Disease control with pathogen-free bulb

EASTER LILY IMPROVEMENT

FIELD PRODUCTION OF HEALTHY EASTER LILIES FOR FORCING

(1). BULB DIPS: Eliminating root and bulb disease organisms from planting stocks does not ensure the elimination of the disease complex from field grown lilies. Healthy planting stocks need protection from reinfection. The most effective single method of giving protection has been dipping scales, bulblets, and bulbs in PCNB-ferbam before planting. This dip was recommended for the reduction of root and bulb rot before disease-free stocks were available. It has been consistently effective since that time and no better material for use as a preplanting dip for field lilies has yet been found. The original recommendation was 2 lbs of the regular formulation of each material in 100 gallons of water for about 15 minutes. Stirring is necessary to keep the materials in suspension. Some growers use higher concentrations to avoid the replacement of the fungicides removed by treating successive batches of bulbs in the same lot of dip.

(2). BULB STOCKS: Maintain a mother-block of clonal material. A clone consists of plants descended from a single bulb. The growth characterstics and productivity of each clone are known. The mother-block material is maintained true to type and healthy by regular selection and pesticidal treatment of the best bulbs for the next year's mother-block. They are planted in soil that has not previously grown lilies and has been fumigated against nematodes (and possibly simphyllids, fungi, and bacteria).

(3). SPECIAL STOCKS: First year—Soon after flowering, scale a large enough batch of bulbs from the mother block for multiplication to the desired acreage of forcing size bulbs. Treat the scales in hot water with 1 in 200 formaldehyde at 110 to 112°F for 1 hour and dip in PCNB-ferbam before planting. Deep planting is necessary to obtain single stems and bulblets. Shallow planting produces leaf-bearing scales and divided bulblets. Second year—Dig the first year crop, sort into bulblets and yearling size bulbs (if any). Before planting, give bulblets hot water treatment at 110 to 112°F for 1 hour if there is danger from foliar nematodes, and treat with PCNB-ferbam. Third year—Treat with PCNB-ferbam before planting. Under reasonable growing conditions the great majority of bulbs produced will be of forcing size.

First year bulbs of yearling size are treated as second year yearlings, and any forcing-size second year bulbs can be shipped for forcing.

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AN INQUIRY INTO the root and bulb diseases of Easter lilies, begun in the 1950's, has involved the whole lily-bulb industry in radical changes. Growers cooperating with University Extension and Experiment Station research workers field-tested methods developed in the laboratory and useful changes were quickly accepted by growers. Improved planting stocks were introduced, methods of propagation have been radically altered, and cultural practices have been changed. Improved methods of disease control have made many of these advances possible.

Root and bulb diseases were described over 10 years ago in CALIFORNIA AGRICULTURE. Basal roots become rotted, growth is reduced, diseased bulbs become rotted and fall apart, or become yellow and blemished (see photos). Bulbs once took a year longer in the field to reach forcing size than they do today. Diseases carry through to the forcers' greenhouses, reducing bud count and quality, and increasing the difficulty of obtaining uniform plants that bloom at Easter.

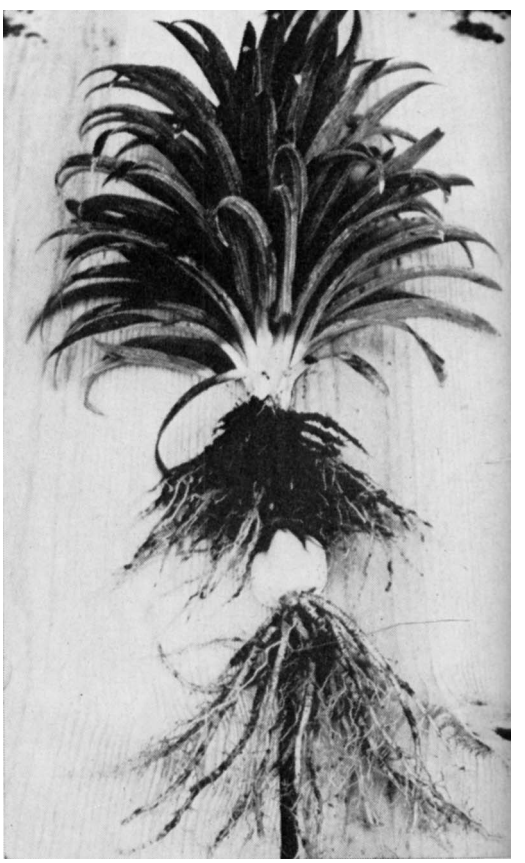
Causes of root and bulb rot

A complex of organisms is involved in lily root and bulb rot including fungi, bacteria, and nematodes. Individual symptoms of the root and bulb disease complex can seldom be ascribed to a single organism. In this study, emphasis is on the fungi and bacteria. The various forms of nematode injury demand separate description, and in farming practice need additional control methods.

Pathogenic fungi and bacteria isolated from lesions on field plants (bulbs, underground stems and roots) are: fungi, *Fusarium oxysporum*, and *Pythium ultimum*; bacteria, *Pseudomonas* of the fluorescens type.

Inoculations have reproduced basal rot symptoms with *Fusarium* isolates, the symptoms being those of the classic disease, described years ago by Imle. Basal rot may also be produced by *Pseudomonas*. Very susceptible seedlings have developed basal rot symptoms in the field from natural infection with *Pseudomonas*. Rotting affects the basal plate of the bulb and the basal portions of the outer scales, which fall away from the bulb when it is lifted. Rotting of the roots occurs, and is sometimes very severe. *Pythium* also causes root rot, and this may be the major disease under greenhouse conditions. Resistant spores of *Pythium* occur in damaged areas on the

Young Easter lily plant from a small disease-free bulblet, grown one season in fumigated field soil. Both basal and stem roots were vigorous and free from lesions. No loss of basal leaves.



stocks for

outer bulb scales, but *Pythium* is not a major cause of bulb rot in the field.

Pseudomonas and *Fusarium* may combine in the same lesions. Strains of *Fusarium* that are relatively harmless by themselves can increase the extent and severity of rotting due to *Pseudomonas*. There is a wide range of symptoms caused by *Pseudomonas*, alone or in combination with *Fusarium*, and the symptoms are sensitive to temperature and soil moisture. They include scale tip rot of the variety Croft and glassy tips of bulb scales in Ace; stem lesions, either browning of the surface, infection of natural stem cracks, or deep penetration and girdling under very wet conditions. Tiny lesions are sometimes produced on developing leaves inside bulbs, and the leaves emerge above ground twisted, with very small dead spots on the concave side. Leaf tips may also be infected.

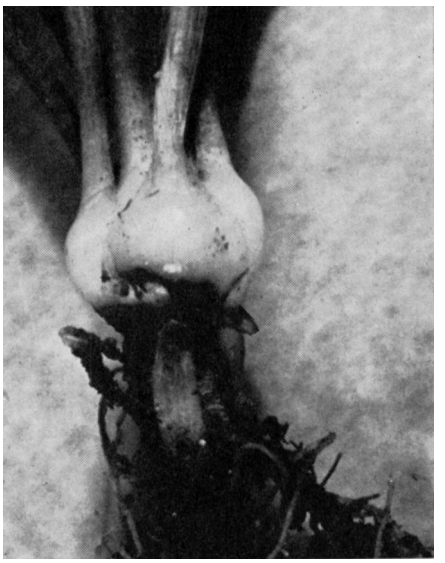
Twist symptom

The twist symptom appears during forcing in greenhouses, but over the years the most widespread damage associated with *Pseudomonas* in forced lilies is the shrivelling of basal leaves, which may occur when the roots are apparently healthy. In affected plants, examined microscopically, bacteria were found inside the stem about an inch above the basal plate near damaged water conducting vessels. Presumably damage caused by the bacteria reduced the water supply to the lower leaves, causing them to die.

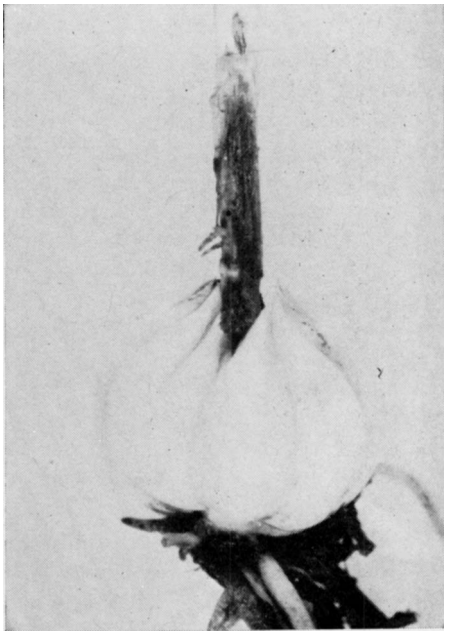
Fungi that may or may not be damaging can be isolated regularly from yellow or slightly damaged bulb scales, roots, and stems. Among them are milder strains of *Fusarium oxysporum*, *Rhizoctonia* sp., *Cylindrocarpon radicicola*, and possibly *Idriella lunata*, which is known as part of the strawberry root rot complex.

Isolates

Certain isolates of *Cylindrocarpon* that are barely capable of tissue invasion around wounds can prevent *Pseudomonas* from infecting bulb scales. Mild strains of *Fusarium* may compete with the basal rot *Fusarium*. Other antagonistic organisms, such as *Trichoderma*, invade dead lily tissues, and may compete with one or more of the disease producing organisms in the lesions.



Bulb basal rot on a small plant grown from a bulb scale. A rotting scale and root are separating from the bulblet.



Close-up of stem lesion. Outer scales removed to show white inner scales.

Healthy bulb stocks

Because the lily root and bulb rot problem is a disease complex rather than a disease, the problem of control has been approached by attempting to get healthy planting stock rather than by attempting to cure the diseases singly. The first principle applied in obtaining planting stock of Easter lilies free from root and bulb rot was to treat and propagate from the best plants of a variety. The final decision concerning which were best was made by growers in their own fields. The initial choice of single plants depended on relative health and vigor, size, number and quality of flowers, and maturation period. All plants of commercial varieties seem to carry at least one virus. Foreseeing the difficulty of getting and maintaining virus-free stocks, plants were chosen

Field grown Easter lily plants, variety Croft, at flowering stage from an average commercial planting, 1955–56 season. Loss of roots and some basal leaves and yellowing of bulbs were evident long before harvesting.

containing mild strains of virus causing no symptoms. Later, if freedom from all viruses seems desirable, proven stocks may possibly be freed through nutrient agar cultures of microscopic stem tips. Tip cultures of Easter lily plants have been produced, but freedom from virus and superiority of the cultured stocks have not yet been proven.

Pathogen-free stocks (i.e. free from fungi and bacteria) were obtained by culturing single bulb scales in test tubes on nutrient agar. Plants derived from a single carefully chosen bulb were kept in a separate group (clone). Unblemished bulb scales from a bulb were selected, trimmed top and bottom with a sharp knife, treated at 125°F for 30 minutes in water containing 1 in 200 parts of formaldehyde, cooled rapidly, surface-sterilized 2 or 3 minutes in 1 in 10 hypochlorite solution, and placed under sterile conditions in tubes (slants) of potato-dextrose agar gel. If any organism, pathogenic or not, was left on or in the scale, it became visible by growing onto the agar gel. All such scales were discarded. At first the yield of sterile scales was 0 to 50 per cent. When bulbs developing from sterile scales and planted in sterilized soil were again scaled and cultured, the yield went up to 80 or 90 per cent sterile.

Scales cultured

Thousands of scales were cultured, grown in pots, and pathogen-free plants were sent to northern California and grown in the field. The cultured plants were the first foundation stocks. They inspired growers to choose the best bulbs from their own fields, treat them with hot water and pesticidal dips, scale them, and plant the scales directly in the field. These produced bulbs of moderate size, excellent in health and conformation. Starting bulb stocks from scales of chosen and treated bulbs has become the routine commercial method for maintaining healthy Easter lilies. This method can only be applied to healthy bulbs; scales from infected bulbs rot in the ground or produce infected and unthrifty plants.

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VEGETATIVE MAPPING

with false-color infrared aerial photography

. . . and comparison with black and white

DONALD T. LAUER

This study was made to determine the extent to which the species composition of timber stands and other types of vegetative cover could be interpreted from high-altitude, small-scale, vertical Ektachrome Infrared Aero photographs. Comparisons were also made between interpretations of conventional black-and-white panchromatic aerial photography—used extensively throughout the world by agriculturalists and foresters—and those derived from color infrared photography (a false-color tri-emulsion layer reversal film type originally developed for military purposes). Results indicate that while color offers only a slight increase in interpretation accuracy (at an added cost) over black and white, other factors involved may be even more significant. These include considerable savings possible in man hours and labor costs through the possibility of faster and less fatiguing analysis by the interpreters.

THE 1,460-ACRE AREA used in this study is a woodland-chaparral-grassland forest within the California coastal range in close proximity to the University of California, Berkeley campus. Predominant vegetation types are: (1) *Sequoia sempervirens* (coast redwood), (2) *Pinus attenuata* (knobcone pine), (3) *Pinus radiata* (Monterey pine), (4) *Eucalyptus globulus* (blue gum eucalyptus), (5) mixed hardwood (big leaf maple, madrone, buckeye, coast live oak and California bay), (6) chaparral (coyote brush and chamise), and (7) annual grasslands.

Coast redwood

Lumber from coast redwood that is produced in the northern coastal counties of California is the mainstay of the economy of that region. Valuable stands of redwood grow in large pure stands principally on the alluvial flats and lower side slopes of the drainage networks. The timber producers within the area are concerned with obtaining accurate inventory data about the location, distribution and number of these important timber stands. This study may lead to a rapid and accurate means of inventorying redwood in this region of California.

Monterey pine, knobcone pine and eucalyptus are less commercially important than redwood, but serve as valuable forest cover types, improving the water retention capacity of watershed lands throughout the arid western United States. Range managers and cattle ranchers are continually seeking accurate survey data on the location and extent of major vegetation cover types (grassland, brushland, and timberland) in the areas they must manage.

Procedures

Optimum photographic specifications were determined for the region and a