DISEASES OF BULBS

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

BULLETIN NO. 117 OF THE MINISTRY OF AGRICULTURE AND FISHERIES

PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE PRICE 5s. 0d. NET

MINISTRY OF AGRICULTURE AND FISHERIES

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DISEASES OF BULBS

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LONDON: HIS MAJESTY'S STATIONERY OFFICE
1949
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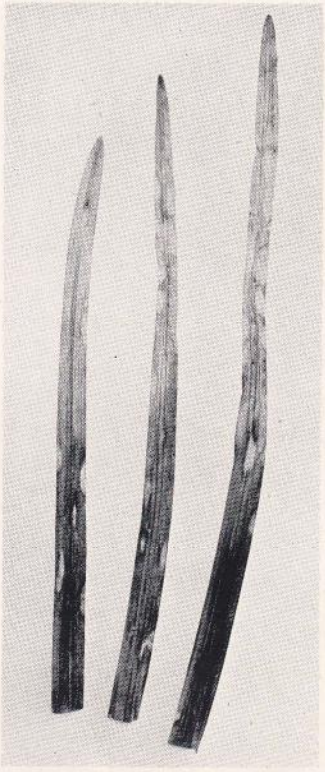
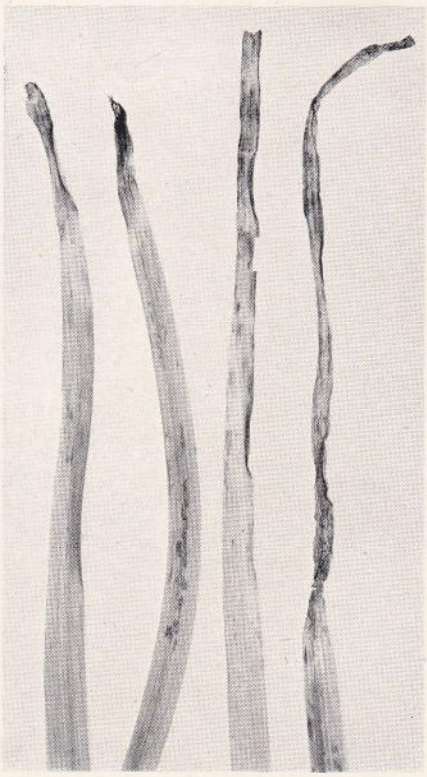
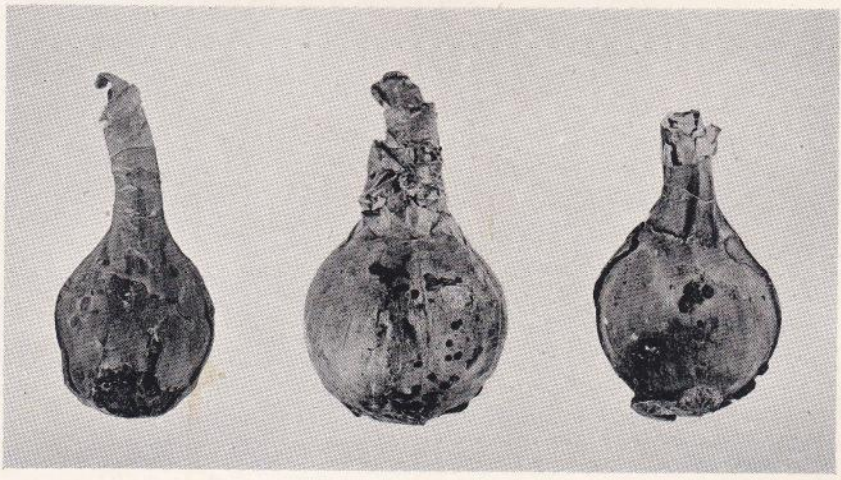


25 Narcissus White Mould
(*Ramularia vallisumbrosae*)



26 Narcissus Scorch
(*Stagonospora Curtisii*)



27 Narcissus Smoulder (*Botrytis narcissicola*)

DISEASES OF NARCISSUS

WHITE MOULD

(*Ramularia vallisumbrosae* Cav.)

White Mould is the name given to a disease of Narcissus foliage caused by the fungus *Ramularia vallisumbrosae* Cav. It is widely distributed in Britain, but rarely becomes epidemic except in the outdoor early flower districts of Devon, Cornwall and the Isles of Scilly. It has been found in Italy, France, Canada and U.S.A., and as far as is known it is restricted in its attacks to Narcissus.

History and Geographical Distribution. *R. vallisumbrosae* Cav. was described in 1899 by Cavara (116) in Italy, where it had severely damaged Narcissus plants near Vallombrosa for three seasons. The same fungus was found on *N. poeticus* in England by Chittenden (123) in 1906, but being unaware of Cavara's work, Chittenden regarded it as new and called it *Ramularia Narcissi*, though later (124, p. 544) he realized the oversight and reverted to the older name. In 1926 Hodson and Beaumont (277, p. 23) referred to the destructive nature of White Mould in the Tamar Valley and Beaumont (47) dealt with it briefly in 1935, but Gregory is the only investigator who has carefully studied the disease. In 1936 (226 see also 227) he described the symptoms and made recommendations for its control and in 1939 (228a) he published an interesting account of the life-history of *R. vallisumbrosae*. White Mould is sometimes destructive in certain areas along the Pacific coast of U.S.A.; it was reported in Oregon in 1931 (372) and 1932 (384) and was found in British Columbia in the latter year (131, p. 92).

Description of the Disease. In south-western districts White Mould may be detected on the susceptible variety Golden Spur as early as January when the leaves are 3-4 inches above ground, but elsewhere it develops some weeks later. Small, sunken, greyish or yellowish spots or streaks appear on the leaves, especially towards the tips, and these increase in size and become dark, greenish or yellowish-brown patches on which, in moist weather, the spores of the fungus soon appear as conspicuous white powdery masses (Fig. 25). Under warm, damp conditions the disease often becomes epidemic and the foliage is completely killed several weeks before the normal time of ripening off. During cool dry weather, on the other hand, the disease is rapidly checked and few or no spores are formed. When the foliage is killed prematurely much of the food that should have been manufactured by the leaves and stored in the bulb for use the following year is lost, and this is bound to have an adverse effect on the subsequent vigour of the bulb. In addition the fungus sometimes attacks and destroys the flower stalks of late varieties, such as Double White and *Poeticus recurvus*, thus causing a direct loss of the flower crop. The bulbs are not attacked. Consequently the disease is not normally

carried with the bulb, and stocks that are lifted and replanted in clean soil do not become badly attacked the first year down unless they are growing alongside older beds previously attacked.

During the spring the spores of the fungus are carried from plant to plant by wind and in drops of water, and they serve to spread the disease rapidly. The spores are short-lived, however, and cannot survive drying for any length of time. Spore production ceases when the leaves are completely withered and large numbers of minute black bodies, just visible to the naked eye, are formed within the dead or dying leaf tissues. These black bodies, sometimes called sclerotia, remain dormant during summer and autumn in leaf fragments present on the surface of the soil. As soon as the young Narcissus shoots appear above ground in winter some of the black bodies sprout and produce numbers of spores, each of which is capable of infecting the young leaves and giving rise to the characteristic spotting or blotching of the foliage.

Varieties differ widely in their susceptibility to White Mould. In the south-west Golden Spur, Sunrise, *Ornatus maximus* and Double White suffer most, whilst Emperor, *Maximus superbus*, Henry Irving, Bath's Flame, the Polyanthus varieties, and in particular King Alfred, are comparatively resistant.

Morphology of the Fungus. Cavara (116) described the spores of *R. vallisumbrosae* as cylindrical, truncated at the ends, unicellular or 1-3 septate, and measuring 14-44 × 4μ. These spores, however, represent only one of several stages in the life history of the fungus, as has been shown by Gregory (228a). It has long been suspected that *Cercosporella Narcissi* Boud., described on *Narcissus poeticus* by Boudier (94) in France in 1901, was another stage; Saccardo suggested it in 1913 (*Sacc. Syll.* 22, 1328) as also did Stevenson (605, p. 117) in 1926. The conidia of *C. Narcissi* are 3-8 (mostly 5-) septate, usually attenuated at the free end, and measure 50-130 × 4-5μ. Spores corresponding closely to this description were found to be intimately associated with typical *Ramularia* spores on plants of Double Ornatus affected with White Mould and received at Harpenden from Cornwall in April, 1928 (479, p. 108). Gregory found that spores very similar to those of *C. Narcissi* Boud. are predominant on the primary lesions early in the season and in the field are as abundant as the *Ramularia* spores at almost any time. He proved that these multiseptate spores, as well as unicellular spores corresponding to those of the form genus *Ovularia*, are genetically related to the typical *Ramularia* spores with which they are normally associated.

Late in May, 1926, the writer found a pycnidial fungus in close association with *Ramularia vallisumbrosae* in material received from the Isles of Scilly. Transverse sections of infected leaves revealed almost wholly submerged pycnidia mixed with the larger, partially sunken black bodies and with conidiophores and conidia of the *Ramularia*. The pycnidia were spherical or nearly so, 55-75μ in diameter, with a very short beak, and contained numerous, minute, single-celled spores measuring approximately 3 × 1μ. Single spores transferred to malt agar slopes gave no growth, but *Ramularia* spores and black bodies were produced in abundance when two pycnidia containing pycnospores were carefully transferred to agar slants,

although the possibility of *Ramularia* spores having been present on the pycnidia cannot be excluded. The pycnidia were quite distinct from those of *Phyllosticta Narcissi* Aderh. (= *Stagonospora Curtisii*) but corresponded to the description of *Phyllosticta narcissicola* von Keissl., which was recorded on *Narcissus poeticus* in Austria by von Keissler (313) in 1916. Similar pycnidia have since been observed by Gregory (228a).

The black sclerotium-like bodies were first noticed in 1924 on material received at Harpenden from the Isles of Scilly. In 1926 (478, p. 67) they were produced abundantly in pure cultures obtained by the writer from single spores of *R. vallisumbrosae*. The bodies range in diameter from 75-150μ. McWhorter (372) believed them to be primordia of pycnidia, which under suitable conditions produce numerous multiseptate pycnospores, whilst Gregory (226) in 1936 stated that they may germinate to produce a crop of thread-like spores. More recently Gregory (228a) has fully described the development and functions of the black bodies and has proved their relationship to the *Ramularia*. Each one is a pseudoparenchymatous mass differentiated into a body and a short, stout neck, and surrounded by a thin black rind. In S.W. England the bodies remain in this state during summer and autumn, but in January and February most of them begin to sprout and produce spores from a shallow depression in the tissues of the neck. The spores are usually of the *Cercosporella* type, 3-7 septate and varying in size from 40-95 × 2·5-3·5μ, but sometimes *Ramularia*-like spores are formed. It is the spores from the sprouted " sclerotia " that bring about primary infection of the young plants in early spring. Gregory adopted the view that the young sclerotia are the fundaments of perithecia which take an abnormal course in development and become sclerotised, and he regarded *Ramularia vallisumbrosae* as probably the conidial stage of an as yet unknown member of the Mycosphaerellaceae. Killian (315) in 1926, described similar but non-fruiting perithecial-like bodies, as well as pycnidia, occurring in the life-cycle of certain other species of *Ramularia*.

Control. It is essential to try to avoid infection of the young shoots by the spores produced when the black bodies present in the dead leaves germinate in winter, and this can often be accomplished by adopting suitable cultural practice. Much of the source of infection can be removed by raking over the beds and burning the infected leaves as soon as possible after the foliage has died down. Frequent lifting and crop rotation should also be practised, though a long interval between successive Narcissus plantings is not necessary, as it is unlikely that the fungus can contaminate the soil for more than one year. Where it is imperative to replant Narcissus in soil that carried an infected crop the previous season a resistant variety should be preferred. It is best not to plant susceptible varieties too close to one another.

In relatively dry districts free from sea mists and fogs these precautions may suffice to avoid epidemics of White Mould, but in the south-west of England spraying is necessary in addition. Gregory (226) has recently demonstrated the effectiveness of freshly-prepared Bordeaux Mixture containing 4 lb. of bluestone and 3 lb. of hydrated lime to 40 gallons of water. To

obtain adequate cover on the waxy surface of the leaves a suitable wetting or spreading agent must be added and several good proprietary products are now available, though it is generally advisable to employ them in a somewhat higher concentration than that recommended by the manufacturers for less waxy plants. The spray should be applied through fine nozzles at a pressure of not less than 50 lb. per sq. in. and the first application should be made when the shoots are 3-6 in. above ground. The need for further applications will depend on local conditions, but one or two more at monthly intervals should suffice. For an efficient cover about 200 gal. of spray fluid per acre is required for each application. Copper fungicides sometimes cause purplish-brown spots or sunken white or brown areas on Narcissus leaves, but with well-made Bordeaux Mixture damage of this nature is negligible except occasionally on the older foliage during dry weather. In districts where water is not readily available, several applications of copper-lime dust may prove effective, though dusts are less efficient than wet sprays.

LEAF SCORCH

(*Stagonospora Curtisii* (Berk.) Sacc.)

The name Leaf Scorch owes its origin (478, p. 67) to the scorched or burnt appearance of the tips of the emerging leaves when they are attacked by the fungus *Stagonospora Curtisii*. The disease is widely distributed in England and Wales, and has been observed in Scotland, but it is rarely of economic importance except in western districts. It also occurs in many parts of Western Europe and in North and South America.

History of the Disease. The fungus now known as *S. Curtisii* was observed in America in 1878, but Aderhold (30), in 1900, was the first to realize its parasitic nature. He found it on dying leaves of *Narcissus poeticus* in Germany and proved by experiment that it could destroy the foliage. During the next 25 years the fungus was recorded on Narcissus several times under different names, in Holland by Oudemans (458) and Westerdijk (681), in Hungary by Hollós (286), and in England by Ramsbottom (511, p. 57) in 1918 and by Hodson and Beaumont (277, p. 24) in 1926, but it occurred only on the leaf tips or on decaying leaves, and attracted little or no attention. In England *S. Curtisii* was not regarded as more than a weak parasite until about 1927, but since then it has caused a significant amount of flower damage and leaf decay most seasons in the West and occasionally elsewhere (478, p. 67, 479, p. 108, 47, 227).

In Europe the fungus has been investigated and its pathogenicity established by Feekes, who published an account of his studies in 1931 (199). The disease has attracted most attention, however, in the United States of America, where Creager published a comprehensive account of it in 1933 (148). Soon afterwards Smith (564) described his work on the host relationships of *S. Curtisii*—a preliminary account of which had been issued in 1929 (563)—and Haasis (245) announced the results of his experiments

on the control of Leaf Scorch. The disease was listed in Oregon by McWhorter and Weiss (384) in 1932 and in the Argentine by Lindquist (338) in 1935.

Description of the Disease. The first symptom of Leaf Scorch is a scorched or reddish-brown appearance of the leaf tips soon after the young shoots appear above the soil. This is frequently wrongly ascribed to frost and is too often disregarded. If ventilation is adequate the disease usually does not pass beyond this stage in the glasshouse, and the same may be true in the open during dry weather, but under moist conditions the disease spreads downwards several inches from the leaf tips (Fig. 26), and secondary, brown, elongated spots arise lower down on the leaves as they lengthen. These spots may remain comparatively small, but they are often numerous. The tissues above and below them become yellow and wither up, so that the leaves often fade and die comparatively quickly. The spots can generally still be seen in the withered leaves as elliptical, dry, brittle areas that retain to some extent their deeper reddish-brown colour.

Fruiting bodies of the fungus develop in large numbers on the dead leaf tips and on the spots. They are called *pycnidia* and they can usually be recognized with the naked eye as minute, brown or dark brown dots, which are appreciably larger than the black bodies of the White Mould fungus (see p. 62). The pycnidia contain large numbers of spores and during wet weather these spores are extruded and are splashed about in rain drops to neighbouring healthy plants, which they infect. Not infrequently the flower stalks and spathes become attacked as well as the leaves, and some of the spores lodge on the expanding flower buds and cause brown spots on the petals. The flower spots may be very inconspicuous at picking time, but they develop in the packing sheds and during transit and sometimes cause wholesale damage. The fungus does not appear to cause decay of the bulbs in nature, though it has occasionally been isolated from diseased bulbs (225, p. 482) and it will induce a rot when inoculated into wounded bulbs (199). On the other hand, there is considerable circumstantial evidence (148) that it survives the dormant period in the dead basal portions of the leaves that constitute the neck of the bulb, and attacks the tips of young leaves as they emerge when growth is resumed. This would explain the frequent occurrence of Leaf Scorch even in newly planted stocks.

The most susceptible varieties are to be found among the Poeticus, Polyanthus and Poetaz groups. In the south-west *Poeticus ornatus,* Horace, Grand Soleil d'Or, Scilly White,

Grand Primo, Medusa, Cheerfulness, Croesus and Bath's Flame suffer most, while the trumpet and Incomparabilis forms are usually reasonably free from attack. In America all types are affected, the Leedsii and Polyanthus forms being particularly susceptible. The disease is almost always worse after the first year down.

Other Hosts. On the Continent and in the United States the large flowered greenhouse hybrids of *Amaryllis* (*Hippeastrum*) *vittata* are commonly, and sometimes very severely, attacked by the fungus that causes Narcissus Leaf Scorch. Conspicuous rounded or elongated red spots are formed on the leaves, stems and bulb scales and the flowers may be blemished or even deformed. The disease has also been observed on the Belladonna lily (*Amaryllis Belladonna*), on *Crinum Powellii, C. longiflorum, C. asiaticum, Sprekelia formosissima* and *Sternbergia lutea,* and Smith (564) has artificially infected various other members of the Amaryllidaceae, including *Galanthus.* In Britain an attack on *Amaryllis Belladonna* was reported by Staniland and Beaumont (597) in Devon in 1933. In August, 1929, the writer received specimens of *Galanthus byzantinus* that had been grown in Buckinghamshire and had been taken from a stock in which 50 per cent. of the bulbs were soft or in a badly rotted condition. A fungus indistinguishable from *Stagonospora Curtisii* was isolated in pure culture from the bulbs and pycnidia of this fungus also developed in large numbers on specimens kept in a moist chamber.

The Parasite. The morphological characters of *Stagonospora Curtisii* on the host and in culture have been dealt with by Creager (148) and also by Feekes (199). It is sufficient to state here that the pycnidia are globose, often somewhat compressed, with a definite ostiole, and measure 110-275μ (average 175μ) in diameter. The spores are very variable in size and septation. They are hyaline, elliptical fusiform or nearly cylindrical, rounded at both ends, 1-6 celled, and range from 4·5-30 × 3-8μ in size. Sometimes nearly all the spores are unicellular and measure 4·5-10 × 3-5μ, while at other times the majority are 3- septate and range from 13-30 × 5-8μ. The many different names given to what is, in point of fact, a single species, is a direct outcome of this extreme variability.

The fungus was first collected on Narcissus in South Carolina and it was very briefly described in 1878 by Cooke (135) under the name *Hendersonia Curtisii* Berk. In 1884 Saccardo (*Syll.* 3, 451) transferred it to the genus *Stagonospora,* listing it as *S. Curtisii* (Berk.) Sacc. The parasite reported in Germany by Aderhold in 1900 (30), and named by him *Phyllosticta Narcissi* Aderh., was evidently nothing other than the unicellular spore condition of *S. Curtisii,* the typical septate spores of which were found mixed with it. The same is probably true of *Phyllosticta Narcissi* Oud., which was described a little later by Oudemans (458) and was renamed *P. Oudemansii* Sacc. and Syd. in *Sacc. Syll.* 16, 1902, 849. The species described by Hollós in Hungary in 1906 (286) as *Stagonospora Narcissi* Hollós is also to be regarded as synonymous with *S. Curtisii,* as Hollós himself suspected.

The parasite occurring on *Amaryllis* and other members of the Amaryllidaceae has been given many names, including *Stagonospora Crini* Bub. and Kab. (1908), *Phyllosticta amaryllidis* Bresad. (1894), *P. gemmipara* Zondag (1929) and *Phoma amaryllidis* Kotth. and Friedr. (1929), but cross inoculation experiments described by Feekes in 1931 (199), by Creager in 1933 (148), and particularly by Smith in 1935 (564) have shown conclusively that one fungus only, viz., *Stagonospora Curtisii* (Berk.) Sacc., is the cause of the disease in all the plants mentioned above.

Control of the Disease. In some districts Leaf Scorch is not of sufficient importance to require special measures of control, but in S.W. England and in parts of Wales, much loss may be avoided by the simple, if somewhat laborious, method of picking off the infected leaf tips as soon as possible after the shoots have appeared above ground. Experiments carried out in the United States by Haasis (245) indicate that much of the primary infection arising as the young shoots emerge can be avoided by dipping the bulbs for 30 minutes in solutions of corrosive sublimate (1 in 750) or formalin (1 in 120), after pre-soaking for 1 hr. in water. According to Creager (148) a 2-hr. dip in ½ per cent. solution of formalin without pre-soaking is also effective. These treatments should be carried out immediately before planting. Where the disease has appeared, spraying the plants with Bordeaux Mixture, as recommended for White Mould (see p. 63) will help to check its progress.

SMOULDER

(*Botrytis narcissicola* Kleb.)

"Smoulder" is the English equivalent of the Dutch word "smeul", a term applied in Holland to a disease due to the fungus *Botrytis narcissicola* Kleb. It causes a decay of stored bulbs and a rot of the foliage and of the flowers in the open, especially in early flower districts during cold, wet seasons. The disease is of universal occurrence but it is not a well-known one and requires further investigation.

History. Smoulder was first described in 1907 by Klebahn (321), who had obtained material of it during a visit to Holland. He proved that the disease was due to a species of Botrytis, which he provisionally named *B. narcissicola* Kleb. According to his description the conidiophores are 1 mm. or more long, unbranched or slightly branched above, brownish grey below and paler above, and the conidia are oval, somewhat pointed at the lower end, pale brown in colour and measure 10-12 × 6-7μ. Further reference to Smeul in Holland was made by Westerdijk in 1911 (680) and again in 1917 (682), and more recently Westerdijk and van Beyma (684) have given fuller details about the morphology and cultural characters of the fungus. The measurements they give for the conidia, viz., 8-16 × 7·5-12μ (Av. 12·3 × 9·5μ) are larger than those mentioned by Klebahn.

A brief account of the occurrence of Smoulder in bulbs imported into England was published by Dowson (165) in 1924, though it was not until two years later (166) that the *Botrytis* associated with it was identified

as *B. narcissicola*. The disease is observed most years in Great Britain but it is rarely serious. Short notes about it have been published in recent years by Beaumont (47) and Gregory (227) in this country, by Weber (654) in Denmark and by McWhorter and Weiss (384) in the United States of America.

Description. On examining the bulbs after lifting, the sclerotia of *Botrytis narcissicola* may be found just below the outer papery scales as small, black, flattened bodies about the size of mustard seed or up to half an inch long, if several are joined together (Fig. 27). During the summer the fungus generally remains inactive, but if storage is prolonged into the autumn it begins to attack the basal plate and the scales, producing yellowish-brown rotted tissue in which sclerotia can usually be found embedded. The fungus grows best at about 20° C. (68° F.) (225, p. 476) and if kept at this temperature the bulbs, and especially those of the Poeticus varieties, may in time be destroyed completely. The disease may pass unrecognized in less badly attacked bulbs and if these are planted they either fail to grow or give rise to malformed or yellowish shoots that do not thrive and sooner or later die.

The occurrence of the disease in individual plants scattered about the field supports the view that the fungus is introduced mainly by planting infected bulbs. Nevertheless, it is probable that infection may also arise from sclerotia present on infected leaf fragments remaining on or in soil where the disease occurred the previous year. During the early part of the season when low temperatures prevail and growth is slow the fungus is often found attacking the leaves at or near soil level. In such instances infection may well have taken place by mycelium emanating from sclerotia present in the soil. The invaded tissues become brown and the distal portions of the leaves wilt and turn yellow.

Under moist conditions the young malformed or blighted plants become covered with the grey spore masses of the *Botrytis*. These spores are carried about, and they may infect the tips of leaves damaged by wind or may produce brown spots on the petals, especially in cool, wet seasons, but it is uncertain exactly how much injury is due to such infection. That *Botrytis* sometimes causes severe loss in this manner is undoubtedly true, but the evidence suggests that it is the common grey mould, *Botrytis cinerea*, rather than *B. narcissicola*, that is mainly responsible, at any rate for the leaf damage. According to Klebahn (321) and Dowson (166) the spores of the last named fungus, as those of *B. cinerea*, are unable to enter uninjured Narcissus tissues, though they readily invade the leaves and flower stalks through wounds. Neither of these writers could infect tulips with the fungus from Narcissus, but

Dowson found that the foliage, flower stalks and fruits of snowdrops were destroyed when artificially inoculated with *B. narcissicola*.

There is no known cure for Smoulder and every effort must be made to prevent it by carefully inspecting the bulbs before planting and discarding any that are diseased. The beds should also be examined when the shoots have pushed through, and plants that look malformed or obviously unhealthy should be removed and burnt.

FIRE

(*Sclerotinia polyblastis* Gregory)

In wet seasons much flower damage is caused in Devon, Cornwall and the Isles of Scilly by a fungus formerly called *Botrytis polyblastis;* but now to be named *Sclerotinia polyblastis*. During and after the flowering period the fungus passes over from the flowers to the foliage and causes a rapid premature leaf decay known to growers as " Fire ". Occasionally the disease is observed in other parts of England and it occurs in Scotland, Ireland and Jersey, but it is unknown abroad except in the Pacific Northwest of U.S.A.

In 1926 Dowson (166) received Narcissus foliage attacked by Fire from Cornwall and Northern Ireland, and he was the first scientific worker to report the disease, though it had evidently been familiar to growers for some time. Dowson named the fungus that causes it *Botrytis polyblastis* Dows. and in 1928 he published (167) a full account of the disease. The symptoms on the flowers were first recognized by Small (560) in Jersey in 1933, and were seen again the following year by Wallace (646) in Lincolnshire. Brief notes on the occurrence of the disease in S.W. England have appeared from time to time (47, 227, 280, p. 20), and the behaviour of *B. polyblastis* in culture has been described by Westerdijk and van Beyma (684). The only record of the disease abroad is one published in America in 1934 by McWhorter and Reynolds (383) who found it doing considerable damage at two localities in Washington State.*

The conidia of *Botrytis polyblastis* are borne on erect, mostly bent, unbranched or sparsely branched, pale brown conidiophores. They are spherical or pear shaped, colourless when young, faintly coloured brown when mature, and are unusually large, measuring 30-50μ (- 60μ) in diameter (up to 90μ in American material). Each conidium has a relatively thick wall with a distinct papilla at the narrower end.

Recently, Gregory (228) has described the perfect stage of this fungus and has named it *Sclerotinia polyblastis* Gregory. He found abundant apothecia of a Sclerotinia in February, 1938, on dead Narcissus leaves in the Isles of Scilly and in Cornwall, and demonstrated the genetic connection between it and *Botrytis polyblastis*.

Fire usually develops first on the flowers. Small, watery or light brown spots appear on the perianth and the corona before or at picking time, and under moist conditions these extend

* The record of *B. polyblastis* on Narcissus bulbs imported into Canada in 1926 (172) was an error, which was later (173) rectified.

rapidly and destroy the blooms. The spotting may develop in transit and flowers that appear to be sound when packed are often ruined by the time they arrive on the market. During the flowering period, or soon afterwards, the disease appears on the leaves as yellowish or dark, reddish-brown elongated blotches. The *Botrytis* spores of the fungus are produced on the affected parts, and on examination with a hand lens they can often be seen glistening like minute, clustered drops of water. In warm, moist weather they spread the infection so rapidly that the foliage may be killed to the ground over several acres within a few days. The fungus does not pass down and attack the bulbs, and there is no evidence that it is carried on the bulbs. On the other hand, it remains dormant in the dead leaves during the summer and winter in the form of black resting bodies or *sclerotia* up to ½ inch in length. It has been found (228) that in early spring these sclerotia may give rise to brownish, stalked disc-like bodies about ⅛ inch in diameter. The latter are called *apothecia* and they liberate a second type of spore (the ascospore) which is believed to be responsible for the earliest attacks on the flowers and foliage, though this is a point that has not yet been proved.

Varieties of *N. Tazetta* parentage, particularly Grand Soleil d'Or, are attacked most severely, but Fire is also commonly found on Trumpet varieties, such as Golden Spur, Victoria and Emperor, and on Sir Watkin. In America, Poetaz and bicolour varieties (especially Spring Glory and Glory of Sassenheim), as well as Jonquils, have been badly attacked, while Stripe-free Minister Talma appeared to show true resistance. Fire can largely be prevented by burning all diseased foliage and by spraying early with Bordeaux Mixture as recommended for White Mould (see p. 63).

WHITE ROOT ROT

(*Rosellinia necatrix* Prill.)

In 1878 Massink (415a), a Dutchman who was working in Germany at the time, recorded the presence on the outer blackened scales of Narcissus bulbs of a species of *Rosellinia*, that Saccardo (*Syll. Fung.* 9, 1891, 500) later named *R. Massinkii* Sacc. Nothing more seems to have been heard of this fungus but in recent years a species of *Rosellinia*, identified as *R. necatrix* Prill., has been found causing rotting of Narcissus bulbs and other plants in the Isles of Scilly and West Cornwall. It was first recorded in the Islands by Pethybridge in

1926 (476, see also 478, p. 67), but had been present some years previously and still regularly occurs there. A brief description of the disease was given in 1930 by Hodson and Beaumont (280), who called it Black Bulb Rot.

In the field White Root Rot gives rise to small or relatively large bare patches in which the shoots have either failed to appear or have died off. The bulbs in the centre of the patch are completely rotten: the inner tissues are deep brown in colour and the outer scales are blackened. If the plants near the outside of the patch are pulled up an earlier stage of the trouble is observed. The roots of these plants are dead and the bases of the bulbs, as well as the lower parts of the scales, are deep brown in colour, while portions of the outermost scales are blackened externally. A characteristics feature of the disease is seen when a bulb is cut lengthwise. Narrow white strands, consisting of fungus mycelium, are observed running in all directions through the brown rotted tissue (see Fig. 32) or sometimes radiating from one point in fan-like fashion. Under moist conditions a white woolly mass of mycelium also develops externally at the base of the bulb. The external blackening of the outermost scales is due to the presence of mycelium in a dark, compacted form. The fungus grows out into the soil from affected bulbs and is often visible as thin, white strands, which are able to attack the roots of adjacent plants.

Rosellinia necatrix lives in the soil and it may be carried over in slightly infected bulbs. It is able to attack a wide range of hosts, including apple, pear and other fruit trees, and attacks in bulb fields often occur where infected fruit trees had previously stood. Among ornamental plants the disease has been observed on Arum and Ixia in the Isles of Scilly (478, p. 69, 479, p. III), on Iris and tulip in Cornwall (279, p. 35, 479, p. III) and on *Iris stylosa* and Montbretia in Devon.

Species of *Rosellinia* cannot tolerate dry conditions and if the soil in an affected patch is turned over repeatedly during the summer to give it full exposure to sun and air the fungus will usually be killed out. To make doubly sure, however, it might be wise to incorporate bleaching powder (calcium hypochlorite) evenly and thoroughly with the soil at the rate of 1 lb. per 20 sq. yards. The chlorine gas that is liberated kills the fungus, but time must be allowed for the gas to be dissipated and this may take 4-5 weeks. Nothing should be planted in the treated soil until this period, or even longer, has elapsed.

BASAL ROT

(*Fusarium bulbigenum* Cooke & Mass.)

In Britain the name Basal Rot has for many years been given to almost any form of basal injury in Narçissus bulbs. The term is a well-known one and likely to persist. It is desirable, therefore, to define its meaning more precisely and, as employed here, it is applied to a brown decay of the bulbs caused by the fungus *Fusarium bulbigenum* or by closely allied species of *Fusarium*. It is primarily a storage rot which almost invariably spreads upwards from the base of the bulb, and it is doubtless of world-wide distribution. In Holland the disease is called " bolrot " (bulb-rot).

History of the Disease. About 50 years ago much concern was felt in this country regarding a very troublesome " basal rot " of Narcissus bulbs, and between 1889 and 1900 frequent reference was made to it in the horticultural press. According to Wolley Dod (156-7) plants affected by it were stunted, the tips of the leaves turned brown and the flowers developed imperfectly. On digging up affected plants the base of the bulb was found to be soft and rotten and few, if any, roots were present. Some writers stated that the rot developed after planting, others that it began during storage, and a similar diversity of opinion was evident in the attempts made to explain it (2). Dod, for instance, concluded that it was due to unfavourable conditions of soil or climate, while Crawford (145-6) maintained it was caused by a species of *Penicillium*. No real effort was made to investigate the trouble and the impression gained from reading many of the articles published is that the term " basal rot " in its original meaning signified almost any form of decay that originated at or near the base of the bulbs.

After 1900 interest in " basal rot " waned and little more was heard about decay in Narcissus bulbs until the exceptionally hot summer of 1911, when large numbers of bulbs rotted during storage in England and Holland. The rot mostly began at the base of the bulbs and gradually extended up into the scales, which became reddish or greyish-brown. In this country Jacob (304) briefly described the rot and stated that it was due to the combined action of heat and *Fusarium bulbigenum*. This species had been described as a new British fungus in 1887 by Cooke (136, p. 49), who listed it as *F. bulbigenum* Cooke and Mass. On that occasion it had also been found on diseased Narcissus bulbs but was not recognized as a parasite, and the description given of it was very brief and quite inadequate from the modern point of view. In 1913 Massee (406) published the results of an investigation into the disease mentioned by Jacob. He also attributed it to *F. bulbigenum* but his work fell far below present-day critical standards. He made no pure cultures, carried out no proper infection experiments, and in all probability was confusing two or more diseases. His views, though accepted at the time, soon became discredited and under the aegis of the Royal Horticultural Society a re-investigation of the disease was made, first by Miss Welsford (672) and later by Ramsbottom (511). Welsford made inoculation experiments with pure cultures of various organisms isolated from diseased bulbs, including bacteria and a fungus identified as *Fusarium bulbigenum*, but in no instance did infection succeed or rot occur. On the other hand experiments with eelworms obtained from the rotten bulbs proved successful and the conclusion was drawn that the eelworm, *Anguillulina* (*Tylenchus*) *dipsaci*, was the sole cause of the disease. Welsford's results, published in 1917, were fully confirmed the following year by Ramsbottom, who rarely found the

Fusarium and then only in association with the parasitic eelworm. Meanwhile, in Holland Westerdijk (680) stated in 1911 that the rot was due to a *Fusarium* of the group *elegans,* which she had shown to be capable of rotting Narcissus bulbs rapidly when these were kept at 26° or 30° C. At 22° C. infection proceeded more slowly and at 18° C. no rotting took place. By 1915 (11, 681) this fungus had been accepted as *F. bulbigenum,* but some doubt about possible eelworm attack had crept in, despite the fact that further successful infections had been obtained, not only with *F. bulbigenum* but also with another species referred to as *"F. gemmiperda."* In 1917, however, Westerdijk (682) clearly distinguished between the eelworm disease (see p 82) and the bulb rot due to *Fusarium* and expressed the opinion that in Massee's material both diseases had been present. There can be no doubt whatever that the disease so prevalent in 1911 and the ensuing years was, in part at least, the one now called Basal Rot, though it was never referred to as such. Convincing proof of the parasitic nature of the eelworm, coupled with Massee's uncritical work and the unfortunate mischance that in her inoculation experiments Miss Welsford did not use varieties comparatively susceptible to the *Fusarium,* served to focus attention on the eelworm disease, and for the time being the *Fusarium* disease was regarded as non-existent or at most as a purely secondary phase of eelworm attack.

In 1926 and for some years afterwards a rot, referred to in the trade as basal rot, was found to be very prevalent in bulbs imported into this country. Samples of many affected consignments were examined at the Ministry's Plant Pathological Laboratory and a species of *Fusarium,* unaccompanied by eelworms, was invariably associated with the rotting (478, p. 67). Similar experience was reported by Hodson and Beaumont in England (277, p. 21), by McKay in Oregon (366) and by Drayton in Canada (173) and a conviction that *Fusarium* alone was responsible for widespread loss among stored bulbs was subsequently fully confirmed by investigations carried out in America, in Holland and in England.

In the United States the disease formed the subject of a series of articles published by Weiss between 1927 and 1932. A popular account of Basal Rot appeared in 1927 (662) and was followed by abstracts of a paper read at the Meeting of the American Phytopathological Society in December, 1928 (663-5), in which it was stated that the disease is widely distributed in U.S.A., is of considerable economic importance in the Central and Atlantic Coastal States and is due to a species of *Fusarium,* that has not been further identified. Four further papers, issued in 1929 (666), 1930 (667-8) and 1932 (669) dealt almost exclusively with the control of Basal Rot by suitable fungicidal treatment carried out in conjunction with, or independently of, the hot-water treatment for controlling eelworm disease. Similar experiments were reported by Newton in 1928 (433), by McWhorter (370) in 1929 and by Miles in 1932 (419). A general account of the disease was given by McWhorter and Weiss in 1932 (384). The root rot described in Mississippi by Wedgworth in 1928 (659, 660) was an early stage of Basal Rot occurring in the field before lifting.

In Holland the hot-water treatment in relation to bulb rot caused by *Fusarium* was discussed in an article published by van Slogteren (549) in 1931, and the same year Feekes (199), after studying the disease, concluded that it was caused by *F. orthoceras* App. and Wr. and not, as had been supposed, by *F. bulbigenum* Cooke and Mass.

In England Gregory (225) published the results of an exhaustive study of Fusarium bulb rot and its control in 1932. He proved that *F. bulbigenum* is the cause, and his observations were confirmed and extended by Hawker (262) in 1935. Experiments with fungicides in the hot-water bath were described by both these investigators and similar experiments are being carried out by Wallace (645-7). The disease formerly referred to in S.W. England as Basal Rot (280, p. 18) is a distinct trouble now called Root Plate Rot (see p. 87).

The occurrence of the disease in Denmark was referred to by Weber (654) in 1931.

Description of the Disease. In this country Basal Rot does not normally become apparent until about a month after lifting. The first external symptom is a brown discoloration in the region of the basal ring, which is soft (Fig. 29). The rot gradually spreads in through the basal plate and up the inner scales, the tissues of which become chocolate-brown to greyish-brown in colour (Fig. 30), sometimes brick-red or even a bright violet in the variety Loveliness. A white or pinkish-white fungus coating is generally present on and between the inner scales and sometimes it also develops externally at the base of the bulbs (Fig. 28). This coating consists of the spores and mycelium of the *Fusarium* that causes the disease. Occasionally the rot appears to begin in the old flower stalk and progresses from above downwards. Moderately attacked bulbs may be detected by their softness and eventually the whole bulb dries up to a hard, shrivelled mummy.

Severely attacked bulbs can be recognized and discarded at planting time, but less badly affected ones frequently do not show any external sign of the trouble and may therefore be overlooked. If planted they rot in the soil without producing a plant or give a poorly developed shoot consisting of a few narrow, yellowish leaves and occasionally a flower bud that rarely unfolds.

Method of Infection and the Factors Governing It. The *Fusarium* is believed to occur naturally in some soils and it may be introduced into any soil by planting infected bulbs. In the light, warm soils of the eastern coastal regions of U.S.A., Basal Rot commonly develops in the field during the later stages of growth, when the soil temperature rises above 21° C. (70° F.). The fungus invades the roots and advances up them into the basal plate and scales, causing a rot which may reach an advanced stage even before the bulbs are dug.

Where the disease is found in the field in Britain it is generally the result of planting bulbs already infected, though it is possible that infection sometimes begins before or at the time of digging. Generally speaking, however, the bulbs are sound when lifted and active invasion does not begin until later. When the stocks are lifted from contaminated soil it is believed that spores or mycelium of the *Fusarium* are present in dead tissues at the bases of the bulbs or on dead or moribund roots, from whence the fungus later passes into the bulbs through wounded tissues. Entry may be effected at any point around the base of the bulb, but it occurs especially at the junction of the components of a " mother " bulb or where an off-

set has been accidentally broken off during cleaning operations. Infection may also occur through tissues scorched by exposure to hot sun or damaged mechanically. Gregory (225) obtained evidence that the natural wounds caused by root emergence are sufficient to permit entry and this was later confirmed by Hawker (262) who, in addition, proved that the fungus can invade the roots and, in susceptible varieties, pass back into the bulbs.

Basal Rot is greatly aggravated if the bulbs of a contaminated stock are kept in a poorly ventilated place where the temperature rises to between 22° and 30° C. (71-86° F.), or if " heating " occurs later on during transit. The *Fusarium* apparently does not pass from bulb to bulb in the trays but during the routine hot-water treatment of stocks for eelworm extermination (see p. 84), spread can take place by means of spores carried through the water from diseased bulbs to healthy ones. Hawker (262) found that bulbs are less liable to become infected in the bath if the treatment is carried out in late August and early September, when most varieties are in the stage of maximum dormancy, and fortunately this period is the one during which the hot-water treatment causes least flower damage. Before this time the fungus enters through the old roots and root scars. By the end of August the roots are dead and the scars healed, while new roots do not normally push out until the second half of September.

Varietal Susceptibility. Different varieties show marked differences in liability to Basal Rot. The trumpet varieties, especially Henry Irving, Obvallaris, Victoria, Horsfieldii, Spring Glory, and white trumpets such as Madame de Graaf, Peter Barr, Sulphur Beauty and Loveliness are particularly susceptible. Emperor and King Alfred do not suffer much in this country but both are badly affected at times in America.

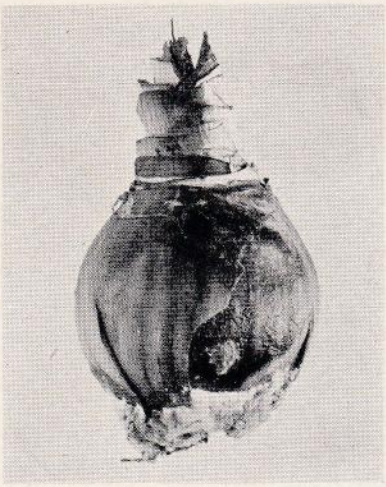
Among other groups Lady Margaret Boscawen, White Colossus, Barrii conspicuus, Mrs. Langtry, Cylgad and Poeticus ornatus are moderately susceptible. Cynosure, Seagull, Sunrise and Bridesmaid are comparatively resistant, while members of the Triandrus, Jonquil and Tazetta groups are rarely, if ever, attacked. The disease occurs more frequently in " double-nosed " and " mother " bulbs than in " rounds "

The Parasite. It is now accepted that Basal Rot is a distinct disease caused by a *Fusarium* of the group *elegans*, but the exact identity of the parasite is still a matter of opinion. The original description of *Fusarium bulbigenum* Cooke and Mass. is too meagre for purposes of comparison, but a full and adequate description of this species was published by Reinking and Wollenweber in 1927 (512) and again in 1935 (704). In England, according to Gregory (225), it is this fungus that causes Basal

Rot, whereas in Holland, Feekes (199) attributed it to *F. orthoceras* App. and Wr., and in each case the identification of the fungus was made by Wollenweber. In America the *Fusarium* has not yet been named specifically. *F. moniliforme* Sheld. was isolated from affected bulbs by Hodson and Beaumont (280, p. 18) in 1930 and Gregory (225) also found it on eelworm-affected bulbs, on the outer papery scales, and on the leaves, but his inoculation experiments with it gave negative results and it cannot be regarded as a cause of bulb-rotting. The identity of the species with blue coloured masses of chlamydospores, named by Westerdijk (682) "*F. gemmiperda,*" is uncertain. According to Wollenweber (704) *F. gemmiperda* Aderh. is synonymous with *F. lateritium* Nees, in which chlamydospores are rarely found.

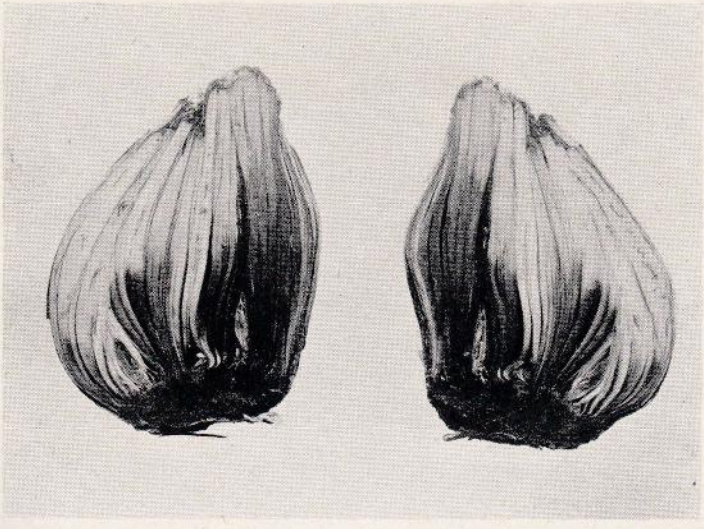
Control of the Disease. There is no cure for Basal Rot, but the trouble can be avoided to a large extent by careful lifting and handling to prevent bruising and other mechanical damage, and by avoiding exposure to hot sun immediately after lifting. When compound bulbs are divided after drying and cleaning care must be taken to avoid too much splitting. The vital importance of storing Narcissus bulbs in a cool, well-ventilated place is obvious, when it is remembered that infection is dependent on moderately warm conditions (about 70° F.) and is greatly advanced by still higher temperatures (80-90° F.). Moreover, every effort should be made to avoid heating during transport. Early planting in autumn is said to check the disease, though this has not been substantiated in experiments designed to confirm the belief (225). Where the bulbs can be planted again soon after lifting, before the disease normally makes its appearance, this should be done. All diseased bulbs must, of course, be discarded at planting time. In America efforts are being made to find suitable soil fungicides for arresting the spread of infection that takes place there in the field, and mercuric oxide, applied at the rate of 40 lb. per acre with the fertilizer, has given promising results in some instances (670a).

Spread of Basal Rot during hot-water treatment may be reduced by adding formalin or some other suitable fungicide to the water in the bath. Formalin in concentrations up to 1·5 per cent. can be used with safety, provided the treatment is carried out properly at a time when the bulbs are in a state of maximum dormancy. A 0·5 per cent. solution has proved very satisfactory (262): and to prepare this 1 quart of commercial (38 per cent.) formalin should be added to every 50 gallons of water in the tank. Equally good, and sometimes better results have been obtained with certain of the proprietary organic mercury compounds (549, 669), which should be used in accordance with the instructions issued by the manufacturers. Formalin tends to hasten killing of eelworm wool, while the mercury compounds have the advantage of leaving a fungicidal



28 Narcissus Basal Rot, showing external growth of *Fusarium bulbigenum*

29 Narcissus Basal Rot An earlier stage



30 Section through Narcissus Bulb attacked by Basal Rot (*Fusarium bulbigenum*)

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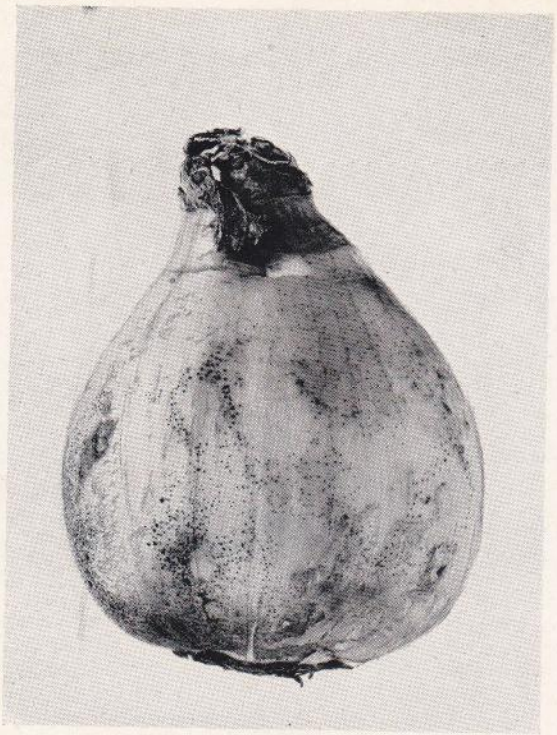
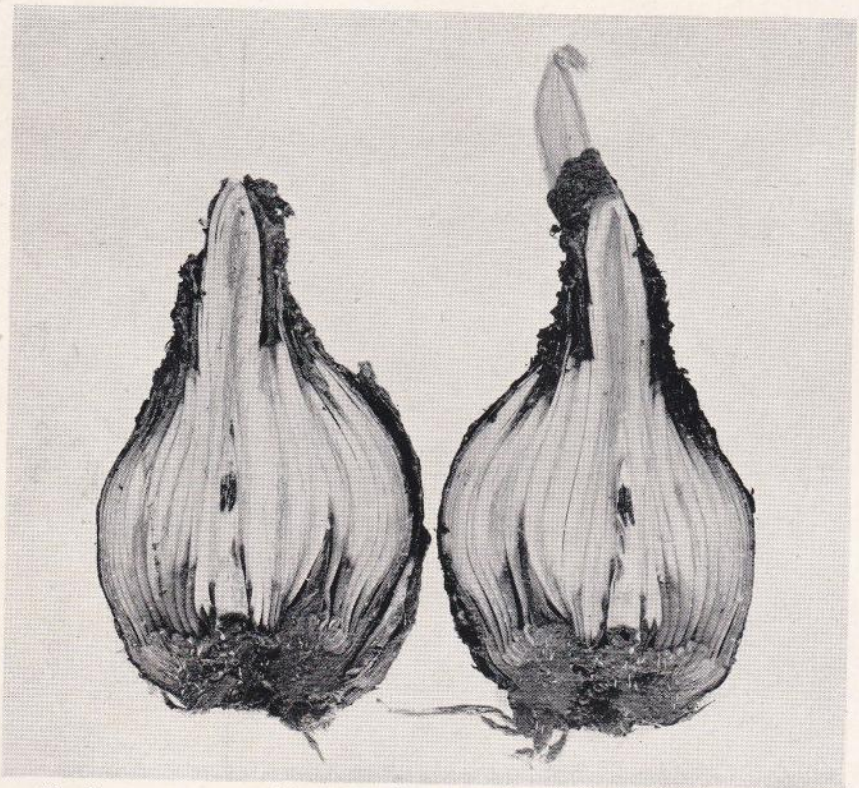


31 Narcissus Bulb with numerous minute Sclerotia of an unidentified Fungus



32 Section through Narcissus Bulb affected with White Root Rot (*Rosellinia necatrix*)

deposit on the surface of the bulbs. The addition of the fungicide usually has no harmful effect on growth, flowering and subsequent yield, and it often has a beneficial effect in this respect even when the stocks treated are free from disease. The adverse effects reported from time to time are probably the result of treating the bulbs at the wrong time or in the wrong manner.

After treating the first batch of bulbs the water in the bath may be made up to its original volume by adding double strength of the fungicidal solution, but the bath should be cleaned out and fresh solutions made up at frequent intervals. When taken out of the bath the bulbs should not be left lying in the bags or in heaps, or kept long under an enclosed covering. It is best to let them cool off and dry as rapidly as possible (but not in hot sun) and then plant as soon as convenient.

These treatments, carried out perforce comparatively late in the storage season, will obviously not prevent the attacks of Basal Rot that begin soon after lifting, and the same applies to cold dips carried out independently of the hot-water treatment in late August or early September. Such dips have also given good results but on the whole they are rather less satisfactory than hot fungicidal treatment in reducing Basal Rot (419, 549, 669). On the other hand a cold dip for use immediately after lifting would be of great value in preventing early infection, and efforts are now being made in this country to devise suitable treatment of this nature.

STRIPE
(*virus*)

The disease that is perhaps giving rise to most concern among Narcissus growers in this country at present is the one known as Stripe or Yellow Stripe. It has existed here for at least 40 years, but even now its precise nature is not fully understood, although sufficient evidence has been accumulated to justify the conclusion that much, if not most, of it is a result of the plants becoming infected by one or more viruses. In America the disease is usually called Mosaic or Gray Disease.

History of the Disease. In 1894, at a meeting of the Scientific Committee of the Royal Horticultural Society, Wolley Dod (159) exhibited leaves of *Narcissus incomparabilis* marked with longitudinal stripes of yellow, and there can be little doubt that they were affected with what is now called Stripe. Ten years later (7) an appeal was issued for information about the cause of " Yellow-Stripe disease," and subsequently the matter was discussed at some length in the horticultural press. The divergent views put forward to account for the trouble were summarized in a general article

on the disease published by Darlington in 1908 (150), but nothing conclusive emerged from this and for over two decades the subject was given no further attention in this country. From 1927 onwards the number of inquiries about Stripe received at the Ministry's Plant Pathological Laboratory steadily increased (478, p. 67, 479, p. 109) and in 1932 Hodson (274) referred to the almost universal occurrence of the disease in commercial varieties. Brief practical observations on Stripe have been published from time to time by growers and others (41, 47, 125, 227, 276, 699) and in 1935 Gould (215) fully described the disease and gave an account of his attempts to transmit it by artificial means. Recently a full investigation of the disease has been undertaken at University College, Exeter, by Caldwell and James, and in the first of a series of articles on the results of this study, published in 1938 (107), they described the nature and significance of the histological modifications shown by plants infected with Stripe.

The occurrence of " Gray Disease " in the United States of America was briefly mentioned by Griffiths and Jueneman (234) in 1919, by Griffiths (230) in 1924, and by McKay (366) in 1926. Experiments on its transmission by artificial means, begun in 1926, were summarized by McWhorter (373) in 1932, and in the same year McWhorter and Weiss (384) published an interesting general article on the disease. Brief abstracts of the results of further studies by McWhorter, mainly on symptom expression, have appeared more recently (374, 376, 382).

Stripe has been reported in Denmark by Weber (652), in Bermuda by Ogilvie (445), in Bulgaria and Holland by Atanasoff (39) and in Canada by Drayton (173, 175).

Description of the Disease. The symptoms displayed by different varieties are so diverse as to suggest that the term Stripe is being used to cover more than one specific disease. Nevertheless, as a result of the uneven distribution of chlorophyll (green colouring matter) in the leaf tissues, the leaves of " Stripe " plants are invariably mottled or striped in one form or another. Most frequently the leaves exhibit longitudinal stripes of varying length and width, or rounded, mottled areas, ranging in colour from pale green to bright yellow, while in a less common type (for which the name Grey Disease seems particularly apt) the stripes are silver grey in colour and extend practically the entire length of the leaf. A third type, found in some trumpet varieties, and especially in King Alfred and Victoria, is quite distinct. The plant is badly distorted, the leaves are bent through a wide angle, and they often show bright yellow, rather broad stripes, especially towards the inner curve of the bend. In some varieties, notably Czarina and Minister Talma, the striping is accompanied by marked roughening of the leaf surface, due to the formation of longitudinal yellow-green corrugations or ridges that can be felt without difficulty when a leaf is drawn through the fingers. Similar ridges occur in many varieties but they are often inconspicuous and can be detected only with difficulty. The ridges are caused by the proliferation of certain cells within the leaf tissues.

The symptoms described may also appear in the flower stalks, and in some varieties the flower colour itself is often broken by light or greenish streaks or patches. On the other hand the bulbs, though perhaps small, show no visible sign of infection, even when cut.

The yellow mottling and striping is generally visible soon after the leaves have pushed through the soil, but the silver-grey stripes do not become evident until a few weeks before flowering time. The mottling or striping may become fainter, or may disappear altogether later in the season or when the plants are transferred to a greenhouse. This behaviour is due merely to masking of the symptoms at the higher temperatures then prevailing, however, and it must not be regarded as a sign of recovery. Indeed, in varieties that exhibit leaf ridges, the roughening is often accentuated as the temperature rises.

After flowering time small chocolate-brown blotches or paler, brown streaks frequently develop on the leaves of plants affected with Stripe, and they may reappear year after year on the same individual. The relation of these markings to Stripe disease is uncertain. Attempts by the writer to isolate fungi or other organisms from the brown areas have invariably failed, but apparently identical markings have been found on plants in which the normal symptoms of Stripe were not visible, though they may have been masked. Plants affected with Stripe mature somewhat earlier than healthy ones, and foliage exhibiting the silver-grey stripes usually dies down very rapidly two or three weeks before that of other plants.

Stripe is exceedingly widespread in most cultivated varieties and some, such as Golden Emperor and Minister Talma, are rarely free from it, while almost every individual of some stocks may be affected. Plants of some varieties, including Czarina, show the disease year after year without apparently suffering any ill effects, but the bulbs of most varieties gradually become less vigorous, produce somewhat stunted plants, and eventually cease to flower owing to their reduced size. Once a bulb has become infected it never recovers, and the offsets that it produces are also generally infected, but seedlings are invariably free from the trouble, at least in the first season, even though they may be obtained from affected plants. The symptoms have not yet been detected in the wild Narcissus growing under natural conditions in this country (108).

Other Troubles Likely to be Mistaken for Stripe. (*a*) *Hot-water damage.* Stripe must be clearly distinguished from the leaf injury that may arise during the first season after bulbs

have been given hot-water treatment against eelworm. Such injury takes the form of a mottle of light green, irregular, rounded spots or of leaf roughening similar to that observed in Czarina and other varieties affected with Stripe. This variegation and roughening is restricted, however, to the upper portions of the leaves and does not reappear the following season. Moreover, the ridges are not discoloured and when examined microscopically a tendency to cork formation is seen which is not apparent in the ridges associated with Stripe.

(*b*) The feeding marks of the bulb scale-mite, *Tarsonemus approximatus* var. *narcissi,* visible on the leaves as yellow streaks and blotches often minutely speckled brown, may be mistaken for Stripe, but in addition mite attack gives rise to recognizable symptoms in the bulbs. When a bulb attacked by the mite is cut across minute brownish stains are observed on the cut surface, usually at the angular bends of the scales. If the scales are carefully pulled apart these brown stains appear as narrow brown or yellow streaks running longitudinally down the scales from the neck to the basal plate. No such discoloration occurs in the bulbs of plants affected with Stripe.

(*c*) The severe leaf distortion characteristic of Stripe in King Alfred and other trumpet varieties is in some respects very similar to the symptoms of eelworm disease. The latter can readily be distinguished, however, by the presence of brown rings in the bulbs and by the lumps or " spikkels " on the leaves (see p. 82).

Proof of Virus Origin of the Disease. Among the many suggestions put forward from time to time to account for Stripe, inherent weakness of the bulbs, the use of fresh manure, late planting, waterlogged soil and the effect of cold may be mentioned. It is possible that one or another of these factors may lead to symptoms that have been, and still are, regarded as characteristic of Stripe, but experimental proof has now been obtained that the disease is largely the result of infection by one or more viruses. Griffiths and Jueneman (234) in 1919 regarded it as a Mosaic disease but the first hint that proof of this had been secured did not appear until 1927. In that year a report issued by the U.S. Department of Agriculture (15) contained the statement that investigations carried on in co-operation with the Oregon Agricultural Experiment Station had shown gray disease of daffodils to be an infectious mosaic transmissible artificially by juice transfer. On the other hand, in the Biennial Report of the Oregon Station for 1928-30, published in 1930 (21), it is stated that repeated attempts to transmit the virus of Narcissus Mosaic by one means or another had failed, until in 1929 very successful results were obtained by the use of a simple leaf-mutilation method. Further details of the experiments were given by McWhorter in 1932 (373). From 35-63 per cent. successful transfers were obtained by rubbing juice from affected plants into the leaves of healthy plants through scratches made with a penknife. Meanwhile, in 1928, Atanasoff (39), working in Bulgaria, announced that he had infected very young tulip and Narcissus leaves with sap expressed from affected Narcissus plants and that Narcissus was susceptible to infection

with the viruses of tulip Breaking and hyacinth Mosaic. It was on the strength of this work that Kenneth Smith (571, p. 414) later included Stripe among the diseases caused by *Tulipâ virus 1*.

In England Gould (215), in 1935, reported that in preliminary trials he had failed to infect healthy plants artificially by juice inoculation and by grafting. Caldwell and James (107), in their first article published in 1938, mentioned that they had not succeeded in transmitting the disease artificially, but they were nevertheless of the opinion that it was caused by a virus complex having at least three components. Shortly afterwards Caldwell (108) stated that infection had been obtained by inoculation with a hypodermic needle into the bases of injured leaves. About the same time van Slogteren (558) also announced that artificial transmission had been obtained in Holland by bulb grafting and by sap inoculation.

Spread of Stripe. Although the virus nature of Stripe is now generally accepted, very little is known about the natural spread of the disease. Analogy with virus diseases of other plants would lead one to suppose that the virus is transmitted by means of aphides or other insects, but no evidence to this effect has yet been obtained. It is unlikely that transmission by greenfly takes place because, as far as is known, aphides do not feed on Narcissus plants. In 1932 Hodson suspected (274) that certain species of thrips might act as vectors, but his later experiments (276) with these insects gave negative results. McWhorter (373), on the other hand, believed that natural transmission takes place by contact between injured roots of diseased and healthy plants growing side by side, but his work has still to be confirmed. The former widespread belief that the disease is carried from bulb to bulb during hot-water treatment has been disproved by experiments carried out at Wisley by Gould (215).

Control. In the present state of our knowledge the only promising method of control for Stripe is constant and thorough roguing out of affected plants from the time the leaves are only a few inches high until flowering time. The effectiveness of this method for some varieties has been demonstrated both in the United States (230, 382) and in Holland. Some stocks are so badly affected, however, that it would probably be more profitable to select the Stripe-free individuals and replant them as far away as possible from affected crops. If this operation is carried out with sufficient care, very few Stripe plants should become apparent the following season and, provided these are removed forthwith, a clean healthy foundation stock can be obtained. Where it is desired to retain rare and valuable stocks affected with Stripe, or varieties in which the disease, though present, apparently has no harmful effect, they should be kept at a distance from healthy stocks. Treating the bulbs with

hot water or dipping them in hot or cold solutions of chemicals does not lead to recovery from the disease, as is sometimes supposed (215).

EELWORM DISEASE

(*Anguillulina dipsaci* Kühn)

Although the present publication is not primarily concerned with bulb troubles originating in attacks by insects or other animals, yet, in this country at least, so much confusion has existed up to comparatively recent times between Basal Rot of Narcissus due to *Fusarium bulbigenum*, and the disease caused by the stem eelworm, *Anguillulina* (*Tylenchus*) *dipsaci*, that it appears desirable to include a short account of the eelworm disease here.

Origin of the Disease. A similar eelworm or Ring Disease of hyacinths, known at least as long ago as the middle of the 18th century, has already been dealt with (see p. 14). The Eelworm Disease of Narcissus is a much more modern trouble, but opinions are divided as to the exact time of its first appearance and the country in which it originated. Welsford (672) stated that a well-known grower of bulbs in England believed that he observed it here about 1905 in bulbs of *N. Horsfieldii* imported from Holland. van Slogteren (536), on the other hand, stated that he was practically certain that this could not have been the case, because he was familiar with the disease to which this variety was especially liable (although he did not specify what it was) and it had nothing to do with the eelworm disease. The majority of Dutch bulb growers were apparently of the opinion that the disease was first introduced into Holland from England, but there were some who thought it had originated in Holland from the "old" disease of the hyacinth there. van Slogteren, after pursuing his enquiries, came to the conclusion that the disease probably did not exist in Holland prior to 1910 and that it was introduced from England, where it could not have been present very long before 1909. It may be added that the occurrence of *Anguillulina dipsaci* in Narcissus bulbs in Holland was first recorded in 1888 by Ritzema Bos (77), apparently therefore many years before there were any complaints in that country of an eelworm disease in Narcissus.

There is no doubt that in England the eelworm disease was at first looked upon as being caused by *Fusarium bulbigenum*. The investigations of Welsford (672), in 1917, and Ramsbottom (511), in 1918, clearly showed this to be an error, but they also led to further misunderstanding, because these workers failed to realize the existence of two diseases, one caused by the eelworm and the other by the *Fusarium*. Westerdijk clearly distinguished between them in 1917 (682) but it is only recently that the matter has been settled beyond dispute (see p. 73).

Description of the Disease. Bulbs in which the eelworms are present are not easily detected on superficial examination, or distinguishable from bulbs affected with certain other pests or diseases. When the attack is moderately severe, however, affected bulbs feel soft when squeezed, and some signs of browning or decay may be evident at the neck of the bulb. On cutting the bulb transversely, brown rings are seen.

When planted, badly affected bulbs produce little or no foliage, whilst those less seriously affected develop prematurely, producing leaves which are usually much twisted, bent and distorted. They are pale in colour and on them are to be seen fairly large pale yellow or yellowish-brown areas termed in Holland " spikkels ". These areas can be distinguished readily from spots otherwise similar, owing to the lump or thickening which is felt when a leaf exhibiting them is drawn through the fingers. With the aid of the microscope the stem eelworm in one stage or another of its life history can be detected in the tissues below the skin in such places.

In a field in which the bulbs planted included some originally affected with eelworm, single badly affected ones, showing practically no growth, are usually found in the centre of groups of less severely diseased ones. Those plants nearest the central ones show twisted and yellow leaves, while those towards the outside of the group are more or less normal, apart from the presence of " spikkels ". It is from the centrally situated bulbs that those surrounding it have become infected subsequent to planting. The exact manner in which the eelworms leave the originally diseased plants has not yet been established; but, after entering the soil, they proceed to neighbouring plants and either attack the young leaves as the latter push upwards through the soil or enter the bulb at its most vulnerable part, viz., the soft tissues in the region of the neck. The eelworms that enter the leaves do not migrate down into the bulb but are carried upwards as the leaves elongate and remain localized in the lumps or " spikkels " referred to above. As the leaves age and dry up the eelworms in them become inactive, but as soon as the foliage becomes moist and decayed they revive and pass into the soil. The parasites that enter the neck of the bulb wander downwards into the corresponding bulb scales. Having reached the bases of the scales they enter the basal plate and from this they pass into the bases of other scales, so that ultimately the entire bulb may become involved. The attacked scales assume a dark brown or reddish-brown colour, and as the direct passage of the eelworms from a diseased scale laterally to an adjacent healthy one does not normally occur, an affected bulb, when cut across, frequently shows one or more rings of brown, disorganized scales lying between still white and healthy ones, as already mentioned. Eggs, larvae, and adults of *Anguillulina dipsaci* are present in abundance in the brown disorganized tissues, and can be recognized with the aid of the microscope.

The control of this disease in the field is a difficult matter, but under garden conditions, and where a small patch only in a field is affected, all affected plants should be removed and destroyed as soon as it becomes apparent that they are attacked. Burning is the best method of disposing of such dangerous refuse, and in no case should it be thrown on the manure or waste heap or into the sea, from which it would again reach the land. Disinfection of soil in which the eelworms are present, by means of chemicals or by steam, has been suggested, but such methods of treatment are too costly or of no avail. Where field crops are affected it is best to lift the entire stock as soon as possible and give it the hot-water treatment mentioned below. Infested soil should not be planted with Narcissus again until the eelworm has been starved out, and that may take three or four years. At least 18 months must be allowed to elapse after every stray bulb has been removed, and during the whole period weeds should be kept down by systematic and thorough cultivation.

The best method of preventing the introduction of eelworm into clean land, and of killing eelworms within infected bulbs, is to soak all bulbs before planting in hot water maintained at a temperature of 43½° C. (110° F.) for 3 hours.

The value of hot-water treatment for diseased bulbs appears to have been realized first in connection with the control of Narcissus Flies. In 1902 Saunders (see Wilks 696) suggested, although apparently did not try, steeping infested bulbs for 20 minutes in water at a temperature of about 115° F. In 1911 Theobald (617) announced that good results had been obtained by steeping bulbs for about 10 minutes in water heated to 120° F. In 1915 Fryer (206) after testing various methods of treatment, both chemical and by heat, found that the best means of destroying the larvae of Narcissus Flies in infected bulbs was to steep them for one hour in water kept at a steady temperature of 110° F. He also observed (though he did not publish the fact) that under these conditions eelworms, if present, were destroyed up to approximately 90 per cent. The importance of the matter was not recognized at the time, however, owing to the too ready acceptance of the view that eelworm-affected bulbs had first been attacked by *Fusarium bulbigenum* Cooke and Mass. In 1917 Welsford (672) showed experimentally that the eelworm disease was of a primary character and subsequently the method of heat treatment was developed by Ramsbottom (511) from the point where Fryer left it in 1914. Meanwhile, the existence of eelworm disease had been clearly recognized in Holland in 1915 (92, 682) and attempts in that country to control it by hot-water treatment were begun independently by Maarschalk, according to Ritzema Bos (92) and by van Slogteren (534).

A full account of Narcissus eelworm disease and of the standard Hot-Water Treatment is given in the Ministry's Bulletin No. 51 on *Narcissus Pests*. The essential requirements for an efficient hot-water treating plant and the difficulties met

with in carrying out the treatment are discussed in Bulletin No. 105—*The Efficiency of Baths used for the Hot-Water Treatment of Narcissus Bulbs.*

ROOT ROT

In the Isles of Scilly and in certain parts of Devon and Cornwall some concern is felt about the increasing prevalence of Root Rot, the cause of which is still in doubt. It has also been observed in Lincolnshire and probably exists elsewhere in the country. The disease is widespread in Holland, where it is called " het van den wortel gaan " (" the going-off of the roots ") and a very similar " root-decline " has been reported from British Columbia. It has not yet been carefully studied in this country but abroad it is attributed by some authorities to the fungus *Cylindrocarpon radicicola* Wr. and by others to an eelworm named *Anguillulina pratensis,* while a few believe it to be a result of unfavourable soil conditions. It may ultimately be shown that the term Root Rot is being applied to more than one specific disease.

Historical Review. Root Rot does not appear to have been recognized on Narcissus in Holland until about 1914 (681), though a similar, if not identical, disease in hyacinths (see p. 18) had been known there many years before. In 1916 (11) and again the following year (682) Westerdijk reported that she had isolated *Ramularia macrospora* from the roots of Narcissus plants affected with the root disease and had on several occasions induced rotting of the roots and basal plate by inoculating healthy plants with this fungus. The species in question was probably *R. macrospora* Wr. (non Fres.), a synonym of *Cylindrocarpon radicicola* Wr. The symptoms of the disease were clearly described in 1917 by Ritzema Bos (91, p. 77) who emphasized the resemblance between Root Rot and the " veenkoloniale ziekte " (Grey Leaf) of oats, a disease now known to arise where there is a deficiency of available manganese in the soil. De Wit (702), in 1924, thought the trouble was due to the presence of sulphides in the soil, but his opinion has not been confirmed. An investigation of Root Rot was begun in 1921 at Groningen by Gerretson and his colleagues and a preliminary report of this work (13) was followed by a full account published in 1927 (212). The occurrence of the disease could not be correlated with the physical or chemical nature of the soil and a fungus constantly present in the roots of affected plants was believed to be the cause of it. No attempt was made to isolate or identify the fungus or to carry out inoculation experiments with it, and attention was directed mainly to controlling the disease by soil disinfection. Various methods were tried but steam sterilization and treatment with formaldehyde alone proved to be effective. Feekes also studied the disease in Holland and in the account of his work published in 1931 (199) he stated that *Cylindrocarpon radicicola* Wr. was by far the commonest fungus present in the affected roots. Healthy bulbs in soil contaminated with this fungus became affected with Root Rot and the *Cylindrocarpon* was re-isolated without difficulty from the diseased roots. Feekes therefore concluded that *C. radicicola* was the primary cause of the disease.

A " root decline " of Narcissus, to all appearances identical with the disease observed in Holland, was reported from British Columbia by Hastings *et al.* in 1932 (261). A species of *Cylindrocarpon,* later (257)

identified as *C. radicicola* Wr., and *Anguillulina pratensis* (de Man) Goff. were found associated with it but the presence of the eelworm was regarded as sufficient to account for the diseased condition of the roots. More recently, Hastings and Bosher (260) have shown that *A. pratensis* checks the growth of various kinds of seedlings much more markedly than does the *Cylindrocarpon*.

Root Rot was first recognized in this country in 1929, when material of it was received at Harpenden from the Isles of Scilly. The following year, during a visit to the islands, the writer saw the disease in several places causing dwarfing and paling of *Poeticus ornatus* plants in patches up to 40 yards across. Since that time the disease has undoubtedly been on the increase in Devon, Cornwall and the Isles of Scilly (479, p. 108) and it has also been seen in Lincolnshire. *Cylindrocarpon radicicola* Wr. is almost always present in the affected roots, and has been isolated in pure culture from time to time, but negative results only were obtained in the few inoculation experiments carried out to test its parasitism. Gregory (225, p. 486) also isolated this fungus from dead basal tissues of Narcissus bulbs and from the surface of healthy scales, but was unable to infect basal tissue with it. *C. radicicola* has been recorded on the roots of a wide range of host plants, but the evidence so far obtained for regarding it as the primary cause of disease is not convincing, and for the time being the writer prefers to consider it as at most a very weak parasite. Despite careful examination of many specimens the writer has only once found *Anguillulina pratensis* associated with the disease in England. It occurred along with *Cylindrocarpon* in the roots of affected plants of the variety Granada, collected in the Isles of Scilly in March, 1939. Hodson (274a) has also found it in *ornatus maximus* and *praecox*.

Description of the Disease. The appearance of Root Rot in the field is quite distinct. Patches of ground a few yards across or up to 50 yards or more in diameter occur, in which the plants, though looking healthy apart from a slight pale cast in the foliage, are decidedly dwarfed compared with the plants outside the patches. The leaves of the dwarfed plants are apt to wilt in sunny weather, and they die down prematurely towards the end of the season.

If the plants are lifted the roots are seen to be diseased. In the early stages of attack small reddish-brown spots or stripes are present on the surface of the roots and the tips are brown and dead. As infection proceeds up the roots towards the basal plate the softer inner tissues become completely rotten and soon nothing is left but a number of dead root stubs or a collection of empty, flabby tubes consisting solely of the skin of the root. Plants in this condition can be pulled out of the ground quite easily. Occasionally the rot spreads into the lower portion of the basal plate, giving rise to a layer of dead tissue that can easily be peeled off, but generally speaking the bulb itself is not attacked, though it rarely attains its normal size. Mycelium of the fungus *Cylindrocarpon* can usually be found within the affected tissues, but it is still uncertain whether this fungus is to be regarded as a cause of the rotting or merely as a secondary invader.

Root Rot occurs in light as well as in heavy soil. It is most prevalent in fields where the same crop is grown repeatedly, but it may develop also in virgin soil. The symptoms reappear year after year in the same patches, which slowly increase in size. If the bulbs from an affected patch are lifted and planted in soil where the trouble has not been observed, they usually grow and flower normally. Water-logging of the soil appears definitely to be a predisposing factor in some instances.

The *Poeticus* varieties, particularly *P. ornatus,* are most liable to suffer from the disease, but the Barrii section and trumpets such as Emperor, Glory of Leiden, Madame de Graaf and Victoria are also susceptible. Van Sion (*N. Telamonius* var. *plenus*) and Obvallaris (*N. Pseudo-Narcissus* var. *obvallaris*) are commonly affected, but Jonquils and Tazetta forms appear to be highly resistant.

Little is known about the control of Root Rot and not much further progress can be expected until the true nature of the disease has been established. In Holland (212) steam sterilization of the soil in the patches proved to be effective, but this is impracticable except on a small scale. Satisfactory results were also obtained by treating the beds before planting with a solution of formaldehyde containing 1 or 2 parts of commercial (38 per cent.) formalin in 25 parts of water, applied at the rate of 2 gallons per sq. yard. The application should preferably be made three or four weeks before the bulbs are to be planted. Experience has shown that certain varieties such as Grand Soleil d'Or can sometimes be grown successfully in places where a susceptible variety such as *Poeticus ornatus* has suffered badly.

ROOT PLATE ROT

(Cause unknown)

For many years the name " basal rot " has been used in the Tamar Valley and elsewhere in western England to define a disease, the chief symptoms of which are lack of roots and partial or complete brown decay of the basal plate (277 p. 22, 279). The name naturally led to much confusion between this disease and the entirely different and more familiar Basal Rot caused by *Fusarium bulbigenum* (see p. 72). In 1930, therefore, it was suggested (280 p. 18) that the first-named trouble should preferably be called Root Plate Rot and this term is adopted here.

When bulbs exhibiting Root Plate Rot are planted they either fail to root or produce a few short and very weak roots. As a result of this root failure the bulbs may not produce a shoot above ground, so that gaps are present in the rows. More often a plant is formed but it does not flower, and remains stunted and pale green or yellowish throughout the season. Some plants are rather more vigorous and bloom, but the flower is borne on a short or very short stalk and lying, as it does, well down among the leaves, it consequently attracts attention. Affected plants do not occur in patches but are more or less uniformly distributed among the healthy ones.

The bulb scales usually remain white and sound, and the brown decay is restricted to the basal plate, but mites and moulds sometimes supervene and cause partial or complete rotting of the bulbs (384). Even where no secondary invasion occurs, however, the bulbs remain small and do not multiply. Root Plate Rot is particularly common in Golden Spur, Henry Irving, van Sion (*N. Telamonius* var. *plenus*) and *obvallaris*, but it may also occur in other varieties. Various fungi, and especially *Cylindrocarpon radicicola* Wr. (280 p. 18) have been found associated with the disease but the true nature of the trouble has still to be established. Perhaps soil conditions play a leading part, for the trouble is apt to be much worse in badly drained soil, though there is little doubt that, whatever may be the cause, the disease can be transported with the bulbs.

It is commonly thought that an affected stock will gradually deteriorate if left undisturbed, but will recover if the bulbs are lifted and planted under better conditions elsewhere. Experiments carried out by the writer tend to show that this is not invariably so. In 1931, 500 bulbs, taken at random from a stock of Golden Spur grown in Cornwall and showing 25-30 per cent. Root Plate Rot, were planted in stiff clay soil at Harpenden, and left down for three years. During that period the behaviour of the individual plants was carefully followed. Casual observation suggested that the stock had improved considerably by 1934, but the detailed records revealed that nearly 20 per cent. of the plants still showed Root Plate Rot. The experiment appeared to show that the affected bulbs did not recover to any appreciable extent. The healthy ones, on the other hand, grew and increased normally and this tended to give the false impression that the bed showed a decided improvement. Too much reliance must not be placed on the results of a single experiment carried out in one type of soil, and

further trials, with affected bulbs only, are necessary before any definite conclusion can be reached about the value of transplanting as a means of overcoming Root Plate Rot.

" DEGENERATION "

" Degeneration " is a term commonly used by growers to signify an apparently progressive deterioration in flowering capacity of a " degenerate " stock. Foliage is produced at the expense of flowers and there is a tendency to excessive splitting of the bulb. Damage to the basal plate by Narcissus fly and bulb rotting fungi, and failure to flower following attack by the bulb scale mite (*Tarsonemus approximatus* var. *narcissi*), is undoubtedly responsible to some extent for this, but observations and experiments carried out by the writer on alleged degenerate stocks have revealed another explanation of it. The behaviour of three different stocks of Golden Spur was followed throughout the four seasons 1933-1936. Many of the bulbs in each stock gave perfectly normal flowers but a varying number either failed to flower or produced flowers not unlike those of Golden Spur but of inferior quality and with recognizable differences. Some of them flowered a week or so before and some a week or two after the typical Golden Spur. It was noticed that the inferior flowers were usually, though not invariably, borne on plants having many narrow, grass-like leaves instead of the comparatively few, longer and broader strap-like leaves characteristic for the variety, and it soon became apparent that these abnormal plants were nothing other than rogues. The commonest one was *Narcissus major* var. *spurius*, but Ard Righ (Yellow King) was also recognized.

A selected number of the rogues or " grassy " plants and of genuine Golden Spur plants were staked, and for three seasons careful counts were made of the numbers of flowers and shoots on the individual plants, and of the progeny from them. The Golden Spur plants all flowered well and remained true to type. No " grassiness " was observed and there was no evidence of reversion to an inferior flower or of unusual splitting of the bulbs. The rogues were very shy flowering compared with the Golden Spur and none of them ever produced genuine Golden Spur flowers. Most of them exhibited " grassy " foliage and abnormal splitting of the bulbs, and these characters were reproduced when their progeny was lifted, divided and planted afresh. The plant illustrated in Fig. 34 was derived from a single nosed bulb planted in 1932. In 1934 this plant bore 5 shoots and 0 flowers, in 1935 16 shoots and 3 flowers and in 1936, when the photograph was taken, 27 shoots and

o flowers. As a further illustration of the rapid splitting it may be mentioned that the progeny of 72 rogues planted as " rounds " in September, 1932, consisted of 24 multi-nosed, 26 double-nosed and 262 rounds and offsets when lifted in July, 1934. The corresponding figures for an equal number of Golden Spur planted and lifted on the same dates were 11, 77 and 82 respectively. The flowering results were equally striking. Two hundred " grassy " bulbs gave an average of 0·5 flowers per bulb the first year and 1·3 flowers per bulb the second year down, while the figures for a similar number of true Golden Spur were 1·4 and 2·2 respectively.

The main conclusion drawn from these observations was that the stocks in question did not show degeneration due to the actual deterioration of the individuals composing them. On the other hand they were probably the product of a mass selection and consisted of certain undesirable types (e.g. Spurius, Ard Righ) mixed with a desirable type (Golden Spur). As the undesirable types split up much more rapidly than the desirable type they gradually become predominant and the effect of this, considered in conjunction with the shy flowering of the undesirables, tends to give the impression that the individuals of the stock are actually deteriorating. The only remedy appears to be to rogue out the undesirables during forcing, in the field, or, if possible, during grading. Where the proportion of undesirables is very high it might be more convenient to select the desirables for replanting and discard the remainder.

The question arises whether the " grassiness " in these stocks is analogous to the well-known Broodiness seen, for instance, in Victoria (Fig. 35), but this is thought not to be the case. Genuine Golden Spur, selected from a stock known to contain many " grassy " individuals, showed no indication of developing " grassiness " during the years it was kept under observation. Moreover, the flowers produced by broody Victoria, though smaller, appear to be true to type, whilst the flowers produced on " grassy " plants are invariably quite distinct from those of Golden Spur.

" Grassiness " is therefore not regarded as a form of Broodiness in Golden Spur. It seems more probable that it is an inherent character of one or more distinct varieties producing flowers inferior in quality to, but fairly closely resembling Golden Spur, and sometimes occurring among mass selections of Golden Spur. On the other hand, the inferior forms do not appear invariably to be " grassy ". It may be that " grassiness " is an inherent character of some of these forms but not

of others, or the possibility remains that it may be an " acquired " character, to be interpreted as a form of Broodiness, not in Golden Spur, but in a variety very similar to it.

MISCELLANEOUS

FUNGI. Rusts. Two Rusts have been observed on rare occasions in this country. *Puccinia Schroeteri* Pass. was found on the common double Narcissus (? *N. Telamonius* var. *plenus*) and on *Poeticus ornatus* in Cheshire in 1889, according to Smith (581), and Grove (*British Rust Fungi* 1913, 232) listed it also on Jonquil. In 1922 Grove (239) described a new species of *Coleosporium* found on leaves of *Poeticus ornatus* in Lincolnshire, and he named it *C. Narcissi* Grove. An aecidium observed on *Narcissus Tazetta* in France in 1924 was described by Liou in 1929 (339) as *Aecidium Narcissi* Liou.

Smut. *Urocystis Colchici* (Schl.) Rabh. f. *Narcissi* G. Frag. was recorded on the leaves and scapes of Narcissus in Spain in 1914 (see *Sacc. Syll. Fung.* 23, 1925, 607 where it is erroneously cited as an *Ustilago*). More recently Liro (342) has reported *Tuburcinia* (*Urocystis*) *Colchici* on *N. triandrus* in Spain as a new host record.

Botrytis spp. The diseases caused by *Botrytis narcissicola* Kleb. and by *B. polyblastis* Dows. have been dealt with on p. 67 and p. 69 respectively, and reference has also been made to the presumed occurrence of *Botrytis Tulipae* (Lib.) Lind on Narcissus (p. 23). The common grey mould, *Botrytis cinerea* Pers. sometimes causes leaf and petal spotting in this country (478, p. 67, 479, p. 108, 277, p. 24) and in Holland it is mainly responsible for a " Fire " disease that begins at the tips of the leaves and works downwards (682). An unidentified species of *Botrytis* causing leaf blight and bulb rot of Jonquils was reported from Washington by Heald and Dana (264) in 1924.

Scale Speck. Minute black sclerotia, about 0·1 mm. in diameter, can be found on the outer papery scales and sometimes on the fleshy scales of individual bulbs in almost any stock of Narcissus (Fig. 31). Mrs. Alcock referred to them in 1924 (33) and found that when healthy bulbs were inoculated at the neck with pure cultures of this fungus, they became infected and failed to flower. This experiment has been repeated by the writer but with negative results; the fungus grew on the outer scales but did not interfere with growth or flowering. McWhorter and Weiss (384) in 1932 distinguished two scale speck fungi, a large one and a small one. According to them the larger one produces black sclerotia of pin head size on the superficial scales, mainly of bicolor trumpets, and is probably saprophytic. The small one forms minute sclerotia, scarcely larger than pin pricks, on the papery and fleshy scales of all types of Narcissus bulbs. It develops best under moist conditions and is believed to be parasitic under conditions unfavourable to the normal growth of the bulbs. Drayton has studied a scale speck fungus which produces sclerotia 1-1·5 mm. in diameter on the outer papery scales, and in a preliminary note (180) he has announced that the fungus is a species of *Sclerotinia* which forms stipitate apothecia with discs 3-4 mm. in diameter. Until more is known about these fungi it is not possible to relate them to one another or to the sclerotium, 0·7 mm. in diameter, recorded by Saccardo in 1910 (520) from Italy as *Sclerotium ambiguum* Duby var. *Narcissi* Sacc.

Penicillium bulb Rot. The outer scales often show the blistery markings of Skin Disease if they are kept under moist conditions, and species of *Penicillium* are commonly associated with the blistering (415a, 481, p. 51). These blemishes may render the bulbs unsightly but usually have no adverse effect on growth. Nevertheless, as investigations at Cambridge have shown, *Penicillium* may be responsible for some loss among Narcissus

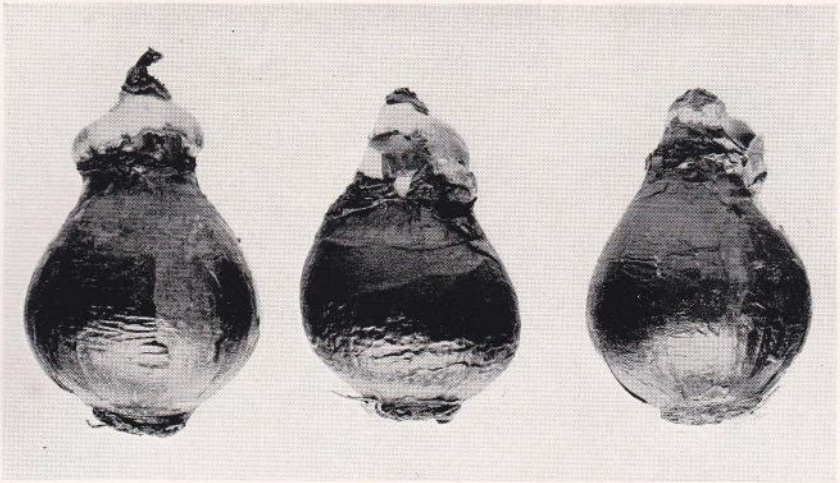
bulbs in storage. A very brief summary of this work appeared in 1926 (561) and Brooks (100) referred to it two years later, but no details have been published. The species concerned is not unlike *P. chrysogenum* Thom. Brooks named it *P. Narcissi* A. Smith but did not describe it beyond stating that the conidiophores are bluish-green in mass, and that it does not form sclerotia. Infection may occur through wounds or through the dead tops of otherwise healthy scales, and the fungus passes down the scale to the basal plate and then upwards into other scales. Artificial infection was secured in a moist but not in a dry atmosphere. Little trouble should be experienced from this rot if the bulbs are dried well on lifting or after hot-water treatment, and are stored in a dry place. A similar rot has been noted by Hodson and Beaumont (282) and, as already mentioned (p. 72), Crawford (146) regarded *Penicillium* as the cause of a basal rot.

Trichoderma spp. In 1930 severe stunting and yellowing of Narcissus foliage in the field in Japan was found by Tochinai and Shimada (629) to be associated with a bulb rot. The decayed portions of the scales were covered with small, cushion-shaped, dark green acervuli, and two fungi, believed to be the cause of the rot, were isolated. These were at first identified as *Sporotrichum Narcissi* n. sp. and *S. radicicolum* Zimmerm., but later the same authors (630 see also 529) decided to rename them *Trichoderma Narcissi* Toch. and Shim. n. sp. and *Pachybasium bulbicolum* Toch. n. sp. respectively. Both fungi were also observed on Crocus, and the first named was found in addition on lily bulbs. It is possible that *Trichoderma Narcissi* is nothing other than the common green mould *T. viride* Pers. ex Fr. (= *T. lignorum* (Tode) Harz), which has frequently been found by the writer growing saprophytically on badly stored bulbs or occurring secondarily on bulbs affected with a parasitic disease such as Basal Rot, or damaged mechanically.

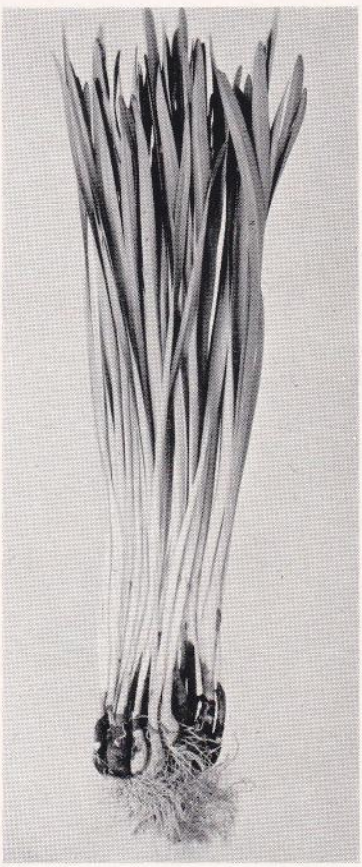
Various. According to McWhorter and Weiss (384) *Sclerotium Rolfsii* Sacc. causes a wet, reddish-brown rot of the bulb scales in the United States, especially in the warmer south-eastern States and in California. *Armillaria mellea* (Vahl) Fr. appears to cause some damage in newly cleared areas in the Pacific Northwest of U.S.A. (384). In this country it was found causing a root rot in Middlesex in 1930 (479, p. 108). An unidentified species of *Pythium* has also been found associated with root rotting in Staffs. and Yorks. A leaf blight caused by *Heterosporium gracile* Sacc. was described by Ritzema Bos in Holland in 1901 (81). The leaves turned yellow from the margins inwards and soon withered, but not before becoming covered with a blackish incrustation consisting of the conidiophores and conidia of the fungus. Bos showed that the disease, which has apparently not been observed more recently, could be controlled by spraying with Bordeaux Mixture.

Septoria Narcissi Passer. occurs on the leaves in Italy, Belgium and Holland, but has not been recorded in this country. A species of *Gloeosporium* was found by Bos (88, p. 127) in 1913 causing a leaf spot in Holland. *Macrosporium caricinum* Fr., as well as *Penicillium*, was found actively associated with a surface blemish of the bulbs by Massink (415a) in 1876. *Verticillium Foexii* van Beyma was isolated from bulbs in Kansas in 1925, according to van Beyma (68) and *Hysterangium Boudieri* Poir. was reported attacking the roots in the Maritime Alps in 1931 by Marchal and Foex (395). *Cylindrocarpon bulborum* Wr. was described on the bulbs by Wollenweber (703, p. 486) in 1931.

The occurrence of various other fungi on Narcissus has been referred to elsewhere, namely:—*Cercosporella Narcissi* Boud. and various species of *Phyllostica* (pp. 62 and 66); *Sclerotium Tuliparum* Kleb. (p. 28); *Rhizoctonia Crocorum* (Pers.) D.C. (p. 147) and *Rhizopus necans* Mass. (p. 48).



33 Narcissus Gummosis (non-parasitic)



34 "Grassiness" in Narcissus

35 "Broodiness" in Narcissus Victoria

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VIRUS DISEASES. Kenneth Smith (571, p. 419) has stated that the jonquil, *Narcissus jonquilla* L., is susceptible to infection by *Allium virus* 1, the cause of onion Yellow Dwarf. An account of Stripe is given on p. 77.

NON-PARASITIC. Soft Rot. Not infrequently large numbers of bulbs in Narcissus consignments exhibit a decay that renders the whole bulb soft and easily squashed between the fingers. The scales are of a dull, greyish-brown colour and the bulbs have a characteristic fetid smell. Mould fungi of various kinds, and especially *Rhizopus nigricans* (384), develop on and in the bulbs, but they are not to be regarded as agents of the decay, which is almost invariably due to overheating in some form or other. Exposure to high temperatures (85° F. and over), lack of ventilation when the bulbs are tightly packed, excessive sunning of freshly dug bulbs and overheating during or after the hot-water treatment may all lead to the development of this type of rot, and the only way to prevent the trouble is to avoid these predisposing factors. As might be expected, Soft Rot is frequently accompanied by Basal Rot (see p. 72) but the two are quite distinct. It is possible that the bulb rot attributed to *Bacillus carotovorus* in England in 1929 (65) was primarily the result of overheating.

If ungreened portions of the young leaves are exposed during cultivation in early spring when the weather is cold, it frequently happens that the exposed parts do not become green and, later on, when the leaves have grown, the chlorotic part is visible as a rather striking yellow band extending across the leaf from one side to the other.

The occurrence of Gummosis in Narcissus has been mentioned on p. 10. The writer has occasionally seen very small " gum pockets " in the inner scales of cut bulbs, but in August, 1938, bulbs of *N. Tazetta* var. *gloriosus* were received from Bristol which showed large swellings in the scales at the necks of the bulbs. (Fig. 33.) The swollen tissues contained gum-like material and no organism was found in them. Four of the bulbs, planted in a pot which was later transferred to the greenhouse, gave vigorous plants that flowered in November, but all the plants were affected with Stripe. When the bulbs were shaken out of the pots in May, 1939, they showed no sign of Gummosis but the outer scales had died back to below the originally swollen parts.

The interrelations of the different factors, such as methods of " preparation ", after-treatment and conditions during and after transit, involved in efforts to accelerate flowering of hyacinth, Narcissus and tulip bulbs destined for forcing, and the non-parasitic troubles attendant upon such processes, have been carefully studied in Holland in recent years. The results of these investigations have appeared in a series of articles published by van Slogteren and his collaborators since 1930 (50-5, 551-7); and part of the work has been summarized by Purvis (506).