Fungicidal dips for Easter lily bulbs

A recent experiment involved dipping Easter lily bulbs in fungicides after the lilies were brought into the packing house from the field, but before they were packed for shipping. The experiment demonstrated the usefulness of dipping bulbs in Benlate before packing, and substantiated a number of earlier experiments with chemicals for forcing Easter lilies and for controlling disease.

. . . treatment before shipment

J. G. BALD · A. O. PAULUS · J. V. LENZ

Photo 1. Easter lily plants showing basal and stem root. **Above,** no treatment. The basal roots were rotting and only partially renewed; stem roots were copious, but on plant to right they were rotting. There were some dark lesions on the bulbs. **Below,** bulbs treated with Benlate before packing. Both root systems were healthy, and the amounts of basal and stem roots were evenly balanced. Only one minor bulb lesion was visible, on plant to left.

TRUBAN, BENLATE and a similar material, Topsin M, were tested as fungicidal dips for Easter lily bulbs. They were used singly and in the following combinations: (1) no treatment (check); (2) Truban; (3) Benlate; (4) Benlate plus Truban; (5) Topsin M; (6) Topsin M plus Truban. Rates of application were: Benlate 50W, 4 oz per 100 gal water; Topsin M 50W, 4 oz; Truban 30%, 4 oz. The same rates were used for the combination treatments. Period of dipping was 5 minutes. The bulbs were Ace yearlings, unsorted and somewhat variable in size. After dipping they were partially dried and packed in moistened peat in standard shipping boxes.

Dipping and packing were done on October 18, 1972. The boxes were labelled and left in the unheated packing shed until November 20, 1972. They were then opened and the bulbs examined. Since there were no obvious differences between treatments, random samples of bulbs from all treatments were put in plastic bags, taken to the University of California, Riverside, and stored in the bags at 50°F. Such storage conditions were calculated to favor disease development, but they also favored premature sprouting, a shorter growing period and reduced bud count. Thus the dipping treatments were severely tested by unfavorable storage conditions. Greenhouse conditions during forcing were uniformly good.

On January 8, 1973, the bulbs were examined, weighed, planted deeply in 6-inch pots, and arranged on the greenhouse bench in randomized blocks.

Forcing dipped bulbs

In the central trial, five blocks of 18 Easter lilies each, variety Ace, were divided among six treatments. A number of plants equivalent to two blocks, includ-

Photo 2. Bulbs and basal roots of a plant from an untreated bulb. Nearly all fibrous roots are destroyed. Recently emerged main roots developing lesions—see arrow.

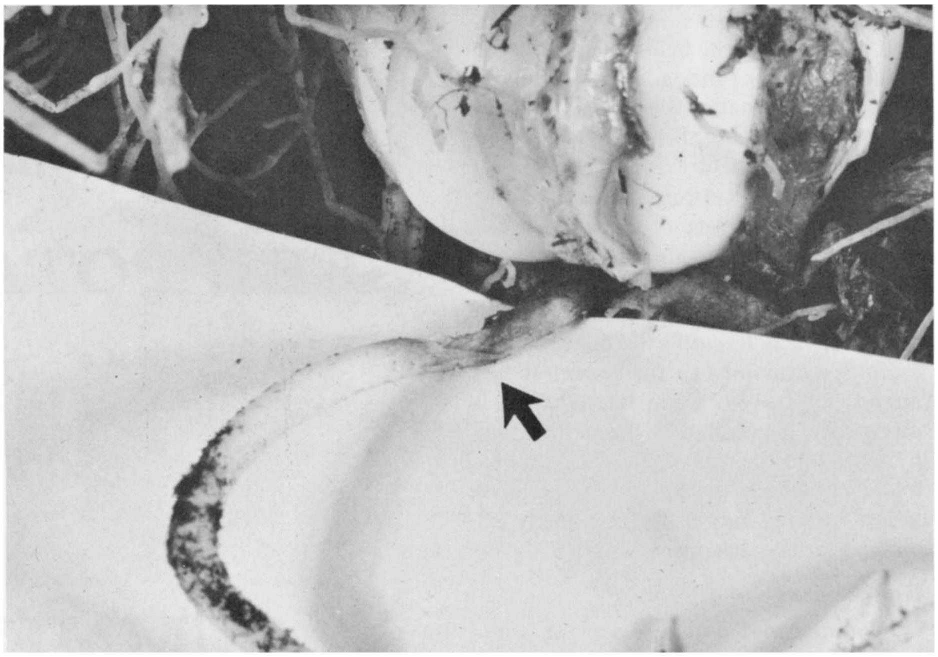

Photo 3. Single root emerging from a bulb; the root is rotted through near the base (arrow). Rotted bulb scale on right.

ing all treatments, were used as buffers against edge effects and for occasional sampling. Table 1 shows bud counts for 15 plants in each treatment. Benlate appeared to be the best treatment. The increase over the check was just significant.

A possible basis for the difference in bud counts was seen when the soil was washed away from the roots and bulbs of three plants of each treatment in one block of the trial. Lesions on roots, bulbs, and stems were rated according to number and severity, and the combined ratings for each plant were averaged (see table 2). Additional ratings from plants outside the main trial gave comparable results. Benlate was outstanding in giving the healthiest root system (see photos 1, 2, 3). Truban combined well with Topsin M, but not with Benlate. These results were statistically significant.

When cultures were made from root and bulb lesions, *F. oxysporum* grew out of the diseased tissue in nearly all instances. In this trial it appeared that Benlate was acting mainly against *Fusarium*. In other trials *Pythium* might be the main pathogen and Truban the effective fungicide. Indeed, *Pythium* may have been present on the roots during this trial, but relatively inactive, because growing temperatures were not too high and soil drainage was good. Plants were left in the pots until the tops died back and new basal roots grew out. Soon after they appeared they rotted, except where the original bulb had been treated with Truban alone. Mixed with Benlate or Topsin, Truban had no effect. In this trial only Benlate alone or Truban alone had a protective effect on the roots. Mixtures were no better than untreated controls.

Organisms

Earlier trials and experiments indicate that several organisms may be involved in root and bulb diseases of Easter lilies originating in the Pacific Northwest. (This discussion does not take account of nematodes, which are in a separate category, and are unaffected by such materials as Benlate and Truban.) *F. oxysporum*, the species of *Fusarium* attacking lilies, has mild and severe variants. The mild ones by themselves cause little more than yellowing of the outer bulb scales and underground stems. The severe variants can cause root lesions which girdle and kill the large basal roots (see photo 3); they can also cause milder root lesions, and basal, side and tip rot of scales (see photo 2), and stem lesions.

When either the mild or severe variants of *Fusarium* are combined with a second pathogen, a bacterium, *Pseudomonas* sp., they may cause very severe rotting. The symptoms of *Pseudomonas* alone, under greenhouse conditions, may be restricted to scale tip rot and minor lesions on the outer scales. Thus, by reducing *Fusarium* one reduces the impact of *Pseudomonas*, although this may not apply in the field under cold and wet conditions, where severe stem lesions and other damaging symptoms may be due primarily to *Pseudomonas*.

Two other pathogens are *Pythium ultimum* and *Rhizoctonia solani*. *Pythium*, a water mold, has been isolated from field infections, but is most damaging as a root rot in the pots planted with Easter lilies for forcing. Truban suppresses this and other water molds. *Rhizoctonia* now appears to be of minor importance, possibly because of the widespread use of PCNB in the dip for field-grown lilies. Nevertheless, it has been found attacking bulbs under abnormal conditions of storage.

Shipping

After packing, bulbs are shipped in the cartons to forcers. They are held as far as possible under cool conditions, but growth and development continue in the apparently dormant bulbs. These processes produce heat. Temperatures may rise inside the cartons to levels favorable for the development of *Fusarium* and other organisms on or in the bulbs. Root and bulb pathogens may penetrate from dead tissues and surface inoculum or spread in the living tissues. Protective treatment with fungicides seems a logical

TABLE 1. TOTAL BUD COUNT ON 15 ACE LILIES GROWN FROM BULBS DIPPED BEFORE PACKING IN BENLATE OR TOPSIN M, USED SINGLY OR PAIRED WITH TRUBAN

	Benlate	Check	Topsin M
Used singly	26	34	26
Truban added	26	25	31

TABLE 2. MEAN RATINGS FOR LESIONS ON ROOTS, BULBS, AND STEMS OF 3 PLANTS IN EACH TREATMENT FROM ONE BLOCK OF THE EXPERIMENT SUMMARIZED IN TABLE 1.

	Check	Benlate	Topsin M
Used singly	11.0	5.3	9.3
Truban added	9.0	10.0	7.7

step. Dipping later, before planting the bulbs in pots for forcing, may be too late. PCNB plus Ferbam, so effective as a dip for field-grown lilies, has generally failed if applied just before forcing. It penetrates very well between the scales, but it stays on the surface of the tissues.

Benlate can follow a pathogen into the tissues, and probably acts on *Fusarium* inside the bulb and roots. With *Pythium*, the problem is less difficult, because *Pythium* lives mainly in the tissues it has already destroyed. Dead tissue is often more easily penetrated by fungicides than living tissue. Reports of successes in controlling *Pythium* with Truban, applied before forcing, may be at least partly explained on this basis.

Root damage

Often the root system of a plant is unbalanced by disease rather than destroyed (see photo 1). Foliage symptoms may result from this lack of balance, because of the arrangement of vessels conducting water from the roots to the foliage. Basal roots are directly connected to the basal leaves. Stem roots arise in clumps from the nodes, and are connected with the leaves and flowers more or less directly above them. The ascending stream of water and nutrients can cross from one channel to another in the stem, but under stress the leaves directly connected with injured roots cannot compete for water and nutrients with the leaves that are linked directly with healthy roots. In consequence, they yellow and die, leaf scorch symptoms may appear on leaves that are less severely affected, and even some buds may abort (blasting). Often a few small basal leaves die, and, as other roots take over from those that were damaged, further symptoms on the foliage are checked.

A grower can control disease in some degree by cultural practices, such as planting bulbs near the bottom of the pot, so that a length of root-forming stem will grow up into soil rather than air. He can provide the plants with adequate nutrition, careful watering, and controlled temperature and light. These are indispensable for growing symptom-free plants, but they are not the ultimate solution for the disease problem. Direct measures, such as dipping, for disease control are also needed.

J. G. Bald is Professor Emeritus of Plant Pathology and A. O. Paulus is Extension Plant Pathologist, University of California, Riverside. J. V. Lenz is County Extension Director, Humboldt County.

Soil conditioning and SEED POTATO HANDLING *are keys to survival of* SUMMER PLANTED PO

H. TIMM · J. C. BISHOP · V. H. SCHWEERS · W. R. CORRIN

R. E. VOSS · J. W. PERDUE · L. J. CLEMENTE · D. B. GRIMES

THE RELATIONSHIP between soil physical condition and plant stand vigor was partially revealed in a report of studies 10 years ago. Additional information is now available on seed potato performance and on cultural adaptations that affect plant survival during high temperature planting conditions. The respiratory response of seed potato pieces to conditioning procedures was measured in the laboratory. At the same time the influence of soil conditioning and soil moisture on potato seed piece survival and plant emergence was investigated in the field.

Kennebec potatoes, harvested in late May, were placed into controlled temperature storage of 20°C (68°F) and held there until two weeks before planting. Sufficient time had elapsed for seed to break rest, and sprouting was evident.

One half of a lot of whole potatoes was cut into 43 to 57 g (1½- to 2-oz) pieces two weeks prior to planting and replaced at 20°C (68°F). These pieces were designated as "old" cut seed. The other half was cut into seed pieces 12 hours before planting, and designated as "fresh" cut seed. Seed pieces from each were planted the following day at the U.S.D.A. Cotton Research Station, Shafter. Sufficient amounts of conditioned seed were set aside for use in a respiration study under controlled temperature conditions in the laboratory. Apical and basal seed pieces were kept separated. While potatoes were being cut it was observed that a number of them were infected at the stem end with dry rot. Infected seed pieces were sorted out. However, it became apparent during the laboratory study that not all seed pieces were free of infection.

Respiration

Fresh and old cut seed were each divided into two lots. One lot in burlap bags remained undisturbed in storage at 20°C (68°F) for 12 hours, while the other lot in burlap bags was loaded onto a pick-up truck and transported for 12 hours with air temperature between 20°C and 35°C, while being protected from the sun. After the 12-hour period, seed pieces from 20°C storage and from the truck were redivided again. One lot of seed from each handling treatment was placed at 30°C (86°F) and the other at 35°C (95°F) constant temperature. The evolution of CO_2 from respiring seed was monitored for 144 hours in a continuous ventilated system.

Essentially similar patterns of respiration were obtained at each of the two