designed by installing a main line lengthwise, dividing the area of the containers into two sections. The containers on each side of the main line are then watered by flexible tubing of 1/8-inch inside diameter. The tubing is connected to the main line by a tap (see sketch), and is fastened to the container either by a clothes pin or hook. The water flows out to the container through an adjustable nozzle, as shown in sketch. By turning the pin at the end of each nozzle, the flow can be turned off completely or adjusted to apply any desired volume of water. The table shows the flow of the nozzle adjusted to its highest application at different pressures. When a container is sold, the unused nozzle is turned off and left on the ground.

NOZZLE DISCHARGE AT VARIOUS PRESSURES

Pressure (PSI)	Flow (GPM)
2.5	0.108 poor discharge
3.0	0.127*
4.0	0.135
5.5	0.190
10.0	0.215
15.0	0.285
20.0	0.340
30.0	0.380
45.0	0.485
60.0	0.570

*Minimum pressure requirement in laterals

The system is operative up to 60 PSI (pounds per square inch). However, best operation is obtained when the pressure at the valve is less than 30 PSI. The size of the main line is dependent upon the number of containers to be watered and the available pressure. The main design factor to remember is to have no less than 3 PSI pressure at the end of the main line. If 3 PSI pressure is maintained at the end of the main line, any number of containers can be watered from the same main line. The cost of the system amortized over 10 years is 7 cents per can per year.

The system can be operated either manually or automatically. To operate the system automatically, tensiometers, electrically wired and connected to a controller, are installed in the root zone of the containers. When the tensiometer gauge reaches a preselected reading of soil dryness, a signal is sent to the controller which turns the valves on. The two valves shut off automatically after the plants are watered for a preselected period determined by the nurseryman.

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Chemical Control Of Pythium Root Rot In Ornamentals with Dexon and Terrazole

A. H. MCCAIN · T. G. BYRNE

Dexon controlled damping-off and root rot of zinnia seedlings caused by Pythium ultimum when used as a drench at 27 to 70 ppm in solution (or incorporated in the soil at the rate of 55 to 110 ppm). However, the drench at 70 ppm and soil preparation at 110 ppm controlled the disease for one month under the conditions of the tests reported here. More chemical was needed when incorporated with the soil (110 ppm = 6.2 oz per cubic yard) than when it was used as a drench (2.5 gal of 70 ppm solution per cubic foot = 0.9 oz per cubic yard). If soil is steamed or chemically fumigated, periodic drenches of 70 ppm at one-month intervals are suggested to prevent reinfection by Pythium root rot. Terrazole controlled Pythium damping-off and root rot when incorporated into the soil at the rate of about 55 ppm (3.5 oz per cubic yard). Terrazole is not yet available for use on ornamentals.

WATER MOLD ROOT ROT caused by species of *Pythium* and *Phytophthora* is a continuing problem to growers of container-grown plants. These fungi are common to all soils and attack the roots of many plants. A disease situation occurs when a significant number of roots are rotted or when the base of a plant is girdled by an infection.

Water molds are killed by heating or chemically treating soil but they are so prevalent that recontamination is a common occurrence. When this happens root rot is usually more severe in treated soil than nontreated soil. Many saprophytic microorganisms which compete with, and limit the growth of, *Pythium* and *Phytophthora* are eliminated when soil is steamed or chemically fumigated. Treatment with chloropicrin, methyl bromide, SMDC, DMTT, and other materials does not eliminate as many saprophytic microorganisms as does steaming at 212°F. Lower temperature treatment with steam-air mixtures also leaves many beneficial saprophytic organisms. However, water mold root rot can be very severe even in soils given these treatments.

Dexon (p-dimethylaminobenzenediazo sodium sulfonate) which is now in wide use in California by the ornamental plant industry is a particularly effective chemical for the control of water mold fungi. Precise information on the minimum effective dosages is not available. A series of experiments were conducted in the Department of Plant Pathology greenhouses at the University of California, Berkeley, to determine the minimum effective dosage (concentration and time interval between applications). Terrazole (5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole), a new fungicide not yet available for use on ornamental plants, was also tested.

Zinnia elegans var. California Giant (Ferry Morse) was used as the test plant in the experiments described in this report. Ten seeds were planted per three- or four-inch pot. Counts of emerged seedlings were made two weeks after planting. *Chrysanthemum morifolium* var. Iceberg was also used in the experiments to determine phytotoxic levels, but was not sufficiently susceptible to water mold root rot under the conditions that existed in the greenhouse to be used as a test plant for pathological studies.

UC mix (50% fine sand, 50% peat, plus nutrients) was used in all the experiments with the exception of those involving soil mixes. The air-dry weight of the mix was 70 lb per cubic ft. Inoculated mix was initially prepared by mixing pure cultures of *Pythium ultimum* with UC mix. The inoculum level was maintained for subsequent experiments by adding sterile mix to the inoculated control pots and growing zinnia seedlings in the mix. This resulted in a natural but high population of the fungus.

Laboratory isolations from diseased seedlings from various treatments were made periodically during the course of the experiments to assure that other disease fungi were not present. *Pythium ultimum* was the only parasitic fungus recovered from the diseased seedlings.

Phytotoxic levels

Virtually all chemicals, even fertilizers, are toxic to plants if used at high levels. On the other hand, there is usually a nontoxic level for even the most poisonous substance.

Increasing amounts of Dexon were incorporated into a disease-free (noninoculated) mix or used as a drench on planted zinnia seeds and chrysanthemums to determine phytotoxic levels. Dexon caused no appreciable reduction in germination or in growth when drenched on zinnias and chrysanthemums at 70 ppm or less. Germination was slightly delayed and stunting occurred at 350 ppm. Higher concentrations resulted in stunting of roots and top growth accompanied by interveinal chlorosis. All plants with the exception of those receiving the highest concentration (2800 ppm) recovered and subsequent growth was normal.

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Drench concentrations

A single Dexon drench was applied to zinnia seeds planted in inoculated mix. Three consecutive crops of seedlings were grown in the same treated soil. The second crop was planted 21 days after the first and the third crop 41 days after the first. A single Dexon drench (27 to 70 ppm) controlled *Pythium* damping-off and root rot of zinnia seedlings. Dexon also exhibited residual activity. The data suggest 70 ppm as a minimum concentration for long-lasting control. Lower concentrations of Dexon might be acceptable for soils with inoculum levels lower than those used in this study.

Soil incorporation

Fungicides are frequently incorporated into soil and potting mixes prior to planting. This is often the most satisfactory method for using water-insoluble fungicides such as PCNB. Soil incorporation is convenient and in some cases has proved a successful substitute for steam or chemical fumigation. Soil incorporation of fungicides may also offer better disease protection than the drench method. Increasing amounts of Terrazole and Dexon were incorporated into noninoculated and inoculated soil to determine the effective level for disease control and levels at which phytotoxicity occurs.

Terrazole was found safe for use with zinnias and chrysanthemums at 53 ppm in the soil (3.6 gms of 60% active per cubic foot or 3.4 oz 60% active per cubic yard). *Pythium* root rot and damping-off were controlled at 27.5 ppm. Partial control occurred at 13.8 ppm.

Small amounts of Dexon incorporated in the planting mix (soil) controlled damping-off caused by *Pythium*. Higher levels of Dexon in the soil were necessary for control of the root rot phase of the disease. The optimum rate of Dexon as a soil amendment for the control of the damping-off phase of *Pythium* disease appears to be 55 ppm (3.1 gm 70% active per cubic yard).

Many soil characteristics such as pH, particle size distribution, organic matter content, moisture-holding capacity and physical structure, may influence the action of a fungicide in the soil. An experiment was conducted to determine whether Dexon is as effective in a mix containing soil as in a mix containing only fine sand as the mineral fraction. The soil mix consisted of ¼ Dublin clay loam, ¼ peat and ½ fine sand. The mixture was steamed prior to inoculation with *Pythium ultimum*. The inoculated growing media were drenched with a 17.5 ppm Dexon solution. The noninoculated media were drenched with 35 ppm to prevent pythium root rot. A less-than-optimum concentration of drench was selected for use on the inoculated media to distinguish any differences present between the soil and UC mix.

Dexon was found as effective in a light soil growing medium as in UC mix. These data indicate that *Pythium* disease may not only become very severe in light, well drained growing media such as UC mix but may, in fact, become more severe in UC mix than in a soil mix.

Residual activity

The purpose of another test was to determine the residual activity of Dexon and Terrazole. UC mix inoculated with *Pythium ultimum* was combined in equal volume with a previously inoculated mix to which fungicide had been added 31 days earlier. One crop of zinnia seedlings had been grown in the fungicide-treated mix prior to this test. The combined mix was then planted to a second crop of zinnias. Both Dexon and Terrazole were shown to have residual fungicidal activity (see table). The residual activity of Dexon is good, with indications that soil incorporation of 110 ppm will prevent *Pythium* root rot for a period of one month in UC mix. Terrazole is not yet available for use on ornamentals.

RESIDUAL FUNGICIDAL ACTIVITY TOWARD PYTHIUM OF DEXON AND TERRAZOLE IN UC MIX

Final fungicidal concentration of inoculated soil	Emergence after 12 days	Height after 27 days	Dry weight of plant tops (2 plants/pot)
ppm	%	inches	gm
Terrazole: 53	73	3.3	0.47
26.5	85	3.2	0.45
Dexon: 220	90	3.6	0.57
110	73	4.8	0.65
Noninoculated control	90	4.3	0.78
Inoculated control	58	3.3	0.35

NOTE: A 70 ppm solution of Dexon contains approximately 54 grams of 70% formulation per 100 gallons. Fifty-four grams is equivalent to 1.7 oz by weight. All weights of Dexon given in this report refer to the 70% active formulation. Amounts of actual material should be doubled when working with the 35% formulation now on the market.

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Dexon (p-dimethylaminobenzenediazo sodium sulfonate) is the registered trademark of Chemagro Corporation. Terrazole (5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole) is the registered trademark of Olin Mathieson Chemical Corporation. Chrysanthemum rooted cuttings were donated for these tests by the California-Florida Plant Corporation, Fremont, California.