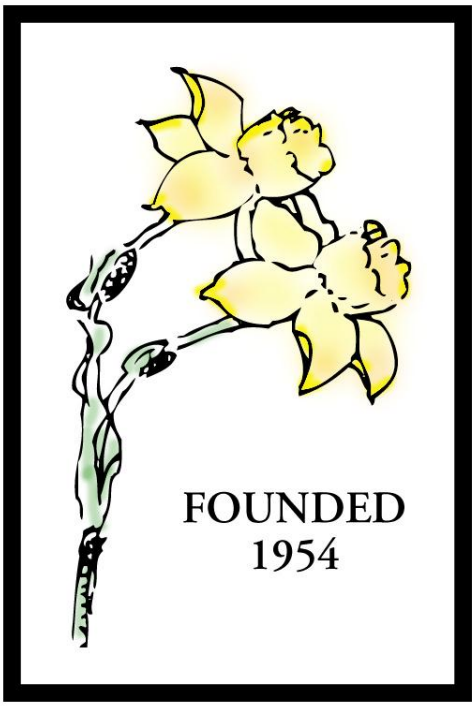
Daffodil Diseases and Pests

Yesterday, Today and Tomorrow

2013 ADS Convention
Columbus, Ohio



Theodore E. Snazelle, Ph.D.
Professor of Biological Sciences
Mississippi College
Clinton, MS 39058

DAFFODIL DISEASES AND PESTS

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I. Why study the maladies of daffodils?

"We see … our plants (daffodils) wither without being able to render them assistance, lacking as we do understanding of their condition."

Fabricius (1774)
Snazelle (XXX)

In order to not feel completely helpless as Fabricius did, we should attempt to learn all that we can about daffodil diseases and pests and how to control them.

II. Definitions:

A. Disease – Disease is simply defined as a departure from a state of health. There are two types of diseases of daffodils:

1. Infectious diseases – An infectious disease of daffodils is one which is caused by a biological agent (i.e. pathogen). Example: basal rot is caused by a fungus.
2. Non-infectious diseases – A non-infectious disease of daffodils is one which is not caused by a pathogen but rather by a non-living agent, e.g. herbicide (Roundup), freeze, and hot water treatment (HWT).

B. Pest – A pest of daffodils is exemplified by organisms such as the large narcissus fly, mites, and slugs.

C. Pathogen – A pathogen is an etiological (disease-causing) agent of biological origin, e.g. fungus, virus, nematode.

D. Sign – The actual presence of a pathogen on a bulb or leaf as seen by the unaided eye, e.g. pinkish-white growth around the basal plate of a diseased daffodil bulb is the basal rot fungus; hence, the sign of a disease.

E. Symptom – A symptom of an infectious disease is the visible effect of the pathogen on the susceptible cultivar, e.g. blackened (necrotic) scales near the basal plate is a symptom of the basal rot fungus.

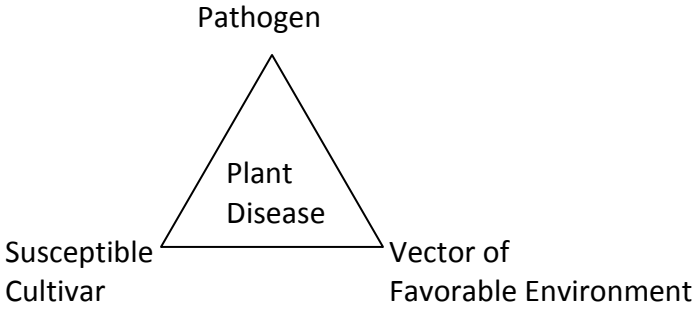
F. Vector – A vector is a biological agent which carries the pathogen from a diseased plant to a healthy plant, e.g. an aphid.

III. Plant Disease Triangle:

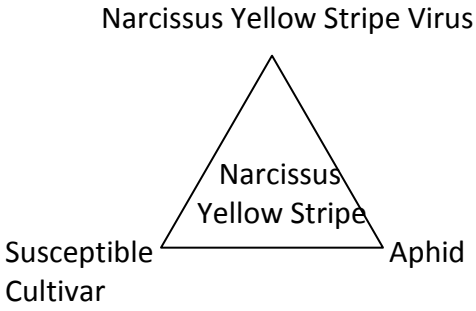
The infectious plant disease triangle illustrates that at least three factors are involved in infectious plant disease:

a. Pathogen
b. Susceptible cultivar or species
c. Vector or favorable environment

A. Plant Disease Triangle

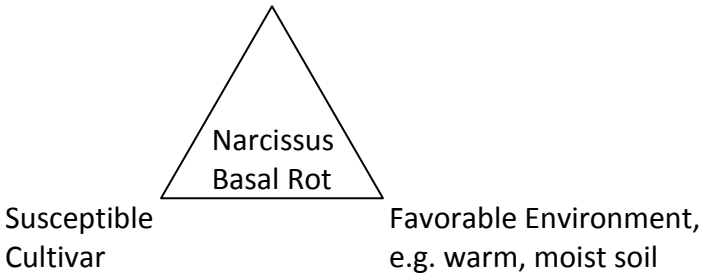


B. Plant Disease Triangle – Narcissus Yellow Stripe



C. Plant Disease Triangle – Narcissus Basal Rot

Fusarium oxysporum f.sp. narcissi



D. Principle of Plant Disease Control

The principle of plant disease control involves attempting to break the plant disease triangle at one or more points. If the triangle is broken at one or more points, then there will not be a plant disease. For example, in the plant disease triangle for narcissus basal rot, control of the basal rot fungus with a fungicide breaks the triangle and basal rot does not develop. In the case of both narcissus yellow stripe and narcissus basal rot, one possible control measure involves the use of resistant cultivars. Of course, the plant breeder will have to provide the resistant cultivars through a specialized breeding program. With regard to vector control, the use of a nematicide might be effective in control of the nematode vector of the tobacco rattle virus which infects narcissus. Where environmental conditions are concerned, control may be a little more difficult; however, in the case of basal rot, delay in planting until the soil cools (below 54°F) reduces the chance of the bulbs becoming infected by the basal rot fungus.

IV. Fungal Diseases of Narcissus:

A. Narcissus Basal Rot

Narcissus basal rot is just one of several fungal diseases of narcissus; however, it is clearly the most important of these diseases.

1. Pathogen – *Fusarium oxysporum* f.sp. *narcissi*
2. Infection – The basal rot fungus seems capable of infecting bulbs at three different times:
   a. Infection may occur in wounds created in the basal plate of the bulbs as new roots emerge in the fall. Thus, the basal rot fungus is usually considered to be a wound pathogen.
   b. The basal rot fungus may be able to infect the bulb via dying roots at the end of the growing season.
   c. The basal rot fungus may be able to infect the bulbs via wounds which occurred during lifting of the bulbs at the end of the growing season.
3. Symptoms and Sign – The major <u>symptom</u> of an infected bulb is necrotic (brown) scales emanating from the bulb's basal plate. An important <u>sign</u> of infection is the presence of the fungus as a pinkish-white growth around the periphery of the basal plate. The appearance of distorted, yellowed leaves and flowers which are distorted <u>may</u> indicate basal rot. Of course, the failure of foliage to appear in a two-year-down bulb may indicate that it succumbed to basal rot.
4. Control
   a. Control measures:
      Avoid high nitrogen fertilizers
      Plant in well-drained locations
      Practice crop rotation
      Soil sterilization, e.g. solarization, soil fumigant (dazomet [Basamid]), etc.
      Buy healthy bulbs from a reputable grower
      Avoid susceptible cultivars, e.g. bulb-rotting white daffodils

Plant resistant cultivars, e.g. St. Keverne 2 Y-Y
Use fungicides, e.g. thiophanate methyl (Cleary's 3336)

b. Fungicide dips:
    i. Pre-plant dip – Soak bulbs in thiophanate methyl (1.6 – 2.4 ounces/10 gallons water) for 15 - 30 minutes at 80 – 85^{o}F and plant while still wet.
    ii. Post-plant dip – Wash bulbs and give a thiophanate methyl dip as before (i). After dipping the bulbs, hang the bulbs (in mesh bag) to dry in a well-ventilated storage area.

B. Fire
    1. Pathogen: *Botryotinia (Sclerotinia) polyblastis*
    2. Infection: Spores (ascospores from apothecia produced by sclerotia in the soil or on debris from last year's crop) infect the flowers. Spores (conidia) produced on the flowers infect the stems and leaves below the infected flowers.
    3. Symptoms: Primary infection of the flowers causes spots to form and ultimately the whole flower may wither. Secondary infection by spores produced on infected flowers causes lesions (spots) on the leaves and stems below.
    4. Control: Remove and destroy infected flowers. Foliar spray with thiophanate methyl, chlorothalonil, iprodione (Chipco26019 [not registered for use in California]), contact fungicide.

C. Scorch
    1. Pathogen: *Stagonospora curtisii*
    2. Infection: The fungus survives the winter on neck scales of bulbs. As leaves emerge from the bulbs, they become infected (primary infection). Secondary infection results from spores produced on the primarily-infected leaves.
    3. Symptoms: Leaf tips of the first leaves to emerge are brown and this discoloration may extend down one third of the leaf; looks like freeze damage. Secondary infection results in lesions (spots) on other leaves and on flowers. Scorch is said to be quite common in the Southeastern U.S.
    4. Control: Foliar spray with thiophanate methyl, chlorothalonil, etc.

D. Smoulder
    1. Pathogen: *Botryotinia (Sclerotinia) narcissicola*
    2. Infection: Primary infection of leaves occurs because spores are produced by sclerotia on the neck of the bulbs. Infection of the leaf tips occur when the leaves emerge through the neck of the bulb. Spores (conidia) produced on the tip of the primary infected leaf cause other leaf infections and flower infections as well.
    3. Symptoms: Brown-black leaf tips which may bear masses of conidia (sign) are seen in primary infections. Secondary infections result in additional spots on leaves and flowers.
    5. Control: Foliar spray with thiophanate methyl or iprodione (Chipco26019 [not registered for use in California]), contact fungicide.

V. Viral Diseases of Narcissus

There are at least seventeen or eighteen different viruses which are known to infect narcissus. By definition, a virus is an infectious macromolecule which can replicate (reproduce) itself only inside living cells. Capsid shapes of plant virus virions are usually isometric ("spherical") or helical (flexuous rod or rigid rod). Virion is the term used for a single virus particle. A virion usually consists of two parts – 1) nucleic acid – usually RNA in plant viruses, and 2) capsid – the protein coat which encloses the RNA.

A. Narcissus Yellow Stripe
   1. Pathogen: Narcissus Yellow Streak Virus (NYSV)
   2. Infection: NYSV is transmitted to healthy narcissus foliage by aphids which had previously fed on a NYSV-infected plant.
   3. Symptoms: The major symptom is conspicuous yellow stripes on the foliage. Another symptom in some cultivators is colour breaking in the flowers, e.g. the appearance of white streaks in the yellow perianth, etc.
   4. Control: Rogue and destroy all bulbs showing conspicuous leaf symptoms of NYSV infection.

B. Narcissus White Streak
   1. Pathogen: Narcissus White Streak Virus (NWSV)
   2. Infection: NWSV is transmitted to healthy narcissus foliage by aphids which had previously fed on a NWSV-infected plant.
   3. Symptoms: Foliage symptoms begin first as purple stripes at the tips of the leaves some 3-6 weeks after flowering and finally become white stripes.
   4. Control: Rogue and destroy all bulbs showing NWSV infection.

C. Narcissus Mosaic
   1. Pathogen: Narcissus Mosaic Virus (NMV)
   2. Infection: NMV is transmitted from diseased to healthy plants by NMV-contaminated cutting knives and cultivating tools.
   3. Symptoms: Mild mosaic, e.g. small, alternating light and dark green areas on both foliage and flower stems. NMV is now known to be responsible for colour break in blooms or reverse bicolor daffodils.
   4. Control: Rogue infected bulbs and destroy them. Disinfect cutting tools with paper towels saturated with rubbing alcohol (91% isopropyl alcohol).

D. General Effects of Virus Infection
   1. The cultivar deteriorates for a period of years, e.g. NYSV.
   2. The bulb yield is reduced, e.g. NWSV.

E. Virus Symptoms

   Symptoms in virus-infected plants may vary because of several factors:
   1. Differences in genotype (genetic makeup of the plant) may alter symptom expression from what might be normally expected, e.g. in some cultivars the symptoms of NYSV are often masked.
   2. Environmental conditions, e.g. temperature, soil pH, fertility, etc., may alter the symptom expression for a given virus.

3. A virus complex, i.e. an infection caused by two or more viruses, may be virtually impossible to diagnose because of the synergistic effect (1 + 1 = >2) on symptom expression.

F. Summary of Control of Narcissus Viruses
   1. Nematode-transmitted viruses are controlled by roguing and soil fumigation.
   2. Aphid-transmitted viruses are largely controlled by roguing.
   3. Mechanically-transmitted viruses are controlled by rogue and by disinfection of cutting and cultivating tools, e.g. rubbing alcohol (91% isopropyl alcohol), etc.

G. Control of narcissus viruses
   1. Control of aphid-transmitted viruses in the future ***may*** be accomplished by spraying with a combination of canola oil and pyrethrins (Pyola) spray.
   2. Control of narcissus viruses may someday be accomplished by breeding genetically-resistant cultivars.

H. Meristem culture

   Although not a control measure, meristem culture offers the attractive possibility of recovering desirable cultivars of which no known virus-tested stocks exist.

VI. Nematode Diseases of Narcissus

There are only three species of nematodes (eelworms) which cause problems in narcissus. Firstly, and most important, is the bulb and stem nematode, *Ditylenchus dipsaci*. Secondly, there is the root lesion nematode, *Pratylenchus penetrans*. Lastly, there is the rare bulb and leaf nematode, *Aphlenchoides subtenuis*.

A. Bulb and Stem Nematode
   1. Pathogen: *Ditylenchus dipsaci*
   2. Infestation: The bulb and stem nematode moves through the soil to infest healthy bulbs; there they invade the young leaf tissue and young flower stems. As the season progresses, the bulb and stem nematode will move down to infect the bulb. The source of the original bulb and stem nematodes which caused the infestation is usually a previously infected bulb which has disintegrated completely.
   3. Symptoms:
      a. Foliage and flower stem symptoms. The first symptoms of the bulb and stem nematode in leaves and flower stems are small, localized swellings which are often chlorotic (yellow). These swellings are called spickels or spikkels. The swelling characteristic of the spickel seems to be due to breeding of the nematodes in these spickels.
      b. Bulb symptoms. There are several symptoms displayed by a bulb which is infested with the bulb and stem nematode:
         i. Concentric rings of brown or necrotic scale tissue can be seen in infested bulbs where successive cross-sectional cuts are made beginning near the bulb nose and proceeding toward the basal plate. Brown or necrotic areas only at the angles of the rings suggest bulb scale mite infestation and not infection by the bulb and stem nematode.
         ii. Separation of the basal plate from the bulb is a symptom of bulb and stem nematode infestation.

iii. "Nematode wood," a dried mass of nematodes, may appear on the basal plate looking like tufts of cotton. "Nematode wool" is actually a sign of disease rather than a symptom. The presence of "nematode wool" should not be confused with the basal rot fungus.

4. Control: There are several control measures for the bulb and stem nematode:
   a. Hot water treatment (HWT). The preferred control measure for the bulb and stem nematode is hot water treatment of the bulbs for 3 hours at 112°F (44.4^{o}C). HWT kills the bulb and stem nematodes.
   b. Rogue and destroy all obviously infected bulbs.
   c. Buy bulbs only from reputable growers.
   d. Crop rotation. Don't plant bulbs in an area for three years where bulb and stem nematodes are known to have been. In the intervening period, non-bulbous flower crops, lettuce, potatoes, etc., can be planted. The idea behind crop rotation is to starve the nematodes to death.
   e. Fumigation. Sterilizing the soil with dazomet (Basamid) will rid soil of nematodes.

B. Root Lesion Nematode
   1. Pathogen: *Pratylenchus penetrans*
   2. Infection: The root lesion nematode attacks roots early in the growing season; it does not invade the bulb. The root lesion nematode persists within the soil.
   3. Symptoms:
      a. The root lesion nematode causes small, dark, slit-like lesions on the roots.
      b. The only foliage symptom is retarded growth because of the root damage.
      c. Root rot sometimes occurs because of a secondary infection by the fungus *Cylindrocarpon radicola*.
      d. Bulbs lifted from patches of stunted daffodils are smaller than those from areas where the root lesion nematode isn't present.
   4. Control:
      a. Unlike the bulb and stem nematode, HWT is ***not*** the preferred control measure for the root lesion nematode. Rather, soil sterilization with a nematicide such as dazomet (Basamid) will help control the root lesion nematode.
      b. Biological control of the root lesion nematode might be accomplished by over planting a daffodil bed with African marigolds, *Tagetes erecta*; root secretions from the marigold suppress the population of root lesion nematodes. Where possible, the same suppressing effect may be achieved by tilling the residue of the marigolds into the soil.

VII. Pests

The major pest of narcissus is the large narcissus fly, *Lampetia equestris*. Other pests of narcissus include the small narcissus fly, mites and slugs.

A. Large Narcissus Fly – *Lampetia (Merodon) equestris*
   1. Life History: The adult narcissus fly is about ½ inch in length and resembles a small bumblebee. In the spring, the female adult fly lays her eggs singly on daffodil foliage near the ground level. After about two weeks, the egg hatches and the larva moves down the outside of the bulb and enters the bulb through a pin size hole it creates in the basal plate. Once inside the bulb, the larva devours the inside of the bulb and increases dramatically in size. Winter passes with the larva inside the bulb. Early the next spring, the larva moves out of the bulb, either through the neck of the bulb or through the original hole in the basal plate into the soil. There it forms a puparium (pupal case) just under the soil's surface where the larva transforms into a puparium. After about 5-6 weeks, the adult fly emerges from the puparium to begin the cycle again.
   2. Symptoms:
      a. The pin hole in the basal plate is the primary symptom of infestation by the large narcissus fly.
      b. The major symptom of infestation by the large narcissus fly is a single, large larva inside the bulb.
   3. Control:
      a. The preferred means of control of the large narcissus fly is HWT for three hours at 112°F 44.4°C; the heat kills the larva present in the bulb.
      b. The only insecticide labeled in the USA specifically for control of the large narcissus fly is trichlorfon – Dylox®. Trichlorfon is applied as a rate 2 ounces/gallon/100 feet of row as a direct stream to the base of the daffodil foliage at the beginning of fly activity and should be repeated annually.

B. Small Narcissus Fly – *Eumerus* species

   The small narcissus fly, *Eumerus* sp., is a secondary pest of narcissus, i.e. its larvae usually invade only previously diseased bulbs, e.g. bulbs infected with the basal rot fungus. The small narcissus fly differs from the large narcissus fly in that the small narcissus fly lays its eggs in clusters on the foliage rather than singly. Also, the bulb infested with the small narcissus fly larvae will contain numerous small larvae instead of the typical one large larva as is the case of the large narcissus fly. Since the small narcissus fly is a secondary pest, no recommendations for its control are made.

C. Mites

   There are two mite species which are known to infest narcissus bulbs:
   1. Bulb Mite: The bulb mite, *Rhizoglyphus echinopus*, is a secondary pest as it invades only bulbs which were previously injured or diseased, e.g. basal rot.
   2. Bulb Scale Mite: The bulb scale mite, *Steneotarsonemus laticeps*, is a primary pest of greenhouse-forced narcissus bulbs. Necrosis in the area of the angular spaces between scales of a bulb cut in cross section is a typical symptom of infestation by the bulb scale mite. Typical leaf symptoms of the bulb scale mite are distorted leaves with scars and flower stems with a "saw edge." HWT as for

the large narcissus fly and the bulb and stem nematode is the recommended control procedure for the bulb scale mite.

D. Slugs and Snails - The common garden slug and snails can be a pest of narcissus as they tend to devour the flowers as they feed at night. Slug damage is often greater in wet, warm weather than when it is dry. Usually, control of slugs has been accomplished by broadcasting pellets of metaldehyde in the garden when conditions are warm and moist. Metaldehyde is toxic to pets and wildlife. Escar-Go**!** is a safe alternative to metaldehyde as it is not toxic to pets and wildlife. The active ingredient is 1% iron phosphate. When Escar-Go! granules are consumed by slugs and snails, they stop eating, become less mobile, and die within 3 – 6 days. If the soil is dry, wet it before applying Escar-Go!. Apply Escar-Go! granules evenly on the soil at about 1 lb per 1000 to 2000 sq ft (½ to 1 teaspoon per square yard). Escar-Go! granules not consumed disintegrate into the soil.

VIII. Disease and Pest Control for Today and Tomorrow

A. Today - Biological control of plant parasitic nematodes and soil borne fungi:

1. MeloCon WG® & SoilGard12G® can be used independently or in combination in a program as a methyl bromide alternative to control nematodes and soil borne fungi :
   a. MeloCon WG® is a granular formulation of the fungus *Paeliomyces lilacinus* strain 251 that attacks all stages of plant parasitic nematodes . . . eggs, larvae, and adults.
   b. SoilGard 12G® is a granular formulation of spores of fungus *Gliocladium virens* strain Gl-21 (aka *Trichoderma virens*) that is effective against many soil fungi including *Fusarium oxysporum*.
2. DIEHARD™ (Flower Bed) is a formulation of endomycorrhizal fungi (*Glomus* species) and nitrogen fixing, phosphate solubilizing, and growth promoting bacteria. DIEHARD™ (Flower Bed) also contains several species of *Trichoderma* that attack fungi such as *Fusarium oxysporum*. A variation on DIEHARD™ (Flower Bed) is DIEHARD™ (BioRush) which is basically the same as DIEHARD™ FLOWER BED except for fertilizer (NPK) and 671 times as many CFUs (colony forming units) of *Trichoderma* species as DIEHARD™ FLOWER BED.

B. Tomorrow – GM (genetically-modified) Daffodils

1. Daffodils with the Bt gene – Imagine new daffodil cultivars containing the Bt gene that codes for a larvicidal protein (Cry9C) that kills the large narcissus fly larva as it feeds on a daffodil bulb. Science fiction? No, the Bt gene is already found in some GM maize (corn) cultivars to control ECB (European corn borer), the most important insect pest of maize, causing over a billion dollars a year to the USA and Canadian maize crop. The Bt gene comes from the bacterium, *Bacillus thuringiensis.*

2. Daffodils with an interferon gene – The gene for an antiviral protein (interferon-α-2a) has already been cloned to produce a protein called a cytokine which is being used to treat humans with hepatitis B and hepatitis C, both caused by viruses. Perhaps GM daffodil cultivars possessing an interferon gene will be available some day that produce an interferon that blocks replication (reproduction) of NYSV and NMV!
3. Basal Rot Resistant/Immune Daffodils – Perhaps the gene or genes for basal rot resistance might someday be cloned from the highly basal rot resistant *N. jonquilla* and inserted into highly desirable daffodil cultivars. Imagine! No more basal rot!!