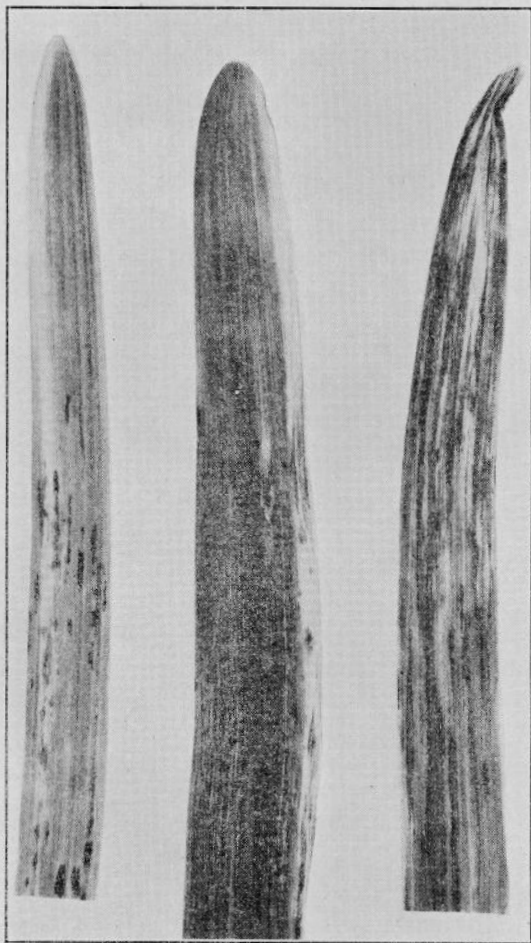


Figure 7. Effect of aging of the plants on narcissus mosaic symptoms. *Left:* Golden Spur leaf yellowed out. The bronzed areas show as black spots. *Middle:* Sir Watkin with roughened areas and whitened edges. *Right:* Minister Talma leaf now largely yellowed out. Pictures made shortly after the blooming period.



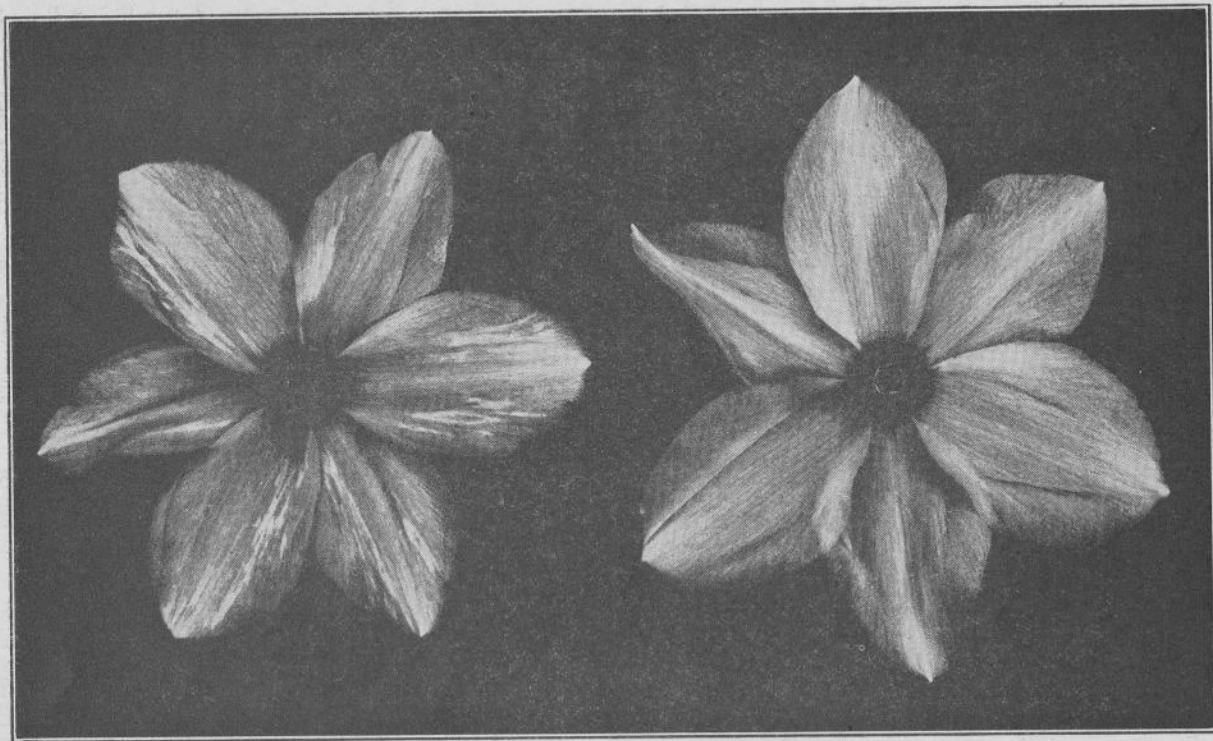


Figure 8. Effect of mosaic on Sir Watkin flowers. Healthy bloom at left, diseased bloom at right. Note white streaking on the diseased flower. (The tube has been removed to permit photographing the thinning of the perianth.)



the upper portion of the leaf. The stripe form of mosaic is entirely different. Hot-water treatment may produce notching and laceration of flower parts but it does not streak the flowers. A very few narcissus flowers, including those of the new variety Radio (1927), have irregular color distribution and display streaks not of mosaic origin, but simply white areas. They are not translucent as are the streaks in mosaic-diseased flowers. The peculiar condition known as "horse teeth," common in Victoria and a few other varieties, is not a mosaic disease. The breaking up of the bulb into tooth-like splits leads to the condition. True mosaic with a prominent leaf and flower mottle occurs in Victoria and in no way resembles the "horse teeth" condition.

Nematodes and the common bulb-mite (*Rhizoglyphus hyacinthi*) or combinations of these may cause yellowing of leaves and extreme leaf distortion, but these little resemble the effects of mosaic. On the other hand, the small narcissus mite (*Tarsonemus approximatus* var. *narcissi*), which feeds on the leaves, produces an effect often difficult to distinguish from mosaic. This is especially true when both mosaic and mite injury are present in the same planting and one endeavors to rogue out the mosaic plants. The *Tarsonemus* mite causes yellow streaks not unlike those of mosaic in appearance, but these are likely to be abundant in the leaf-base region. Mosaic streaking may occur on any portion but especially on the upper part of the leaves. For diagnosis one must endeavor to find the mites with a hand lens, though finding the mites does not eliminate the possibility of mosaic being also present. Severe losses have recently been reported where *Tarsonemus* mite and mosaic were both present in the same stock. Hot-water treatment will kill the mites, but it is of no aid against the mosaic.

**Spread of mosaic.** The history of various narcissus stocks and of certain varieties indicates that the disease spreads, but the natural means of spread has proved difficult to demonstrate. One record at Oregon State College, where experimental narcissus stocks have been maintained for several years, indicates a 25-percent increase during one year in a planting adjacent to a severely diseased field\*. Recent tests with permanent row plantings have shown decided spread within the row during a twelve-month period where infected individuals were planted between healthy ones.† Many growers have reported cases of spread of the disease in their plantings. It has been experimentally transmitted by leaf mutilation and other mechanical methods commonly used in mosaic investigations, but it has not been experimentally transferred by insects. The absence of a frequently present and likely insect vector complicates the problem of finding the natural method of distribution. A large number of experiments have proved that in the case of narcissus mosaic there is little danger of spreading the disease by picking the flowers. This statement does not apply to the mosaics of tulip and iris. It is presumed that narcissus mosaic may spread during cultivation, as for example by the breaking of intermingled roots. While the normal method of spread from diseased to healthy plants

\*This statement is based on observations made by Mr. M. B. McKay.

†A progress report on our natural field transmission studies of narcissus mosaic is given in the paper entitled "Narcissus 'Gray Disease' is a transmissible mosaic" cited above. In this paper it is pointed out that narcissus mosaic may be transmitted by roguing where the bulbs are closely planted, apparently as a result of the root mutilation which the roguing process necessitates.

remains in doubt, there is no question that the disease is perpetuated from year to year in the bulb. Every mosaic-diseased bulb may be expected to yield a similarly diseased or even more severely diseased progeny, and no fertilizer application or cultural manipulation has been devised capable of growing infected bulbs out of their diseased condition.

**Control.** Until we have satisfactorily demonstrated the exact methods of natural dissemination of narcissus mosaic we cannot formulate final recommendations for control. The nature of the disease is such that spray and disinfection methods are absolutely hopeless. On the other hand, roguing tests carried on by growers and numerous careful records at the Oregon Experiment Station have indicated the possibility of almost complete control. Control by roguing may be accomplished in two ways: (1) by removing diseased plants and leaving the good ones, a desirable method where only a small percentage of the plants are diseased; (2) by inverse roguing accomplished by selecting mosaic-free plants from partly diseased stock, a desirable method of starting foundation planting-stocks in varieties (or stocks) which show a large percentage of mosaic. Precautions and suggestions in regard to roguing are considered in the following discussion.

Roguing should commence as soon as the symptoms become evident, or, stated in terms of plant growth, when the leaves are about six inches high, have assumed a green color, and have recovered from the blanching effect produced by cold weather or early spring frosts. Leaf symptoms are very prominent just before flowering time. Final roguing should be made during the blooming period. All symptoms are then available, and those plants that at first appeared doubtful may then prove to be diseased. Roguing after the seed-pods have formed and the shoots are fully mature is difficult and impractical since the typical green-color symptoms may be masked by changes within the leaf or by the attacks of leaf-spot fungi, which are prone to attack mosaic-weakened leaves.

When dealing with a relatively inexpensive variety one should rogue both the diseased plant and the two adjoining. This recommendation is made since both general field observations and direct experiments have demonstrated that the mutilation of intermingled roots which roguing necessitates may serve to spread mosaic.

Where transplanting of healthy plants to form foundation-stock is practiced, one should do a thorough job of transplanting and not simply "heel in" the transplants. The bulbs should be planted to a depth at least equal to that from which they were taken, and the soil should be firmed around the leaves. This practice is aimed not only to effect continued growth of the bulbs during the season but to discourage inroads of flies and other insect pests. When a foundation-stock is started by the selection of clean, desirable plants, less than two to three percent mosaic should be apparent in the ensuing crop; roguing of these few remaining defectives and the adjoining healthy ones leads to an absolutely clean planting. The foundation-stock planting should be made at a reasonable distance from any narcissus known to contain mosaic.

The disposal of diseased bulbs is a serious problem where large plantings are being dealt with. Some growers hesitate to destroy mosaic-plants even though they realize that they are of inferior quality. In considering this question it is well to realize that many growers—at least in the Pacific Northwest—have thoroughly rogued their plantings and have started clean

foundation-stocks of varieties which usually contain large percentages of mosaic. As home growers and forcers become informed of the superior qualities of mosaic-free bulbs, they will insist on clean bulbs. The damaging effects of this disease are such that there is no excuse for leaving mosaic plants in the propagation stock of valuable varieties. The buyer, moreover, has every right to demand clean stock for his use.

## FUNGOUS DISEASES OF NARCISSUS BULBS

Rotting of narcissus bulbs may result from various primary causes, though the actual decay of the bulb tissue is brought about mostly by fungi. In some cases the development of these fungi is merely the sequel to some previous injury, caused by mechanical or environmental factors, or by other organisms such as parasitic eelworms, narcissus flies, mites, etc.

A considerable variety of fungi may develop on or in bulbs which have been cut, bruised, exposed to extremes of temperature, grown in wet soil, or invaded by other organisms of the types mentioned above. There are also several diseases of the narcissus in which well-grown and previously sound bulbs may be invaded by parasitic fungi, as a result of which either the outer scales or often the entire bulb may rot. In these cases a diseased condition having distinctive characteristics develops which is specifically associated with the presence of certain fungous parasites. Some of the most prevalent and destructive diseases of narcissus bulbs belong to this group, and special measures for protecting the bulbs against them are often necessary, whereas in the miscellaneous group of fungous infections prevention is largely effected by providing appropriate growing conditions, controlling the primary pests, and handling the crop with requisite care during all harvesting and storage operations.

The parasitic fungous infections of narcissus bulbs may be named and classified as follows:

A. Shallow scale rots and neck rots. Infected areas occur primarily in the outer scales or in the apex of the bulb.

1. Wet-scale rot or white mold. Caused mostly by *Sclerotium rolfsii* (including *S. delphinii*), or sometimes certain wood-rotting fungi.
2. Dry-scale rot or black-scale speck. There are two forms, the large and the small scale specks, caused by two slightly different fungi thus far known in nature only in the form of black specks on the scales.
3. Neck rot. This is in part the small scale-speck disease, and in part is due to infection of the leaf bases, passing into the neck of the bulb, by the parasitic fungi that caused the foliage diseases, smoulder and leaf scorch or fire.

B. Internal scale rots and basal rots. Infected areas occur primarily in the root plate and in the interior scales.

1. Soft rot. This is caused by the black mold *Rhizopus nigricans*, invading bulbs previously damaged by sunscald and overheating.

2. Basal rot. Caused by a species of the fungus *Fusarium*, and known also as *Fusarium* rot. Distinguished by its typical development in the root plate or base of the outer scales, or sometimes in the crevices between divisions of mother bulbs, and by the moist, chocolate-brown, internal decay usually destroying the bulb.
3. Root-plate rot. A dry, shallow decay of the root plate starting on the root-bearing surface but usually not penetrating into the fleshy scales. Color darker than in typical basal rot. This is the condition often termed basal rot in European writings on bulb diseases, whereas what is termed basal rot above is usually called *Fusarium* rot in Europe.

In the next section these diseases and the causal organisms are described in more detail; this is followed by a section on the disinfection of narcissus bulbs for preventing bulb rots.

#### A. SCALE AND NECK ROTS

1. **Wet-scale rot.** Infection of narcissus bulbs by *Sclerotium rolfsii*, or variant strains of this fungus, is of rare occurrence in Oregon but is not infrequent in warmer sections of the United States such as California and the Southeastern States. The same fungus also attacks bulbous iris and sometimes tulips in Oregon. The surface of infected bulbs is covered by a conspicuous coarse white mold. Several layers of the scales may be rotted through, the color of the decayed tissue being light reddish brown with white streaks and the texture moist or slimy, later becoming tough and woody on drying. There is an odor suggestive of rotting wood. Embedded in the rotted scales, lying between them, or sometimes borne on the superficial white mold, are small, round or oval, reddish-brown bodies which vary in size from that of a mustard seed to that of a small pea. Their surface may be either smooth or minutely pitted.



Figure 9. Sclerotia of the wet-scale rot fungus *Sclerotium rolfsii* on narcissus. (Enlarged.)

This fungus has a very wide host range, occurring on the following plants in addition to those already mentioned: garden iris, peony, delphinium, violet, calla, tomato sugar beet, muskmelon and many others. It is a soil inhabitant of warm regions, especially where the soil is light and often wet. It may be introduced in the form of the seed-like resting bodies or sclerotia, or in infested plant remains. Once introduced it is likely to persist indefinitely unless repressive measures are promptly taken against it, such as the thorough removal of infected plants, including all underground parts, and treatment of the soil with a fungicide, followed by the maintenance of a bare fallow or the use of a resistant cover crop (grasses, clover, cow peas) for at least two years.



On newly cleared areas in the Northwest a superficially similar fungous infection of narcissus bulbs has been observed which invests the bulbs with a coarse white mold but produces no sclerotia. This infection is due to one or more of the wood-rotting fungi that persist for a time in the fragments of roots and stumps remaining buried in the ground. Such fungi disappear as the wood decays completely and the soil becomes better aerated and drained, but occasionally plantings on newly cleared ground are materially damaged the first year of culture. The fungus *Armillaria mellea* seems to be responsible for most of the damage.

**2. Dry-scale rot or black scale speck.** Both types of scale speck diseases have been observed in narcissus bulbs in the Pacific Northwest. They occur generally wherever narcissi are grown, but the effects on the development of the plant are not definitely known.

The large scale-speck fungus is probably entirely saprophytic—that is, thrives only on the dead outer scales and does not injure living tissue. It is often found on forced bulbs. It forms flat black specks with a dull surface, about the size of a pin head, on the superficial scales. These specks are arranged in regular order like a check-row planting. No other effect than the development of these resting bodies or sclerotia is known. Even this is largely restricted to the bulbs of certain Bicolor Narcissi, such as Victoria, Princeps, Spring Glory, and van Waveren's Giant.

The small scale-speck fungus, when grown in artificial cultures, shows a very close resemblance to the parasitic fungus *Sclerotinia gladioli*\* which causes dry rot, one of the serious diseases of gladiolus corms, and also causes a scab or canker of crocus and freesias. It is very widely distributed and may occur on practically all types of narcissus bulbs including the Polyanthus group. It is frequently associated with small, poorly grown bulbs, but whether it is a factor in their retardation or merely finds bulbs of low vitality a favorable substratum for its development has not been ascertained. Like the large scale-speck fungus it is known in nature only in the form of sclerotia occurring on necrotic areas in the superficial scales, especially of the neck portion. Unlike the former, it is not limited to the



Figure 10. Golden Spur bulb seriously damaged with small scale-speck *Sclerotium gladioli* fungus. Note the extremely rough condition of the scale areas.

\*This gladiolus fungus formerly called *Sclerotium gladioli* has recently (1932) been shown by F. L. Drayton, working at Cornell University, to have a perfect stage belonging to the genus *Sclerotinia* to which genus belongs the brown-rot fruit fungus common in the Northwest. Mr. Drayton is continuing his investigations using the similar fungus found on narcissus.



outermost scales. It is occasionally found on dead scales several layers deep and it develops frequently on the dry upper portions of the fleshy scales after the leaves have been removed, sometimes extending well down

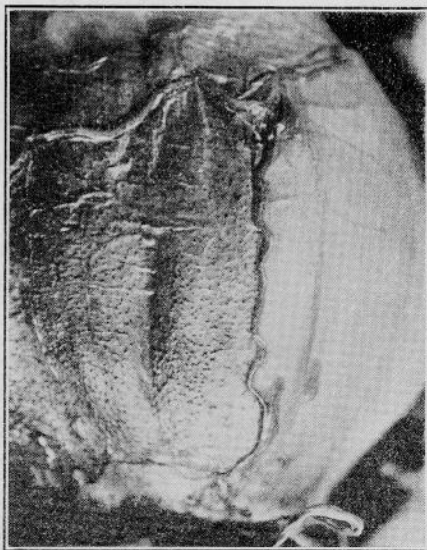


Figure 11. Scale lesion caused by the small scale-speck fungus. Note the tiny sclerotia and the prominent margin of the lesion.

into the bulb. It frequently accompanies nematode invasions and may itself form dead-tissue rings which superficially resemble nematode rings. The sclerotia are minute, scarcely larger than pin pricks, but are readily discernible with a hand-lens. The surface is shiny black. An abundance of moisture seems to be a prominent factor in the development of the small scale-speck, as it is most prevalent on bulbs grown in heavy, retentive soils, and it often develops copiously on bulbs planted wet after a hot-water treatment. There is a good deal of presumptive evidence that the small scale-speck is a parasitic disease, capable of seriously weakening the growth of narcissus under conditions which may be naturally somewhat unfavorable for the bulbs.

bodies of the leaf-scorch fungus, *Stagonospora curtisii*, may sometimes be found on the dead ends of the bulb scales in the neck. Other fungi, including *Botrytis narcissicola* which causes the "smoulder" disease, may also develop or overwinter in the necrotic terminal portions of the bulb scales, and the mite *Tarsonemus* and the eelworm *Tylenchus* may also produce flecks and patches of dead tissue in the neck region. Likewise chemical injury from the materials used for disinfecting the bulbs may affect the tissue and incite decay here. To this entire complex of necrotic effects the name neck rot may be given, but a precise segregation of the parts played by the various agents in this injury is beyond the purpose of the present writing. It suffices to note that diverse causes contribute to this condition, and since neck rot or soft neck may betoken the presence of dangerous pests, affected bulbs should be carefully excluded from high-grade forcing or planting stock. Furthermore, as a means of minimizing this defect, care must be taken to avoid violent injury to the neck in digging and cleaning the bulbs, which means of course that digging should be delayed until the foliage is in the process of naturally dying down, but not until it dies clear to the neck.

## B. INTERNAL SCALE ROTS

The deep-seated rot of narcissus bulbs resulting from infestation by *Tylenchus dipsaci* and other eelworms has already been described, and the character-

istic type of decay which follows infestation by the narcissus fly, *Merodon equestris*, is also easily recognizable from descriptions published in entomological treatises on narcissus pests. There remain for consideration the fungous rots, which have already been classified as soft rot, basal rot (*Fusarium* rot), and root-plate rot.

1. **Soft rot.** The condition designated as soft rot is a mushy type of breakdown which is chiefly brought about by excessive temperature, dense

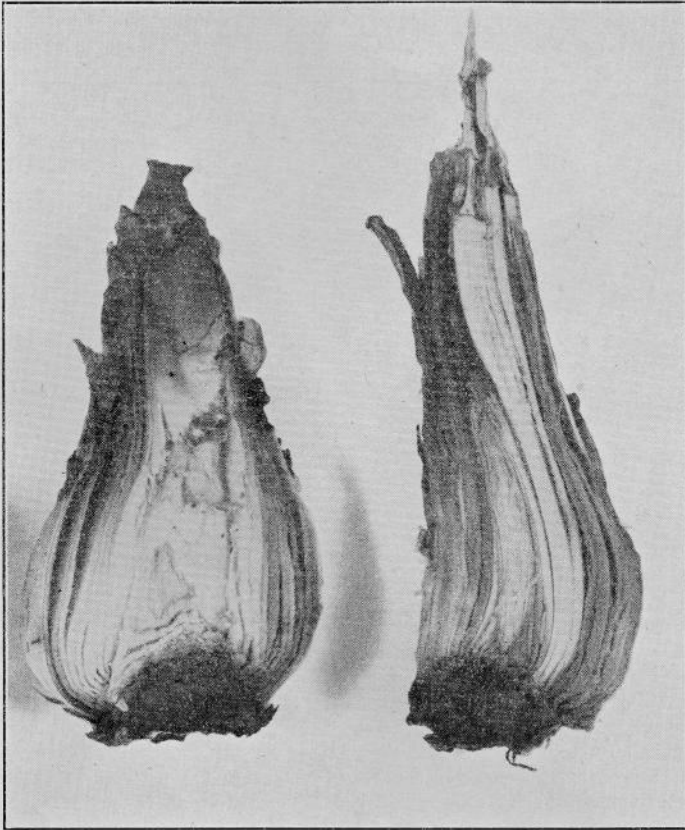


Figure 12. Narcissus bulbs affected with soft rot caused by a black mold (*Rhizopus* sp.). Note that the scales are only slightly discolored.

packing and lack of ventilation, permitting the development of the ordinary black mold, *Rhizopus nigricans*, which also causes decay of a number of vegetables under similar conditions. Excessive sunning of freshly dug bulbs, producing sunburn or scald, is one of the primary factors in causing soft rot, especially in *Poeticus* and similar non-dormant bulbs. Overheating during the hot-water treatment, and failure to spread the bulbs out prompt-

ly for cooling and drying after this treatment often leads to the development of soft rot as well as augmenting basal rot.

In soft rot the affected tissues have a soggy, dull appearance, and they readily disintegrate under pressure. When of recent occurrence, the decay has a yeast-like odor. A rather dense cobweb-like growth, of dirty grayish-white color, may cover the affected bulbs. Minute black specks enmeshed in this growth are the spore capsules of the fungus. As they dry, affected bulbs are reduced to mere shells, containing a brown powdery residue.

The presence of this mold is definite evidence that the bulbs have been exposed to overheating in some form. Except under very moist conditions,

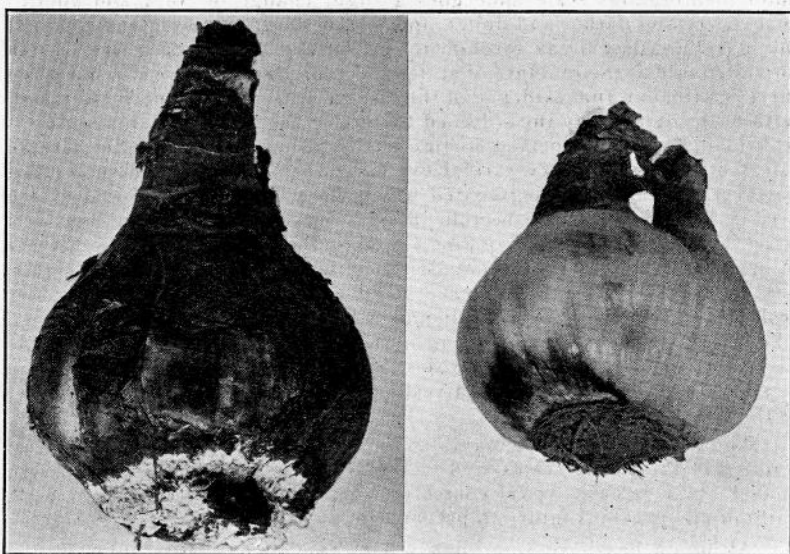


Figure 13. Basal or Fusarium rot. *Left:* External aspect, showing patch of mold at base of bulbs. *Right:* Early stage of infection, outer scale removed to show origin of rot at margin of root plate.

it does not develop to any appreciable extent at temperatures lower than 85° F., and it does not attack bulbs that were not previously weakened by overheating or injured mechanically. Prevention of soft rot is entirely a matter of avoiding the primary injury. Disinfection of the bulbs is useless because the mold *Rhizopus* is so generally distributed that even sterilized surfaces quickly become contaminated again by contact with the air and with various articles.

2. **Basal rot.** A second type of internal rot has been given the name basal rot by growers, because the decay usually begins in the root plate or at the base of the scales (Figure 13), and thence spreads through the inside of the bulb, showing generally a preference for the central portions. After infection has begun at the base of a scale, extension of the rot is more rapid within this scale than across the faces of successive scales, but the

fungus is capable of spreading in all directions, so that in highly susceptible varieties the decay progresses along all fronts. In partly resistant varieties such as Sir Watkin, and sometimes King Alfred, the decay tends to advance in streaks and layers, with healthy tissue intervening. The rotted tissue has a characteristic chocolate-brown or purplish-brown color, and the mycelium or vegetative body of the fungus appears as a web of delicate white or pinkish-white threads between the scales. The tissue is softened, though less so than in the soft bulb rot, but in the early stages it is difficult to detect the rot merely by feeling the bulb. Later, affected bulbs become readily detectable by touch, but the rotted tissue remains somewhat dry and spongy. There is usually no slimy or mushy breakdown. The outer membranous scale undergoes a slight change in color and appearance, becoming darker and duller, and in a moderately humid environment the mycelium may break through to the surface, producing a small patch of white mold at the juncture of scales and root plate (Figure 13), but often there is little external evidence of the disease until it is advanced sufficiently to be recognized by the softened texture of the bulb. For this reason it is difficult, even by repeated sorting in the ordinary way, to eliminate all infected bulbs. If a very careful examination is made of the root plate, however, and all bulbs segregated which show few, shriveled and discolored roots, together with necrotic pockets in the root plate or especially along its margin—i.e., the root ring—most of the diseased bulbs, even those in incipient stages, can be removed. In critical cases, as with small numbers of valuable bulbs, it may even be advisable to strip off the dry outer scale and examine the fleshy scale underneath for evidence of initial decay. The object of such careful sorting is to segregate the bulbs showing the earliest stages of infection because it is possible by chemical disinfection or special storage treatment to arrest the decay and prevent the entire loss of the bulbs.

The same type of rot may also enter the bulbs through mechanical injuries in the fleshy scales, and in the crevices between the divisions of mother bulbs, but the typical course of infection is through the basal plate, without any previous injury to prepare the way.

Although basal rot is primarily a disease of narcissus bulbs during storage or transit, in warm regions it may develop during the later stages of growth in the field, and more or less destroy the bulbs before they are dug. As an accompaniment of the bulb infection, the tops turn yellow and die down in advance of normal maturity. Sometimes slightly infected bulbs survive storage and are planted again, but the rot eventually resumes activity and a generally stunted development of the plant results, the leaves being short and a pale yellow green; there is little or no root growth. (See Figure 14.)

Basal-rot infection is dependent upon a moderately warm temperature, (about 70° F.) and is greatly advanced by still higher temperatures (80° to 90° F.) such as bulbs may be exposed to when they are dug in warm weather and are left lying on the ground or are gathered into burlap bags and not removed at once to a cool, well-ventilated place. For this reason it is sometimes supposed that basal rot, like soft rot, results entirely from overheating. It is, however, a very different sort of disease. It is caused by a parasitic, soil-inhabiting species of *Fusarium*, the botanical name for a group of fungi among which there are many plant parasites. Although the



species causing basal rot is very similar to certain other members of the group, it appears to be specifically adapted to the narcissus and is not known to attack any other flowering bulb; on the other hand, among the different species of *Fusarium* which infect potatoes, onions, cereals, and many other plants, very few are capable of infecting narcissus bulbs and none have been found which produce the identical symptoms of basal rot.

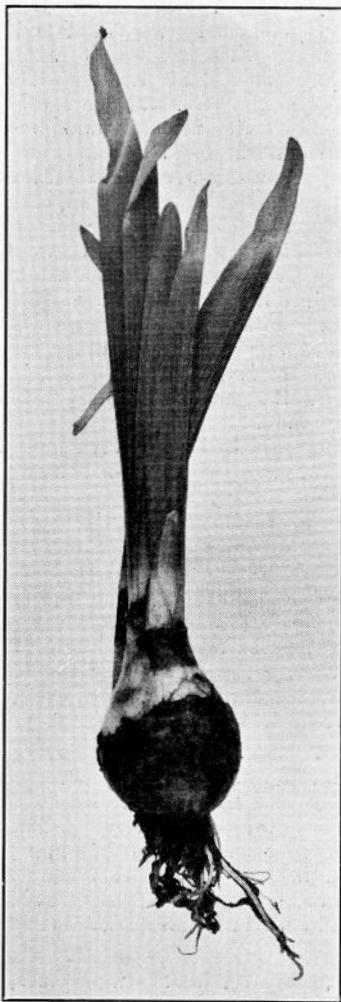


Figure 14. Effect of basal rot on foliage and root growth. The bulb appeared to be sound when planted, but it was already obscurely infected with basal rot.

The basal-rot *Fusarium* is probably introduced into narcissus plantations originally in infected planting stock, but it can persist thereafter for an indefinite time by living on plant residues in the soil. This is the saprophytic phase of its life cycle. The parasitic phase begins when narcissus bulbs of susceptible varieties, which are planted in the *Fusarium*-infected areas, come into contact with the organism. Climatic and soil factors, and the conditions of culture surrounding the bulbs, doubtless greatly influence the beginning of the parasitic phase. Among such factors is the soil temperature which may determine whether or not infection occurs. If it averages as high as 75° to 80° F., the bulbs are likely to rot completely in the ground. If the temperature is only periodically above 70° F., incipient infections through the roots and basal plate develop, comparable to the course of infection under average field conditions in warm sections of the country, and the bulbs may either keep or rot in storage depending on the temperature, moisture and other conditions prevailing there. When the soil temperature remains as low as 60° during the maturing period, the roots and bulbs remain healthy even in contact with infested soil.

This effect of soil temperature on basal-rot infection explains at least in part why narcissi grown in the light warm soils of the Atlantic Coastal Plain, and maturing during the relatively warm periods of early summer, are so subject to this disease, whereas in the Pacific Northwest there is almost no rotting of bulbs in the field and but little ordinarily in storage. During exceptionally warm seasons even here the amount of infection contracted during the last stages of growth may be considerable, and

when the bulbs thus exposed are further subjected to warm storage conditions, or are shipped to sections of the country where high temperatures may prevail well into the narcissus planting season, the incipient infections in the bulbs resume development and the bulbs may rot entirely within a few days. For this reason it will not suffice that bulbs produced in the Northwest merely keep through the storage season here, with perhaps insignificant losses from rot, but they must be grown initially as free as possible from latent infections which may destroy them as soon as the requisite environmental conditions are encountered. *It can not be emphasized too strongly that basal rot is not solely a problem for growers of narcissus bulbs in regions of warm summers and light soils; it is almost equally a problem for growers in more favored localities who expect to market their bulbs where exposure to warm conditions can generally be expected.*

Basal rot chiefly affects the large trumpet types of narcissi, especially the bicolors and white trumpets. Some of Poeticus varieties also are very susceptible to this rot, but most of the Incomparabilis, Barri, and Leeds varieties are resistant, or at least do not ordinarily rot under circumstances in which the trumpet types break down badly. The Poetaz and Jonquilla types are highly resistant and offer no problem in keeping throughout the storage season. The Polyanthus types are practically immune. Among the trumpet narcissi it has been generally supposed by growers that King Alfred and similar "hard bulb" types were not susceptible. This appeared for a while to be the case but in recent years heavy losses from basal rot have occurred in this variety. It may be said of the yellow trumpet narcissi as a whole, that no variety is immune but certain ones, Minister Talma for instance, are very resistant. The amount of damage actually occurring in any particular instance is influenced more by the recent history

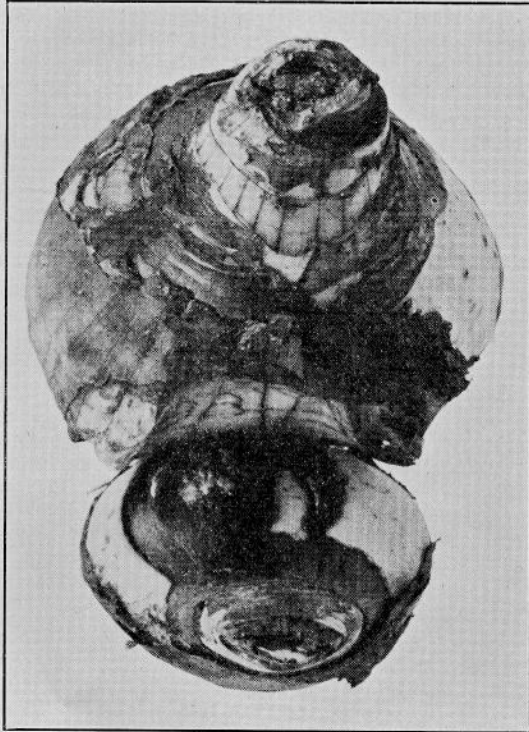


Figure 15. Basal rot of a type that may develop in storage or transit. Note the incipient lesion developing between the bulbs.

of the stock—i.e., whether hot-water-treated or not and if so whether without an antiseptic—and by the conditions of cultivation and storage, than it is by the variety. Among the bicolors of the commoner varieties, only *Empress* shows any marked degree of resistance, though *Glory of Sassenheim* is noticeably less susceptible than *Victoria*, *Spring Glory*, and *van Waveren's Giant*.

As an example of semi-resistant varieties suffering from basal rot when exposed to contamination through careless manipulation of the hot-water treatment, it has been noticed that certain stocks of *Sir Watkin* have become addicted to rot. It is relatively easy, however, to overcome this tendency in such varieties by appropriate disinfection methods. Even in a rather susceptible variety like *Emperor* the inclination to rot has been practically eliminated from stocks that were initially badly diseased by persistent disinfection for two or three years. Considerable progress along this line has been made in the still more susceptible bicolors, but though the indications are promising for continued improvement, it is not yet demonstrated that stocks of these varieties can be maintained virtually free from rot under adverse conditions.

In attempting to prevent or control basal rot it is presumed that the grower will follow the cultural practices detailed in numerous treatises on narcissus cultivation, and adopted by the leading commercial growers. These include the selection of the most propitious available planting site, deep and thorough preparation of soil, correct depth of planting, and digging at a proper stage of maturity. After the bulbs are dug, the grower will of course protect them against unnecessary sunning, will handle them carefully to avoid cutting or bruising, will not keep green bulbs in deep or unventilated crates or in bags beyond the minimum feasible time, and will store them where they can be kept dry and cool, adequately ventilated, and subjected to the least possible disturbance during this period. It is also presumed that the cleaning and sorting process will be carefully carried out so that defective bulbs of all sorts may be excluded as far as possible from the planting stock. It is particularly important that the sorting out of rot-infected bulbs be thorough if the bulbs are to be hot-water treated, as this precaution will keep sources of fungous contamination at a minimum during the cooking process and in ellworm-infested stock will get rid of the bulbs that are most difficult to sterilize. Bearing in mind the tendency for wet bulbs, when densely packed, to hold and develop heat, and the fact that overheating predisposes to rot, the grower will handle hot-water-treated bulbs with a view to cooling, drying, and aerating them as promptly as possible. Even with these precautions he may lose many bulbs from basal rot, since the control of this disease often requires active steps to destroy, not merely reduce to a minimum, the existing contamination. This subject will be dealt with in a subsequent section on disinfecting narcissus bulbs.

**3. Root-plate rot.** In almost any crop of narcissus bulbs some are found with irregular bases and poorly developed roots. Such defects commonly originate in mechanical injuries due to accidental splitting of divided bulbs, irregularities in planting, and breakage of roots caused by the heaving of frozen ground. They are most prevalent in bulbs grown in heavy, wet ground, and when narcissi or other flowering bulbs are planted on the

same land at too close intervals. The common bulb-mite *Rhizoglyphus* may invade and enlarge the injured areas, and various fungi may cause minor decays, most of which do not penetrate through the root plate. Besides these miscellaneous factors in causing "bad cases," at least two fungi parasitic on the roots of narcissi have been described, and others are known. The symptoms produced by the different kinds of fungi are not distinctive, but the roots become discolored and die prematurely, and more or less extension of the decay into the root plate may occur. In the aggregate these root-plate rots may cause an appreciable loss of bulbs and retardation of the rate of increase. In addition to correcting the cultural conditions which promote these root defects, it is advisable to practice periodic disinfection of the planting stock, since improved growth usually repays many fold the cost of this operation.

## CHEMICAL TREATMENTS FOR NARCISSUS BULBS

There are two periods at which fungicidal treatments to prevent bulb rot may be given, and there are several methods of applying the fungicide as well as a considerable choice of materials. The preferred time for treating is in the fall just before planting, but narcissus bulbs may also be treated, with satisfactory results under certain conditions, before placing them in summer storage.

One general precaution should be observed in applying any fungicidal treatment. The bulbs must be mature, firm, and as nearly dormant as possible. If the tops are at all green so that succulent tissue is exposed in the neck of the bulb when the leaves are removed; if the scales are soft and moist, or are mechanically injured; if live roots still persist or if new root growth is beginning, more harm than good is likely to result from chemical treatment. It may sometimes be necessary to treat soft bulbs, or those having loose necks and possibly more or less scale and root-plate rot already active, in order to save a stock from complete loss. In these circumstances one can not expect perfect results. He must choose between the probable loss of the stock from rot or a treatment which involves some risk of chemical injury. It has happened more than once, however, that stocks threatened with extinction have been brought back to a fair state of health by fungicidal treatments, and while this possibility remains such treatments must be conceded a legitimate place even though they are occasionally ineffective or even injurious. The methods involving the graver risks will be specifically indicated.

**Disinfection processes in connection with hot-water treatment.** An explanation has already been given of the manner in which the hot-water treatment often serves to spread and increase basal rot, the reason being of course that the temperature attained during the cooking process, though sufficient to kill animal life, scarcely affects fungi at all, while the prolonged soaking process not only activates latent fungous lesions but distributes fungous spores from bulbs bearing incipient rot lesions generally throughout the stock and provides favorable conditions for these spores to cause infection.



The most strikingly favorable results from chemical treatments applied to narcissus bulbs have been secured in connection with the hot-water treatment. In experiments, the bulbs that received certain chemical treatments far out-yielded those that had only a hot-water treatment or no treatment at all. Earlier and more vigorous foliage growth, normal or sometimes superior flowering, better root development, a longer growing season, an increase in total production, and a marked increase in bulbs of the larger sizes, all have been noted as resulting from the combination of heat and chemical treatments. The treatment may be carried out in either of two ways: (1) the fungicide may be added to the water in which the bulbs are heated; (2) the bulbs may be given the hot-water treatment in the usual way, after which they are given a short treatment in the fungicide. It will be obvious that because of the length of exposure (3 to 4 hours) in method 1, the concentration of the fungicide will be less than in method 2, where the chemical treatment is for only a minute or two.

Numerous experiments have been conducted to determine what kinds and concentrations of fungicides are best for treating narcissus bulbs, but so many variable factors have had to be accounted for, including the variety, the date of treatment and the inherent differences in the bulbs from year to year, that a final answer is not yet possible.

One of the treatments that proved very successful in the experimental trials, and one that has been rather thoroughly tested by commercial growers with generally successful results, is the use of the organic mercury Ceresan at the rate of 1 pound to 25 gallons of water; or, if the capacity of the tank is known in cubic feet, this figure multiplied by 0.3 gives the number of pounds of Ceresan required. The toxic component of Ceresan is completely soluble in water at this concentration, but a large proportion of insoluble inert material remains in suspension. From the standpoint of effect on the bulbs, the best results with Ceresan added directly to the water have been obtained when there was no mechanical agitation to keep the inert material in suspension. In a few cases where chemical injury occurred, it seemed that it might be associated with the deposition of the inert material between the scales in the neck of the bulb. If the bulbs to be treated have open or loose necks, it may be advisable to make up the Ceresan solution in a barrel, at a concentration of about 1 pound to 10 gallons of water, let the inert material settle after thorough stirring, then carefully pour or dip off the clear solution to use in the treating tank. Water should be added to make the dilution 1 pound to 25 gallons, after which the treatment is then managed in all respects the same as if water alone were used. As the chemical weakens somewhat with use, the concentration should be approximately maintained by adding more solution of the same strength as that in the tank, in order to restore the original level after each batch of bulbs is treated. The same solution may be used for 4 to 8 successive treatments before an entirely fresh solution is required. Ceresan powder should not be added to the solution during or between treatments.

Another fungicide that has given generally satisfactory results in connection with the hot-water treatment is formaldehyde, but in some instances this has retarded and sometimes injured the growth of the bulbs. The addition of formaldehyde, however, contributes to the effectiveness of the treatment against ellworms, and if the bulbs are treated at a proper stage does not involve any greater risk than is inherent in the hot-water

treatment alone. The recommended dilution is 1 or 2 pints of Formalin (commercial formaldehyde solution, containing 37.5 to 40 percent formaldehyde gas) to 50 gallons of water\*. If the capacity of the tank is known in cubic feet, multiply this by 0.15 for the 1-pint to 50-gallon dilution, or by 0.3 for the 2-pint to 50-gallon dilution. The weaker dilution is intended for soft varieties of bulbs in poor condition, the stronger may be used for varieties having hard bulbs in good condition. The original level of solution in the tank should be maintained by the addition of formaldehyde solution of the stated dilution.

If one prefers to apply the fungicide in a second stage following the hot-water treatment the following procedure should be employed. There is some doubt as to how long an interval should elapse for the bulbs to drain and cool after removal from the cooker, before they are treated chemically. The chemical treatment may follow as soon as the bulbs cease to drip, but it seems preferable to wait about two hours. After the chemical dip the bulbs should be planted at once, or spread out to dry. The recommended formulae are:

1. Use 1 pound Ceresan to 8 gallons of water. Any sort of container may be used, but a large barrel is very convenient. Dip the bulbs for 1 to 2 minutes, then let the surplus solution drain back into the vessel, after which the bulbs may be planted out, or dried. The ordinary form of Ceresan may be used for this purpose, and it had best be kept suspended in the liquid by occasional stirring.

2. Calomel (mercurous chloride) may be used in the same manner and at the same rate as Ceresan. It is a particularly safe chemical to use in this way. It must be in the finely powdered form and must be stirred frequently so that the chemical will remain in suspension. Calomel of various grades of fineness is on the market, but for this purpose one should specify the grade with very fine particles especially prepared for fungicidal purposes.

3. Either formaldehyde or corrosive sublimate solution (mercuric chloride) may be used for disinfecting bulbs after the hot-water treatment. The latter corrodes metals and hence should be used only in wood or stone vessels. The treating time should be about 15 minutes. The recommended concentrations are:

Formaldehyde, 1 pint to 12½ gallons of water.

Corrosive sublimate, 1 ounce to 6 gallons of water.

**Disinfection processes independent of hot-water treatments.** Fungicidal treatments may be given apart from the hot-water treatment. In fact, it is by the yearly repetition of such treatment that it appears possible largely to free a stock of basal rot and root-plate rot. For this purpose the concentrations of the various fungicides as specified for the dip treatment following the hot-water treatment should be used, but the time of treatment should be increased to 2 to 5 minutes with Ceresan or calomel, which

\*On page 15 the use of Formalin for the purpose of making the hot-water treatment more effective against nematodes is discussed. Where nematodes are known to be present a strength of not less than ½ percent (1 pint to 25 gallons) is recommended. The foregoing discussion refers to the use of Formalin to prevent the spread of basal rot—in other words, as an antiseptic. For this purpose a minimum strength of ¼ percent (1 pint to 50 gallons) is recommended.

are specially recommended, and to 30 minutes to 1 hour with formaldehyde or corrosive sublimate. The usual precaution to treat only thoroughly dormant bulbs should be observed, and it is preferable to plant the treated bulbs at once.



Figure 16. Leaf scorch or "fire" of narcissus, variety Barri Conspicuus. Caused by the fungus *Stagonospora curtisii*.

Although the most satisfactory time for disinfecting narcissus bulbs is at the end of the summer storage period, it may be desired at times to give this sort of protection during the storage period. This procedure is still under experimental trial and is not recommended except where a stock of bulbs is so threatened with basal rot that it may otherwise be lost. In most of the tests which have been made with this method, the amount of rot was reduced to a small fraction of that in comparable untreated stocks, and in some cases the flowering and general growth of the treated bulbs was all that could be desired. In several instances chemical injury to flowers was sufficiently marked to discriminate against the treatment except as a means of saving bulbs. The procedure is as follows:

The bulbs should be well matured, dry and clean. Round bulbs and bulbs from which flower stems have not been picked have tighter necks and are less subject to chemical injury at this point than double-nosed bulbs or those from which flowers have been picked. The bulbs may either be dipped into Ceresan solution, 1 pound to 10 gallons of water, for 1 to 2 minutes, then spread out at once in a cool, well-ventilated place to dry; or they may be dusted with Ceresan dust diluted with 3 parts of talc or hydrated lime. The talc and Ceresan must be very thoroughly mixed. The dusting process may be carried out by shaking the bulbs and dust, at the rate of 1 ounce of dust to 1 peck of bulbs, together in a heavy paper bag, or by rolling them in a barrel until well coated. A few minutes' agitation suffices. The bulbs should be spread on a

screen and the surplus dust shaken off before they are returned to storage.

### FUNGOUS DISEASES AFFECTING NARCISSUS FOLIAGE

**Smoulder.** The developing shoots of narcissus sometimes show a blighted or deformed condition as soon as they emerge from the ground.

The leaves are crumpled as if unable to expand and separate, and brown streaks appear on the tips or along the margins, on which black crustose bodies develop. A felt-like growth of fungus filaments and spores may be present on those bodies during wet weather. In Holland this disease is known as Smeul, and in England as Smoulder. Most growers are familiar with the condition, which is widespread in America but not ordinarily of serious importance. At times, however, the uniformity of a stand is considerably reduced, and in plantings which stand for two years, a number of plants may be lost, as affected individuals seldom amount to much. The disease is caused by *Botrytis narcissicola*, a fungus related to the one which causes tulip fire and lily blight. The fungus is introduced on infected planting stock, in the form of black, granular sclerotia, somewhat larger and thicker than those of the large scale-speck fungus, and these bodies may develop on the surface of or between the outer scales. Careful sorting to exclude infected bulbs from planting stock, and the avoidance of low, wet sites with heavy soil and subject to frosts and persistent dews, are recommended for overcoming this difficulty. The disinfection methods advised for control of bulb rots have usually afforded no appreciable control of this disease (Figure 18).

**Leaf scorch.** In this disease the leaf tips appear blighted upon emergence, somewhat as if injured by frost. The blighted area may extend down one-third or more of the length of the leaf, and is separated from the healthy basal portion by a definite margin. Within the necrotic tissue minute fungus reproductive bodies form, which erupt through the surface on either side of the leaf, and which appear as minute, round or oval, reddish-brown pustules when examined under a hand-lens (Figures 16 and 19). During wet weather spores are released from these pustules, which spread to adjacent plants, chiefly by the spattering of rain, and there cause secondary infections. The latter are elliptical, round or irregular, raised spots of a distinctive reddish-brown



Figure 17. "Smoulder" disease of narcissus shoots caused by *Botrytis narcissicola*.



color. Such spots may coalesce, resulting in the killing of considerable areas of leaf tissue. In severe infections the foliage may die down several weeks in advance of normal maturity. This disease has been given the name leaf scorch in England. It is caused by the fungus *Stagonospora curtisii*. The means by which the fungus survives from year to year is not fully known, but it may evidently be carried on the bulbs used for planting, since the plants that show primary infections are very irregularly distributed in a field. The fungus also has been found in the sheathing bases of leaves as they issue from the bulb. The fungus is also harbored in the dead foliage of naturalized narcissus plantings, and the disease is sometimes severe in such plantings which remain undisturbed for a number of years. There

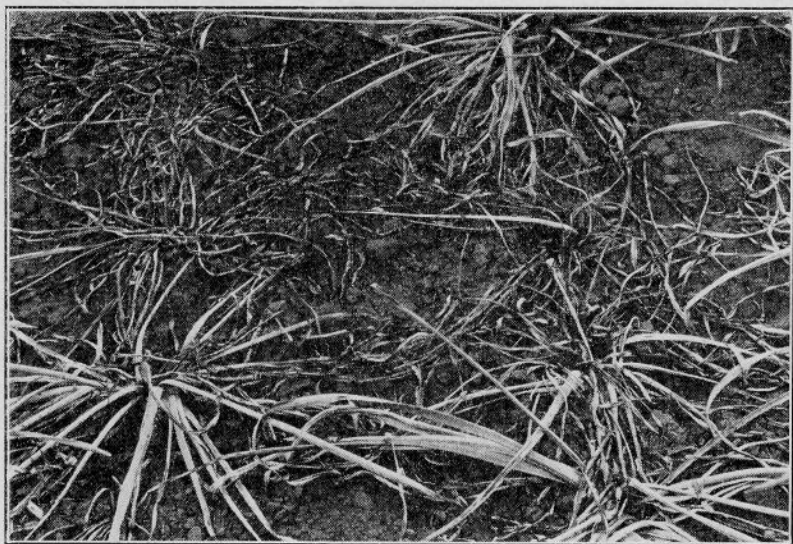


Figure 18. General appearance of Leedsii narcissus plants severely diseased with *Stagonospora*.

are marked differences in varietal susceptibility, the varieties most affected being Polyanthus types, especially the Chinese Sacred Lily and Soleil d'or, and also certain Leedsii and Poeticus sorts commonly used for naturalizing. Among the trumpet narcissi Sir Watkin and King Alfred seem to be most frequently infected. It has been observed that plants which have been weakened by mosaic are particularly susceptible to attacks by this fungus. The disease is most prevalent in warm and humid regions, and the same fungus also causes a leaf-spot of the *Amaryllis*.

Field observations indicate that disinfection of planting bulbs in formaldehyde or corrosive sublimate solution appreciably reduces the amount of primary infection. Dusting the foliage when wet with dew, or just before a rain, with copper-lime dust as used for potato blight control, or spraying with Bordeaux mixture, will largely prevent secondary infection. The annual change of planting site in commercial bulb culture, and the

removal of mature foliage in naturalized plantings before it disintegrates in the ground, will suggest themselves as additional control measures.

**Ramularia-blight.** Advanced stages of *Ramularia*-blight may be readily distinguished from all other narcissus troubles by the presence of conspicuous masses of fluffy-white spores covering the upper portions of affected leaves. These spores are produced by the fungus *Ramularia vallisumbrosae* Cavara. When plants come up through soil that harbors the fungus the leaf-tips are browned in a fashion that can hardly be distinguished from the *Stagonospora* leaf-spot described above. The browned leaf-tips and green tissues below these later become so covered with white spores that if one walks through an infected planting one's clothes become actually whitened with the spores. Close examination of such leaves with a hand-lens will show the presence of small, round, black or greenish bodies embedded in the leaf surface beneath the white spore masses. These bodies are another stage of the fungus and when present with the white spore masses offer conclusive evidence of the disease. Narcissus-fire or *Botrytis* diseases also produce spore masses on the leaves, but these are gray or brown in tone and are not nearly so conspicuous as those of the *Ramularia*-blight.

The *Ramularia*-blight has been observed in a few localities in the Northwest and in western Canada. It was first described in Italy by Cavara\* in 1899, who observed the disease in the botanical garden of Vallombrosa. It has since appeared in several English localities and in recent years has been a serious disease in the Scilly Isles. When the disease develops under favorable circumstances it severely damages plantings and accomplishes this damage with extraordinary rapidity. Its powers of destruction are well described in Cavara's original description in the following words "... It spares no

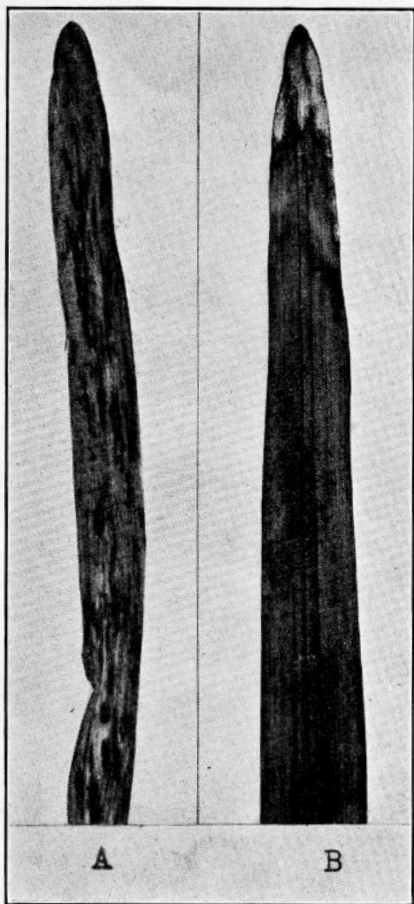


Figure 19. Comparison of the *Stagonospora* leaf scorch and *Ramularia*-blight.

A: *Ramularia*. Note white spore masses at tip.

B: *Stagonospora*. Note dark elongated lesion.

\*Fridiano Cavara, *Revue Mycologique*, 1899, p. 101.



Figure 20. General appearance of Spurius planting where *Ramularia*-blight is present. The infection is of soil origin and the tips of the leaves were badly diseased before the flowering period.



Figure 21. General appearance of leaf tips severely diseased with *Ramularia*-blight. Note the large fluffy spore masses on the dead curled leaf tissues.

species of this genus of ornamental plants and it attacks with such frenzied violence as to wither and dry up the foliage in a very short period of time." The fungus literally defoliates the plants and withers them, thereby causing ripening of the planting several months prior to the normal time. This removal of shoots obviously reduces bulb growth so that in a severely diseased planting the bulbs remain static, no increase occurring. It does not rot the bulbs. Contrary to Cavara's original statement quoted above, we have found in the Northwest that the disease shows decided varietal preference. The early varieties of the Golden Spur type, some of the grass-leaved kinds, and some of the Poetaz hybrids are most severely attacked. It destroys the shoots of Golden Spur, Henry Irving and Poeticus Emperor. Empress shoots are practically defoliated. King Alfred, on the other hand, is almost immune, but the fungus does produce ugly canker-like lesions on the flower-stems and leaves of this variety.

Fortunately serious development of the disease appears limited to those

areas where rain and fog are abundant. The few places where it has caused significant damage have all been in localities where the annual precipitation was heavy, in some instances being more than 100 inches. Evidence that these climatic requirements are limiting factors is afforded by the results of transplanting diseased stock. When diseased stock is transplanted from one wet locality to another the blight has continued at the second planting. On the other hand, when diseased stock is transplanted to a relatively dry location the ensuing plantings have been entirely clean. The disease is far more serious in plantings that have been left undug for one or more years than in those that have received proper rotation.

**Control of Ramularia-blight.** From field studies of this disease we can recommend the following control suggestions:

(1) Thorough rotation of plantings. The disease can become established in the soil and when susceptible varieties are planted in such soil one may expect serious trouble the following year.

(2) Disinfection of the bulbs as practiced for basal rot. Before treatment the bulbs should be thoroughly cleaned and all debris about the neck portion should be removed during the cleaning process. The cold Ceresan dip as recommended for basal rot appears to be a satisfactory treatment for this disease.\* After such treatment the bulbs should be planted in soil where the disease has never occurred.

Since this disease develops only under conditions of extreme moisture and when it does occur progresses with startling rapidity, control through spraying, as with Bordeaux, has proved very difficult. On the other hand, the simple procedures of disinfection and sanitation combined with crop rotation should suffice to control the disease.

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\*Work is now in progress on the control of this disease. As soon as feasible, results will be reported.



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R. H. ROBINSON, M.S.....	Chemist (Insecticides and Fungicides)
J. R. HAAG, Ph.D.....	Chemist (Animal Nutrition)
D. E. BULLIS, M.S.....	Assistant Chemist
M. B. HATCH, B.S.....	Assistant Chemist

### Dairy Husbandry

P. M. BRANDT, A.M.....	Dairy Husbandman in Charge
G. WILSTER, Ph.D.....	Dairy Husbandman (Dairy Manufacturing)
I. R. JONES, Ph.D.....	Associate Dairy Husbandman

### Entomology

D. C. MOTE, Ph.D.....	Entomologist in Charge
A. O. LARSON, M.S.....	Entomologist, Stored Products Insects*
B. G. THOMPSON, M.S.....	Assistant Entomologist
F. G. HINMAN, M.S.....	Junior Entomologist, Stored Products Insects*
S. JONES, M.S.....	Assistant Entomologist
K. W. GRAY, B.S.....	Assistant Entomologist
W. D. EDWARDS, B.S.....	Assistant Entomologist
R. E. DIMICK, M.S.....	Assistant Entomologist

### Farm Management

H. D. SCUDDER, B.S.....	Economist in Farm Management in Charge
H. E. SELBY, B.S.....	Associate Economist (Farm Management)
G. W. KUHLMAN, M.S.....	Assistant Economist (Farm Management)
A. S. BURRIER, M.S.....	Assistant Economist (Farm Management)

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# Home Economics

MAUD WILSON, M.A. Home Economist

## Horticulture

W. S. BROWN, D.Sc. Horticulturist in Charge  
A. G. BOUQUET, M.S. Horticulturist (Vegetable Crops)  
E. H. WIEGAND, B.S. Horticulturist (Horticultural Products)  
H. HARTMAN, M.S. Horticulturist (Pomology)  
C. E. SCHUSTER, M.S. Horticulturist, Hor'l Crops and Dis., Bur. of Pl. Industry\*  
G. F. WALDO, M.S. Ass't Pomologist in Charge of Sm. Fruit Inv., B. of Pl. Ind.\*  
B. F. DANA, M.S. Pathologist, Horticultural Crops and Diseases\*  
J. C. MOORE, M.S. Assistant Horticulturist (Pomology)  
F. A. CUTHBERT, M.L.D. Assistant Landscape Architect  
B. S. PICKETT, M.S. Assistant Horticulturist (Pomology)  
D. COOTER Orchard Foreman

## Plant Pathology

H. P. BARSS, S.M. Plant Pathologist in Charge  
S. M. ZELLER, Ph.D. Plant Pathologist  
F. D. BAILEY, M.S. Associate Pathologist, Insecticide and Fungicide Board\*  
L. N. GOODING, B.A., B.S. Associate Plant Pathologist\*  
F. P. McWHORTER, Ph.D. Associate Plant Pathologist  
P. W. MILLER, Ph.D. Associate Plant Pathologist, Hor'l Crops and Diseases\*  
G. R. HOERNER, M.S. Agent Office of Drugs and Related Plants\*  
T. P. DYKSTRA, M.S. Assistant Plant Pathologist\*  
R. SPRAGUE, Ph.D. Assistant Pathologist\*  
H. H. MILLSAP Agent, Bureau of Plant Industry\*

## Poultry Husbandry

A. G. LUNN, B.S. Poultry Husbandman in Charge  
F. L. KNOWLTON, B.S. Poultry Husbandman  
F. E. FOX, M.S. Associate Poultry Husbandman

## Publications and News Service

C. D. BYRNE, M.S. Director, News Service  
E. T. REED, B.S., A.B. Editor of Publications  
D. M. GOODE, B.A. Associate Editor of Publications  
J. C. BURTNER, B.S. Associate Director, News Service

## Soil Science

W. L. POWERS, Ph.D. Soil Scientist in Charge  
C. V. RUZEK, M.S. Soil Scientist (Fertility)  
M. R. LEWIS, C.E. Irrigation and Drainage Engineer, Division of Irrigation\*  
R. E. STEPHENSON, Ph.D. Associate Soil Scientist  
E. F. TORGENSEN, B.S. Assistant Soil Scientist

## Veterinary Medicine

B. T. SIMMS, D.V.M. Veterinarian in Charge  
W. T. JOHNSON, D.V.M. Poultry Pathologist  
J. N. SHAW, B.S., D.V.M. Associate Veterinarian  
R. JAY, Ph.D. Associate Veterinarian, Bur. of Anim. Ind.\*  
E. M. DICKINSON, D.V.M. Assistant Poultry Pathologist  
F. M. BOLIN, D.V.M. Assistant Veterinarian  
O. H. MUTH, D.V.M. Assistant Veterinarian  
O. L. SEARCY, B.S. Technician, Veterinary Medicine

## Branch Stations

D. E. STEPHENS, B.S. Superintendent Sherman County Br. Expt. Station, Moro  
L. CHILDS, A.B. Superintendent Hood River Br. Expt. Station, Hood River  
F. C. REIMER, M.S. Superintendent Southern Oregon Br. Expt. Station, Talent  
D. E. RICHARDS, B.S. Superintendent, Eastern Oregon Br. Expt. Station, Union  
H. K. DEAN, B.S. Superintendent Umatilla Br. Expt. Station, Hermiston  
O. SHATTUCK, M.S. Superintendent Harney Valley Br. Expt. Station, Burns  
A. E. ENGBRETSON, B.S. Superintendent John Jacob Astor Br. Expt. Sta., Astoria  
G. A. MITCHELL, B.S. Asst. Agronomist, Div. of Dry Land Agr.\* (Pendleton)  
G. G. BROWN, B.S. Horticulturist, Hood River Br. Expt. Station, Hood River  
W. W. ALDRICH, Ph.D. Asst. Horticulturist, H. C. and D., B. of P. I.\* (Medford)  
L. G. O. GENTNER, M.S. Associate Entomologist, Sou. Or. Br. Expt. Sta., Talent  
J. F. MARTIN, M.S. Jr. Agronomist, Dir. of Cer. Cr. and Dis.\* (Moro)  
M. M. OVESON, B.S. Assistant to Supt., Sherman County Br. Expt. Sta., Moro  
R. B. WEBB, B.S. Jr. Agronomist, Div. of Cer. Cr. and Dis.\* (Moro)  
R. E. HUTCHISON, B.S. Asst. to Supt., Harney Valley Br. Expt. Sta., Burns  
D. G. GILLESPIE, M.S. Asst. Entomologist, Hood River Br. Expt. Sta., Hood River