Root Rot of Easter Lilies

preplanting fungicidal dip for lily bulbs reduces incidence of disease and improves bloom quality and quantity of plants

J. G. Bald, Philip A. Chandler, John V. Lenz, R. H. Sciaroni, and A. O. Paulus

Clean, white Croft lily bulbs—once a dull yellow—that are now coming from the soil give evidence of a great change in growth, productivity, and quality of Easter lilies, that influences the practices of field growers, brokers and forcers and produces better flowering plants.

The change in color of bulbs from yellow to white is a visible result of the control of the root rot disease caused by a mixed population of fungi, nematodes, and mites carried on the bulbs and in the soil. Those organisms rot the basal roots of the young plants—before their function of feeding the leaves and stems is fully accomplished—and force the plants to depend on later-formed stem roots, which in turn may begin to rot before the flowers and bulbs reach proper size.

The diseased condition of the plants was seen first as a decline in bud count, quality, uniformity, and an increase in leaf scorch on lilies forced in greenhouses. No single pathogen seemed to be responsible. The difficulty of sorting out pathogens from among the variety of organisms carried on the bulbs and roots was matched by the difficulty of finding known disease-free bulbs for inoculation trials. Therefore, a study of lily root rot was initiated in an attempt to produce healthy plants with bulbs and roots free from disease-producing organisms.

As the first step, laboratory studies were made of disease and pest control methods and applied—in a complicated schedule—to 23 of the healthiest available Croft lily bulbs. One thousand scales detached from the subject bulbs were used for propagating tiny bulbils, and 3,500 of the bulbils were planted in pots of sterilized soil for growth and study in an experimental greenhouse.

The second step in the laboratory studies was taken after sizable bulbs had been produced by the bulbil plants. Bulbs with the least evidence that they might carry harmful organisms were hot-water treated, and scales from them were surface sterilized and propagated aseptically in tubes containing nutrient agar. The nutrient medium encouraged and revealed the growth of any fungus or bacterium remaining in or on the scales. Those yielding no sign of growth on the medium —more than 50% in some instances— were held until bulbils were formed; the bulbils were removed, planted in pots of sterilized soil, and grown in the greenhouse.

Improved flower and plant quality result of new disease control practices.

The second step has provided the stocks of Croft lily for future critical work and ultimately for distribution to growers.

The first step provided stocks—not entirely pathogen-free, but of superior quality—for work in fields and commercial greenhouses. All obviously diseased plants were eliminated by careful sorting before some of them were sent to the field or used for further propagation. Less than one plant in 1,000 had symptoms like those of any well defined disease. The bulbs of three plants had Fusarium basal rot and effects of root rot were noticed on about 15% of the plants. The fungi *Fusarium* spp.—including *F. oxysporum*, and *Pythium ultimum*—were isolated from the root rot affected plants. The fungus *Rhizoctonia solani*, which caused much of the yellow discoloration of bulb scales, was practically eliminated by hot water and fungicides, but was recovered from untreated bulbs. *F. oxysporum*, *P. ultimum*, and *R. solani* were used in inoculation trials and shown to be pathogenic. Other fungi have been isolated frequently from diseased roots, but have not been tested for pathogenicity. Pathogenic nematodes have been identified from field soil and from Easter lilies with root rot and also species of mite capable of attacking bulb and root tissues.

Results of Field Trial

Size and condition of 40 harvested bulbs and root systems from Ace lilies given a preplanting dip of PCNB-ferbam, compared with 40 bulbs from untreated checks.

Treatment	Bulbs		Root system	
	Mean size inches	Color	Mean rating*	Number undamaged out of 40
Dipped in PCNB-ferbam	8.2	Predominantly white	3.7	28
Not dipped	7.5	Yellow	2.9	10

* Maximum value, 4, represented no obvious root rot symptoms.

The first of the small plants from treated bulb scales—about 1,600 in all—were sent from Los Angeles to Humboldt and Del Norte counties during the early summer of 1955. They were planted in plots of field soil fumigated with methyl bromide to destroy soil-borne pathogens. A few plants were set out in untreated soil in plowed-up pasture land or in old lily fields. The Croft lilies planted two seasons in methyl bromide treated soil retained their health and grew with exceptional vigor. Those planted in old lily land rapidly degenerated. In untreated land that had not grown lilies before there was some increase in root damage, but in general the plants remained healthy and vigorous.

The extra vigor of healthy plants in clean soil—although not yet measured accurately—has been so striking that it has been suggested that should stocks of equal quality become generally available it will be necessary for growers to recast their cultural programs to allow for the reduced period required to attain forcing size.

To supplement the long-range experimental program, a study was made of a preplanting fungicidal dip for lily bulbs. From earlier work with other bulbs it seemed that a mixture of two quarts of lysol and two pounds of ferbam in 100 gallons of water, was suitable for trial on lilies. It was tested against thiram—Arasan—and mercurial dips, and was found harmless to the plant tissues and more effective than the other materials. At the same time, trials were under way in San Mateo County and at Los Angeles to test pentachloronitrobenzene—PCNB —which soon replaced lysol in the mixture.

Toward the end of 1954 a mixture of two pounds PCNB and two pounds ferbam in 100 gallons of water was used in

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effectiveness is based on contact action in addition to actual feeding.

In making the bait the apple pomace and bran were thoroughly mixed, the endrin added and mixed, then the oil and amyl acetate were sprayed into the dry ingredients as the entire mixture revolved in the mixer. When the oil was warmed a better coverage resulted.

Endrin Oil-base Bait Used in Control Experiments

Ingredients	Amounts/100 pounds bait
Endrin 75% W.P. (1% actual)	lbs. 1.33
Apple pomace	48.335
Bran	48.335
Oil (heavy grade spray oil)	2.00
Amyl acetate	50 ml

Asparagus culls dipped into a 2% endrin suspension also were effective in killing cutworms when scattered on the beds at the rate of 300 pounds per acre.

Tests on McDonald Island during 1956 indicated that baits and sprays of endrin, toxaphene, DDT, dieldrin and heptachlor were not too effective when used under cool conditions when the cutworms were not active. In other tests there were also indications that baits were not readily selected if the soil was too warm and the cutworms remained at a greater depth in the soil.

Commercial applications during 1957 demonstrated the value of a 0.75% endrin bait of the type used in the experiments. A bait was applied on May 10 at the rate of 40 pounds per acre by air to a field where 100% damage occurred. On May 16, a bed area 100′ long produced 67 dead worms, and only 1.2% damage to spears. In a second field 20 pounds per acre of the same bait was applied on May 15 in an area where 30%–40% damage occurred. On May 16 a total of 11 dead worms were found per 100′ of bed and damage dropped to 28%. Some of the damage occurred prior to use of the bait.

Apparently 20-40 pounds per acre of endrin oil-base bait will give good control and 4–5 days are necessary for complete kill.

Endrin baits are effective in controlling small darkling ground beetles—*Blapstinus* spp.—in asparagus. In addition, they have been used effectively in the control of cutworms and darkling ground beetles affecting seedling corn, sorghum, tomatoes, and other vegetable and field crops.

Endrin baits should not be used around leafy vegetables and should be used in all cases in such a way as to avoid contamination of plant parts. If used properly no residues should occur on edible portions of vegetables.

W. Harry Lange, Jr., is Professor of Entomology, University of California, Davis.

Stanley F. Bailey is Professor of Entomology, University of California, Davis.

John P. Underhill is Farm Advisor, San Joaquin County, University of California.

WATER

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quantity of water used. This fundamental distinction between the price components gives rise to numerous possible lines of economic influence. The specific nature of that influence will be governed to a large extent by the relative magnitude of the components of the payment complex. Such a case may be exemplified by an instance of development activities that provide a water supply suitable for agricultural use but where there are individuals within the service area who—although they do not use directly the water provided by the developing agent—are subject to assessment. Any shift of the incidence of the total payment complex from individuals using water to those who do not use it, would represent an economic advantage to the users.

The nonprofit nature of watershed organizations and irrigation districts means that in any one season the total revenue target can be fixed on the basis of estimated expenses for the following year, capital allowance, and other pertinent financial obligations. If that part of the total revenue represented by tolls and assessments is considered as a fixed amount for a given season, increase in the total receipts from sales will reduce the total receipts from assessments.

More particular types of economic effects may be defined. For example, economic advantage for a water using group which has alternative supplies available would result from a large assessment component so long as the total payment complex was less than the variable cost of an equivalent supply. If the total complex were greater than the cost of alternative supply, however, a high fixed cost component would constitute an economic detriment in that the decision on the part of the water user will be made on the basis of the size of the relative variable costs entailed in obtaining water from both sources.

The payment complex is appropriately constituted to be used as an allocating device. Individual decisions about water use will be based on the variable costs. The relevant variable costs will depend upon the nature of the decision, the planning horizon of the individual involved, the physical relationships entailed in the water use contemplated, and their changes over time.

On the other hand, the fixed cost component of the payment complex is suited to provide a source of revenue. Assessments are designated on a property value basis and, in general, do not affect water use.

In a sense, the total payment complex has components that enable it to be purposefully used in allocating water as well as an instrument of revenue.

Michael F. Brewer is Assistant Specialist in Agricultural Economics, University of California, Berkeley.

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forcing trials. The following season it was tested in the field. Two years after the first successful trials a schedule of hot water treatment and dipping in PCNB-ferbam was widespread among field growers of lilies. Approximately 90% of Easter lily bulbs planted on the northwest Pacific Coast for the 1956–1957 season were dipped, the majority in PCNB-ferbam. Where treated bulbs were planted in clean soil, the plants were more vigorous, retained their green color after flowering, basal roots survived, and the harvested bulbs were white rather than yellow.

At the end of 1956 a few bulbs derived from the treated bulb scales were large enough for a preliminary forcing trial. In a commercial greenhouse 7″ bulbs averaged more than four flowers, 8″ bulbs more than five, and 9″ bulbs more than six. The color and form of the foliage and the freedom from leaf scorch were outstanding. Commercial bulbs of equivalent sizes gave at least one flower less.

A comprehensive forcing trial is continuing to check the preliminary results. The continuing trial includes comparisons between relatively pathogen-free Croft and Ace stocks and commercial stocks, including the healthiest available and others carrying such an amount of disease as was common two or three years ago.

The improvement in field-grown Easter lilies already attained has been such that it was easier to find the better stocks for the test than it was to find stocks considered average or typical a few years ago.

J. G. Bald is Professor of Plant Pathology, University of California, Los Angeles.

Philip A. Chandler is Principal Laboratory Technician, University of California, Los Angeles.

John V. Lenz is Farm Advisor, Humboldt County, University of California.

R. H. Sciaroni is Farm Advisor, San Mateo County, University of California.

A. O. Paulus is Extension Plant Pathologist, University of California, Riverside.