THE EFFECT OF pH ON DAMPING-OFF ORGANISMS[1,2]

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Damping-off is a serious disease in both greenhouses and nurseries (1). Symptoms include the rapid decay of plant tissues. Young seedlings and cuttings are most susceptible, but the stems and roots of older plants which remain succulent for an extended period are also subject to damping-off.

Normally, four types of damping-off are recognized: (3)

(a). Germination or pre-emergence damping-off. This type occurs immediately after germination and before the seedling emerges from the ground.

(b). Normal damping off. The roots and stems of the seedling or cutting are attacked, normally at the soil line.

(c). Late damping-off. It occurs after the stems and roots have lost their succulence and have started to become slightly woody.

(d). Top damping-off. This results when the cotyledons fail to drop off after the seedling emerges. The fungi then attack the cotyledons, causing the top to damp-off.

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1 Scientific Journal Series No. 6828, Agricultural Experiment Station, University of Minnesota.

2 A special project conducted by the senior author while he was an undergraduate student majoring in floriculture.

Damping-off is caused by fungi that live saprophytically on organic matter and inorganic salts in the soil. The most important damping-off fungi include species of Rhizoctonia, Fusarium, Pythium, Phytophthora, Thielaviopsis, and Cylindrocladium.

The fungi can spread very easily by many different means, including running water, wind, and soil adhering to plant parts when the seedlings are transplanted. Zoospores of some fungi have the ability to swim short distances and thus spread the fungus locally.

The development of damping-off may be influenced by many factors, such as soil pH, temperature, moisture, structure, composition, plant population, and humidity. Numerous experiments have been conducted to determine the effect of pH on fungus organisms, but none have been noted which specifically refer to the effect of soil pH on damping-off of bedding plants.

Bingham and Zentmyer (2) found that the fungus Phytophthora cinnamomi was killed when the pH in its environment reached 3.0 or lower. The organism grew in a pH range from 3.5 to 8.0, but its virulence was less in the lower end of this range. At pH 8.0 and above, growth was inhibited but the fungus was not killed.

Shanks and Keller (4), working with poinsettias, reported that Thielaviopsis was controlled when the pH in its environment was below 5.0. When the pH was above 5.0, the fungus caused appreciable loss of roots.

Many other studies also indicated that as the pH of the environment was lowered, the virulence of fungus organisms decreased. The fungi were not necessarily killed as pH was lowered, but the detrimental action of the organisms was lessened to various degrees.

The primary objective of the current study was to determine whether pH of the germination and growth medium affected the virulence of the damping-off organisms which attack bedding plants of flowering annuals. Common bedding plants frequently afflicted with damping-off were used. They were:

Petunia - White Magic

Phlox - Twinkles

Salvia - St. John's Fire

Snapdragon - Yellow Sprite

Sweet Alyssum - Carpet of Snow

1967 Study

Three soil pH levels were used: high (7.9), medium (6.5), and low (5.3). These levels were obtained by mixing pulverized limestone or sulfur with soil prior to sterilization (5), and by supplemental applications of dilute phosphoric acid to the surface of a well prepared soil. Sulfur was added at the rate of 38 and 56 grams per cubic foot of soil for the medium and low pH levels, respectively.

Limestone was added at 46 grams per cubic foot of soil for the high pH. Phosphoric acid (85 percent H_3PO_4) was diluted at 2.5 ml. per 2 gallons of water and applied two times to the medium pH levels and four times to the low soil pH levels at two-day intervals.

Four seedlings or 10 seeds were planted in replicated 6-inch containers. Two to three days later, each container was inoculated with a different species of fungus. The fungi (Fusarium, Rhizoctonia, Thielaviopsis, and Cylindrocladium) had been grown on nutrient agar media in petri plates. One-quarter inch squares of the inoculum were placed just below the soil surface.

Results and Discussion

Within a week, plant loss, limited growth, and chlorotic foliage were evident in the low soil pH treatment, and to a lesser extent in plants in the medium soil pH treatment. Plants in the high soil pH treatment grew well, but some were attacked by Rhizoctonia and Cylindrocladium.

Analysis of the soil indicated that the undesirable growth symptoms of plants in the low and medium pH soils resulted from excessive soluble salt levels. Apparently, the quantities of sulfur mixed into the soil caused an excessive soluble salt content. An alkaline water supply was a factor in determining the quantities of sulfur required to maintain the desired soil pH.

The use of sulfur to lower the soil pH to a level where fungi would be inactive or killed, did not appear to be practical under the conditions of the experiment. Therefore, the application of one or more sprays of dilute phosphoric acid to the soil surface was considered. A similar method using dilute sulfuric acid on seed beds has been employed by forest service nurseries. If the use of phosphoric acid were successful in controlling damping-off fungi, it would have the added advantage of supplying a major nutrient to the soil at the same time.

1968 Study

Dilute phosphoric acid solutions at varied pH levels were used as a possible control method.

Experiment I

Fusarium roseum, Rhizoctonia solani, Thielaviopsis basicola and a Pythium sp. were cultured on plates in agar media containing 3 percent malt extract. The cultures were allowed to envelope the plates. Fine sprays of dilute phosphoric acid solutions at various pH levels were applied to the cultures and to the inoculated soil planted with seed and seedlings of the indicated bedding plants. There were 3 replicates per treatment.

Results

Phosphoric acid sprays reduced and even inhibited the growth of the fungi at low pH levels (Table 1).

Table 1. Effect of dilute phosphoric acid sprays at various pH levels on the growth of fungi on nutrient agar culture plates.

Organism	pH of phosphoric acid sprays 1.0	2.0	3.0	4.0	5.0
Fusarium roseum	0	0	I	+	+
Rhizoctonia solani	0	0	+	+	+
Thielaviopsis basicola	0	+	+	+	+
Pythium sp.	0	I	+	+	+

0 = no growth

+ = growth occurred

I = fungus inhibited but not killed

These results indicated the approximate pH at which growth of the fungi was inhibited or killed. To determine the effect of the phosphoric acid on fungi growing in a soil medium, the following test was run:

Experiment II

A well drained soil medium containing 10 percent corn meal was placed in 100 ml. beakers. The beakers were sterilized, inoculated with the various fungi, and covered with cellophane to prevent contamination. Nine beakers were left uninoculated as checks. Within a weeks time, excellent fungus growth was evident in all but the check beakers.

Sweet alyssum seed was sown in all beakers including the checks, and phosphoric acid solutions with pH levels of 1.0, 2.0, and 3.0 were applied as sprays. There were three replicates per treatment. The fungus grew in all the inoculated containers, even at the low pH levels. Plant growth occurred only in two out of three check containers at pH 2.0 and in all three check containers at pH 3.0 (Table 2).

Table 2. Effect of dilute phosphoric acid sprays of the indicated pH on sweet alyssum seed germination in inoculated soil.

Organism	pH of phosphoric acid sprays		
	1.0	2.0	3.0
Fusarium roseum	0	0	0
Rhizoctonia solani	0	0	0
Thielaviopsis basicola	0	0	0
Pythium sp.	0	0	0
Check	0	+	+

0 = no growth

\+ = growth occurred

Experiment III

In order to determine the direct effect of the acid on seedlings of sweet alyssum, phlox, and salvia, seeds were sown in 5-inch plastic containers. When the seedlings were about 1½-inches high, they were treated with phosphoric acid sprays at pH 1.0, 2.0, and 3.0. There were two replicates per treatment. The seedlings were killed at pH 1.0, they were injured at pH 2.0, and normal growth occurred at pH 3.0 (Table 3).

Table 3. Effect of dilute phosphoric acid sprays of the indicated pH on seedling growth.

Plant	pH of phosphoric acid sprays		
	1.0	2.0	3.0
Carpet of Snow alyssum	0	B	+
Twinkles phlox	0	B	+
St. John's Fire Salvia	0	B	+

0 = seedlings killed
B = seedlings injured
\+ = seedlings unharmed

Discussion and Conclusions

The phosphoric acid sprays had a marked effect on the fungi grown on nutrient agar media. When the fungus was grown on a soil medium, the phosphoric acid had relatively little effect on it. This result probably was due to the buffers present in the soil.

The best level for killing the fungus was pH 1.0, but in the seedling test all seedlings were killed at this level. At pH 2.0, the seedlings were injured and a reduction in growth was noted. At pH 3.0, the seedlings grew normally and appeared to be unharmed by the acid treatment.

Because the most effective pH level for killing fungi prevented germination, or injured the young plant, and because applications of phosphoric acid sprays to soil cultures were less effective than applications to nutrient agar cultures, the use of phosphoric acid on seed beds for the prevention and control of damping-off does not appear feasible. The use of a phosphoric acid spray on empty benches, walks, pots and other greenhouse equipment, in instances where steam sterilizing is not practical, could help eliminate fungus diseases. However, one must first determine whether other commercially available materials are equally effective, more economical, or easier to handle.

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The guidance of Neil A. Anderson of the Department of Plant Pathology in the preparation of the fungus cultures is gratefully acknowledged.

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