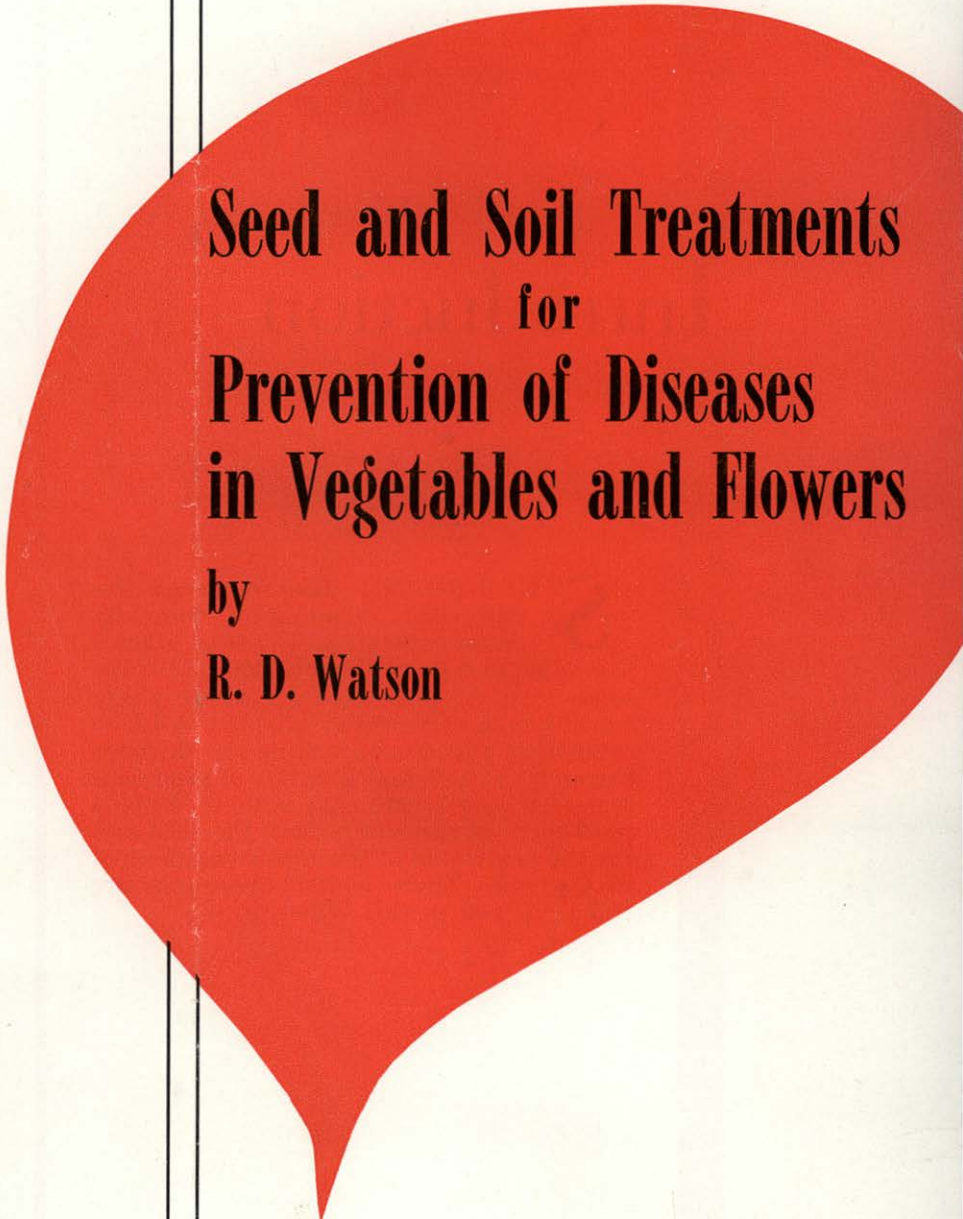


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**Seed and Soil Treatments
for
Prevention of Diseases
in Vegetables and Flowers**
by
R. D. Watson

UNIVERSITY of IDAHO
Agricultural Experiment Station

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Introduction

SEED-BORNE diseases, seed decay, and damping-off annually cause substantial losses to Idaho's vegetable and flower crops. Most of these losses can be prevented by using clean, healthy seed of varieties adapted to Idaho conditions and by controlling the diseases through (1) soil pasturization of seed beds and (2) seed treatments both to destroy seed-borne organisms within the seed and for the protection of the seed when planted in the soil. These control measures are fully outlined in this bulletin.

Seed and Soil Treatments for Prevention of Diseases in Vegetables and Flowers

R. D. Watson

Control of Seedling Diseases by Soil Disinfestation

For the grower of plants that are sensitive to seed-decay and damping-off, the use of soil completely free from decay-producing organisms is a satisfying solution to this disease problem. Soil disinfestation has an important place in the disease-control program for seedling diseases and greenhouse disease problems. Along with the use of clean, disease-free seed and seed treatments, it will do much to overcome the seedling diseases that are so destructive and costly.

The application to disease control on a field scale is limited to specialized high value crops because of the cost of the treatment. The best recommendation for controlling soil-inhabiting diseases of plants on a field scale is still a rotation system which includes soil-building crops. Rotation of crops has proved to be the most economical and effective control for most soil-borne plant diseases.

Control Methods Suitable for Home Use

The home gardener can use three methods that require no special equipment and which will eliminate harmful soil pathogens.

1. *Hot water drench* requires a planting medium in which the water will penetrate readily. Sand, sandy soils, vermiculite, peat moss, or sphagnum are good. Prepare the planting medium for the seed in the flat or pot the plants are to be grown in. This will make sure that both container and soil will be treated. The planting medium should be at room temperature at the start of the treat-

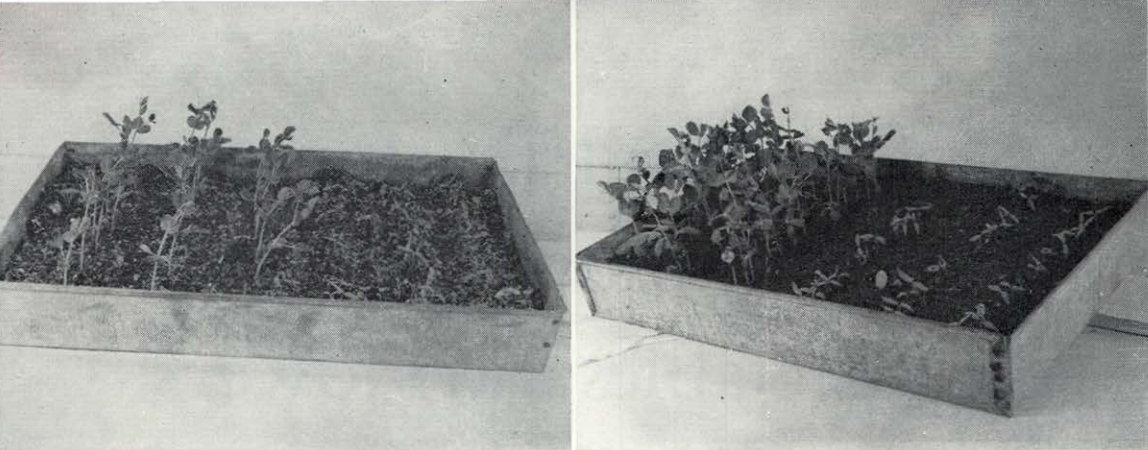
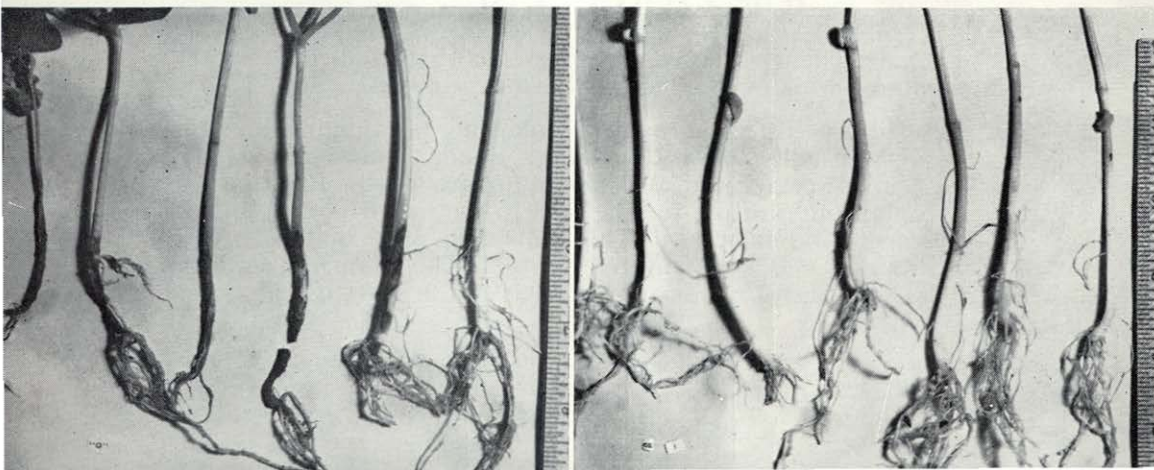


Figure 1—Pasteurized soils at the right in Figures 1 and 2 have produced clean, healthy plants and roots. The soil is free from weeds. Unpasteurized soils at the left produced weak, spindly plants, many weeds, and poor, diseased roots.

ment. Drench the soil thoroughly two to three times with boiling water at 15-minute intervals.

2. (a) *Formaldehyde liquid drench* may be used for soil fumigation. Pure formaldehyde is a gas. It is sold in the form of a 40 per cent solution in water. Make a solution by adding 1 pt. of commercial formaldehyde to 15 gal. of water, 1 part to 120 parts of water. Sprinkle this dilute solution at the rate of 1 pt. per square foot of surface seedbed. Then cover the soil with canvas or heavy paper for 48 hours. Let the formaldehyde gas escape for 10 days, longer if the weather is cold. Formaldehyde fumes are toxic to growing plants. Treat soil only in well ventilated house or outside. The main use for the drench method is in hotbeds.
- (b) *Formaldehyde soil treatment* for immediate planting requires commercial formaldehyde at the rate of $2\frac{1}{2}$ tablespoons for each bushel of soil or 1 tablespoon for each 20 by 14 by $2\frac{3}{4}$ inch flat of soil. With the soil in a pile, sprinkle the dilute formaldehyde over it and mix thor-

Figure 2



oughly. The treated soil is spread out in flats or beds and allowed to stand 12 to 24 hours *before seeds are sown*. After seeds are sown, *water soil thoroughly*. The watering is very important as it releases formaldehyde and prevents seedling injury.

These formaldehyde treatments are inexpensive; the cost of the formaldehyde is about 1 to 2 cents a flat. Formaldehyde leaves no harmful or useful residues in the soil. It disinfects soil and flats in a single operation and gives excellent control of damping-off.

3. *Heat may be used to control soil-borne organisms.* The moist soil in a suitable container can be heated in the electric oven at 160° for 1 to 2 hours. This temperature will control the disease producing organisms and most weed seeds. The odors produced are objectionable. The pressure cookers available in many homes are effective for killing soil organisms but are not recommended on soils because of the breakdown product. The complete sterilization of the wet sand does not release the harmful residues. Heat the sand at 15 lb. pressure for 15 to 30 minutes, depending on the quantity to be treated.

Soil Pasteurization Versus Soil Sterilization

Soil pasteurization at 160° is usually better than soil sterilization at higher temperatures. The pasteurization temperatures are high enough to kill all of the harmful organisms, fungi, bacteria, insects, and most of the weed seeds. Many of the beneficial organisms have spore forms which survive pasteurization temperatures. This treatment leaves the soil in a condition favorable for plant growth. Complete sterilization of soil is not recommended as it breaks down organic materials in the soil and often leaves residues harmful to plant growth. There is a greater hazard of recontamination of sterile soil due to the complete absence of other soil organisms that would ordinarily give competition to the invader.

Methods Suitable For Commercial Uses

Steam, properly used, will control soil-borne pathogens, fungi, bacteria, nematodes, and most weed seeds. The steam is piped from a boiler and introduced into the soil through drain-tiles buried in the soil about 18 to 24 inches apart. Or it is forced into the soil by an inverted metal pan. To be effective, the soil must be held at 122° for 2 hours or at 140° for 1 hour. When the soil in the coldest spots reaches 160° the steam can be turned off.

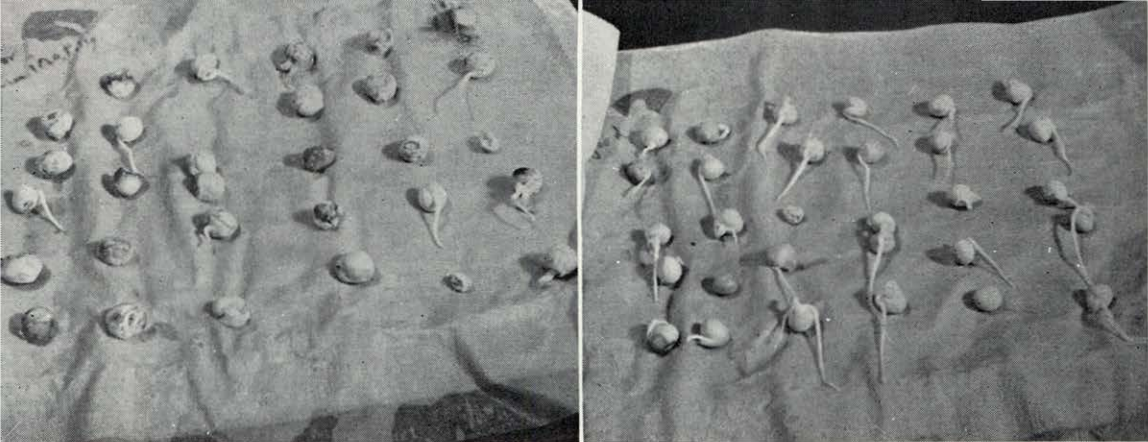


Figure 3—All seeds do not have the same quality. In Figure 3 seed on the left has only a few healthy sprouts after testing. Seeds to the right are high in germination, of good quality, and are free from disease.

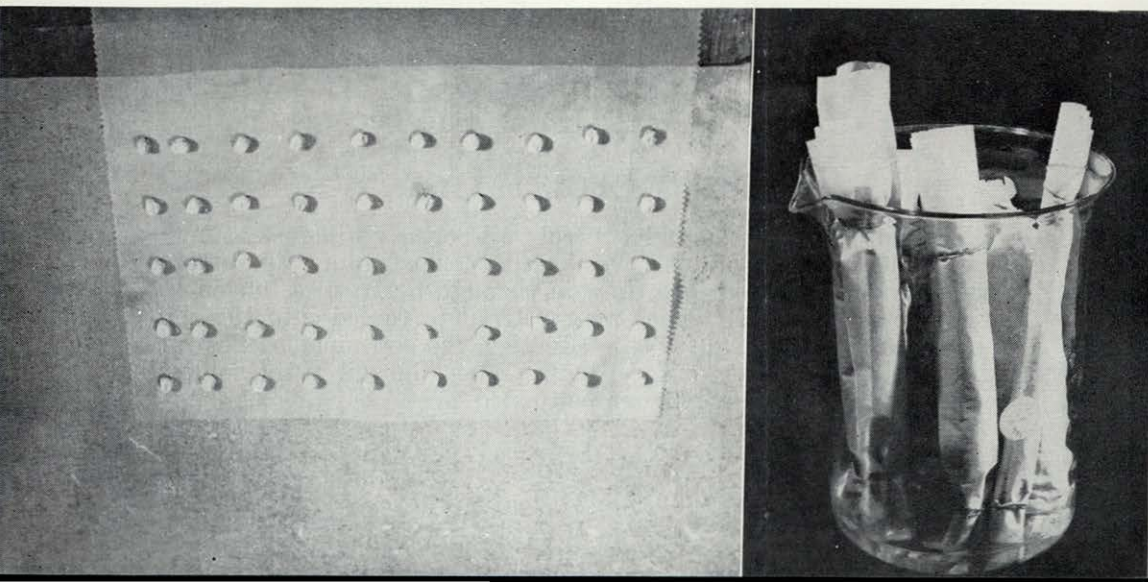
Electric Soil Pasteurizers are built for greenhouses that will handle $\frac{1}{2}$ to 1 cubic yard of soil at a time. Moistened soil, mixed ready for planting, is placed in the hopper and brought up to 160° then turned off. The soil will remain hot for 3 to 4 hours to complete the pasteurization. This does not have the harmful effects on the soil of complete sterilization.

The *liquid formaldehyde* method described earlier can be used on a commercial scale on seed-beds and hotbeds.

Commercial soil fumigants for soil disinfection have developed rapidly in recent years, but their use has been limited in application due to the high cost of from \$100 to \$400 per acre for materials and the fact that on field application control is seldom, if ever, complete. Several good nematocides for nematodes or eelworms have been developed and are used where the crop value justifies the investment; but there are few good soil fungicides available.

The use of these soil fumigants is limited and knowledge about them is developing so fast no specific recommendations will be given here. Persons using these fumigants should follow the manufacturer's recommendations.

Figure 4—Seeds are spaced on a paper towel before being rolled up and placed in water for testing. The rolled towel testers are in container at right.



A Home Method For Testing Seed Germination

Strong, healthy plants come from strong, healthy seed. We get maximum germination only from seed of top quality.

If there is a question about seed quality, here is a simple method of testing its germination. This method requires no special equipment. With a little care you can get good reliable results.

To make the tester you will need two paper hand towels, a piece of waxed paper slightly larger than the towels, some rubber bands or string, and a water container. Soak the towels in water and spread them out on the waxed paper, with one edge of the towel about an inch beyond the waxed paper's edge.

Place the seeds on the towel about an inch apart—10 seeds in each direction or a total of 100. Then fill in the rows. Leave about $2\frac{1}{2}$ inches of space between one row of seeds and the edge of the paper. This will be the bottom when towels and paper are folded up. Before making the roll, cover the seeds with another wet towel. Roll the paper carefully. If you are testing large seeds such as peas, beans or corn, fold the towel in 1-inch folds to start the roll. This leaves space for seeds to swell. Tie the entire roll with bands or string about 2 inches from each end. Put the end with the protruding towel into a pan or bucket containing an inch or so of water. Keep the tester in a warm room for a few days.

To find the percentage of germination, count the strong, healthy sprouts. Sometimes bacteria and fungi grow abundantly on untreated seeds and interfere with germination. You can prevent this by wetting towels in a solution of Semesan, Arasan, or Phygon, using 1 level teaspoon to $1\frac{1}{3}$ quarts of water.

Control of Damping-Off After Infection Appears

Even if damping-off has started in a few spots over the seed bed, it can usually be checked by a surface treatment.

Spray seedlings with Semesan or Arasan solution at the rate of $1\frac{1}{2}$ quarts per 10 square feet of medium or heavy soils, or 1 quart per 10 square feet of sandy soils and sand. Use a sprayer or sprinkling can with a fine nozzle.

Although an application of fungicide generally arrests and prevents the recurrence of damping-off, a second or third application may be necessary. Several days should elapse between applications with the seedlings kept well ventilated following treatment. Semesan will injure melons and lettuce.

Semesan or Arasan solution is made by stirring:

1 level teaspoon of Semesan or Arasan into $1\frac{1}{3}$ qt. of water.

1 level tablespoon of Semesan or Arasan in 1 gal. of water.

1 pound of Semesan or Arasan in 50 gal. of water.

T Types of Chemical Seed Treatments

Dusts are most widely used because of the ease of application. The liquid dip methods have the advantage of better adherence to the seed and more even coverage. They usually give better control of damping-off but are not used so widely because of the added work involved in drying the seed following the liquid treatment. The slurry method was developed to take advantage of both dust and liquid treatments. No drying is necessary because of the relatively small volume of water added in the slurry process. Results in Idaho indicate a much better control of damping-off and seed decay by use of this method. Buying treated seed is most satisfactory for home gardeners as slurry methods require elaborate equipment. For small quantities of seed, the easily applied dust is a good treatment.

TO TREAT SMALL SEED LOTS—Treat small amounts of seed by shaking them for several minutes in a fruit jar containing dust. When seeds are thoroughly coated they are ready for planting. Screen off excess dust. To small packages of seed, add a little dust on the point of a knife. Shake the package until the seeds are thoroughly coated. Screen off excess dust.

WHEN POSSIBLE, buy treated seed. Commercial treatment assures a uniformity and is especially valuable on those seeds requiring hot-water treatment.

PRECAUTIONS—MOST OF THE SEED-TREATING COMPOUNDS ARE POISONOUS EITHER WHEN EATEN OR INHALED. KEEP THEM AWAY FROM CHILDREN AND ANIMALS. NEVER USE TREATED SEED AS FOOD FOR MAN OR ANIMALS. TREAT SEED IN THE OUTDOORS OR IN A WELL VENTILATED PLACE. AVOID ANY DUST ACCUMULATION ON SKIN.

SEED TREATMENT NOT A "CURE-ALL"—Sometimes seed treatment will of itself be entirely effective in preventing diseases, but frequently it is only one step in the disease control plan. Disease organisms may live over long periods in old crops, refuse, in the seed bed, soil, or in weeds. Such practices as seed-bed and field treatment, sanitation, use of resistant varieties, rotation and destruction of weed carriers help to bring full disease control.

H Hot-Water Seed Treatment

Because hot-water treatments sometimes impair germination, it is always well to treat a small sample and to make a germination test before treating large amounts. Be sure to do this if your seed is old and weak. Immediately after treating, spread the seed out in thin layers to cool and dry. Rapid drying is an essential part of the treatment. Stir the drying seed to hasten the process.

Temperatures and lengths of treatment necessary to control diseases of a number of crops are given in the following table.

Temperature and Duration of Hot Water Treatment for Vegetable Seeds

Vegetable	Diseases	Degrees Temperature	Time in Minutes
Broccoli	Alternaria blight	122	15
Brussels Sprouts	Black rot	122	15
Cabbage	Black leg	122	25
Collards		122	15
Kale		122	15
Kohlrabi		122	15
Turnip		122	15
Carrots	Bacterial blight	126	10
Celery (celeriac)	Early blight Late blight Bacterial blight	118	30
Eggplant	Phomopsis blight	122	25
Onion	Alternaria blight Downy mildew	122	25
Tomato	Anthracnose Alternaria blight Bacterial spot Bacterial canker	122	25

Flower Bulb Treatment

Healthy bulbs, free from decay, are essential if we are to produce good yields of near-perfect flowers from them. Diseased bulbs either fail entirely or produce weak plants and poor flowers. Clean your bulbs and remove all rotted ones. Treat each variety as it is harvested.

Bulbs	Diseases Controlled	Method of Treatment
Calla	Damping-off	Arasan* liquid—4 tablespoons
Crocus corms	Bulb & corm rots	to 1 qt. of water or 2 oz. in 1 gal.
Dahlia roots	Storage Decay	of water. Put the bulbs in a
Freesia corms		loosely woven bag and soak them
Gladiolus corms		long enough to wet thoroughly.
Hyacinth bulbs		Agitate the suspension fre-
Narcissus		quently. Bulbs may be planted
(Daffodil,		while wet. If they are to be
Jonquils)		stored, spread them out to dry
Tulip bulbs		before storing. Use Semesan
		liquid as directed on package.

* Arasan, Arasan SF, and Tersan have the same active ingredients. Use ½ teaspoon of synthetic detergent as wetter when using Arasan as a liquid treatment. Arasan SF and Tersan have wetters in them. These materials are compatible with DDT or Chlordane.

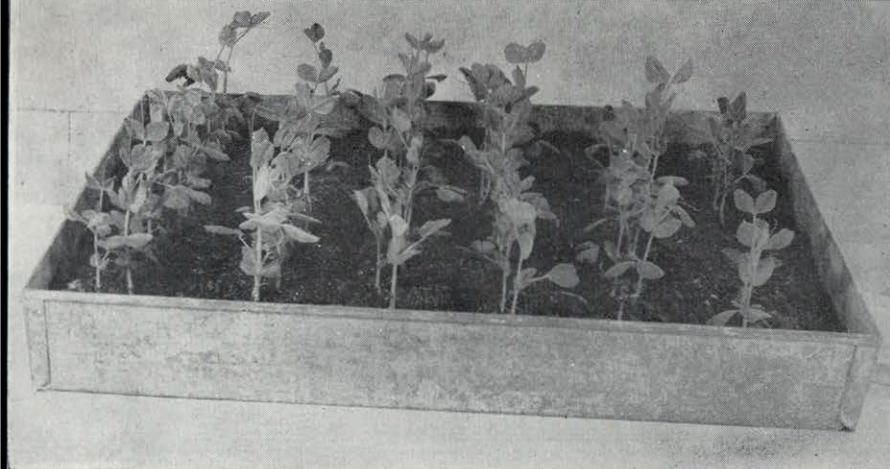


Figure 5—Plants from treated seed, left, are more vigorous, more plentiful in number. Commercial houses are selling more and more treated seed because of greater consumer demand.

Vegetable Seed Treatments

Crop	Diseases Controlled	Method of Treatment
Asparagus		No treatment suggested at present.
Beans Lima Beans	Damping-off Seed-rot	Phygon, Arasan and Spergon, 3 ounces of dust for each 100 lb. of seed or $\frac{1}{2}$ level teaspoon for each pound. Spergon is commonly used on beans but is not so good in severe damping-off conditions as Phygon or Arasan.
Beets Swiss Chard	Damping-off Seed-rot	<ol style="list-style-type: none"> 1. Arasan or Phygon, 1 per cent of seed by weight, or 2 level teaspoons for each pound. 2. Soak 1 hour in copper sulfate solution, 2 ounces in each gallon of water. Beet seed varies greatly in weight, but the amount of chemical suggested is enough for even the greatest areas of seed surface.

Crop	Diseases Controlled	Method of Treatment
Broccoli Brussels sprouts Cabbage Cauliflower Collards Kale Kohlrabi Turnip & other crucifers	Black-rot* Black-leg* Alternaria leaf-spot* Peppery leaf-spot* Damping-off	Buy hot-water-treated seed or soak seed in water at 122° for 25 minutes for cabbage seed, and 15 to 18 minutes for all others. Before planting, treat with 1/2 level teaspoon of Semesan or Arasan for each pound of seed.
Carrots	Damping-off Seed-rot	Treat in water at 126° for 10 minutes. Dry. Before planting treat with 1 level teaspoon of Arasan or Phygon for each pound, or 1/2 per cent by weight of seed.
Celery (celeriac)	Damping-off Seed-rot Seed-borne diseases, as early blight* late blight*	<ol style="list-style-type: none"> 1. If seed is new, treat for 30 minutes at a temperature of 118° in water. Before planting, treat with 1/2 level teaspoon Semesan per pound of seed. 2. Seed 2 years old or more requires no hot water treatment.
Chicory		See treatment for Lettuce.
Cucumber Squash Muskmelon Pumpkin Watermelon	Damping-off Seed-rot	Semesan or Arasan, 1/2 teaspoon per pound of seed.
Dill		See treatment for Lettuce.
Egg Plant	Damping-off Seed-rot	Treat with 1/2 teaspoon of Arasan, Phygon, or Semesan for each pound.
Endive Fennel	Damping-off	See treatment for Lettuce.
Kale Kohlrabi	See broccoli	See treatment for broccoli.

Crop	Diseases Controlled	Method of Treatment
Lettuce	Damping-off Seed-rot	Treat seed with ½ teaspoon Spergon per pound or 6 ounces per 100 lbs. Lettuce and related crops are sensitive to most of the seed treating fungicides. Additional control can be obtained by drenching the soil with Arasan following planting at 10-day intervals. See "Control of Damping-off after Infection Appears" for details.
Muskmelon	See cucumber	See treatment for cucumber.
Onions	Damping-off	Treat with 1 teaspoon of Arasan or Phygon per pound, or 4 ounces per 100 pounds.
Leeks	Seed-rot	See treatment for lettuce.
Parsley	Damping-off	<ol style="list-style-type: none"> 1. Treat with ½ teaspoon of Arasan or Phygon per pound, 2 ounces for each 100 lb. 2. Spergon is most commonly used, 3 ounces to each 100 lb., or ½ teaspoon for each pound.
Parsnip	Seed-rot	
Pea	Damping-off	
	Seed-rot	
Pepper	Damping-off Seed-rot	Treat with ½ teaspoon of Arasan, Phygon, or Semesan per pound.
Potato	Seed piece decay Blackleg Rhizoctonia (seed borne)	When poor stands have occurred previously, stir 1 lb. Semesan-Bel with 7½ gal. water, and dip cut potatoes. Wet thoroughly. Plant immediately. One lb. treats 60 to 80 bu.
Pumpkins		See treatment for cucumber.
Rutabaga	See Broccoli	See treatment for cauliflower.
Radish	Damping-off Seed-rot	Usually no treatment necessary in Idaho. Semesan, according to directions on the container; 1 level teaspoon zinc oxide per pound of seed.
Spinach	Downy mildews* Seed-borne diseases Damping-off Seed-rot	But hot-water treated seed or soak seed in water at 122° for 25 minutes as suggested for cabbage. Before planting treat with Arasan or Phygon, 1 level teaspoon to each pound of seed.

Crop	Diseases Controlled	Method of Treatment
Salsify		See treatment for lettuce.
Squash	See cucumber	See treatment for cucumber.
Sweet Corn	Damping-off	Treat with 2 ounces of Arasan or Phygon to each 100 lb., or
Field Corn	Seed-rot	1/4 teaspoon per pound of seed.
Sweet Potatoes	Scurf	Dip healthy sweet potatoes for 1/2 to 1 minute in a solution of
	Stem-rot*	Semesan-Bel made by mixing 1 lb. to 8 gal. of water.
Sweet Potato	Scurf*	Dip sprouts for 1/2 minute in Semesan-Bel, 1 lb. in 12 gal. of
Sprouts	Stem-rot*	water or 1 lb. wettable Arasan in 5 gal. water. Avoid wetting
		leaves.
Swiss Chard	See beets	See treatment for beets.
Tomato	Bacterial	Buy hot-water treated seed or soak tomato seed in water at
	fruit spot*	122° for 25 minutes. Follow this immediately by soaking the
	Bacterial	seed in a solution made of 2 ounces of blue vitriol (copper
	canker*	sulfate) in 1 gal. water for 1 hour. Dry seed. Dust with Ara-
	Anthrachnose*	san, or Phygon just before planting. Use 1 level teaspoon for
	Damping-off	each pound of seed.
	Seed-rot	
Turnip	See broccoli	See treatment for broccoli.
Watermelon	See cucumber	See treatment for cucumber.

* This disease is not a factor in Idaho at present. The causal organism is commonly seed-borne and may be introduced into the state in this way. Treat all seed to prevent this introduction.

FLOWER SEED TREATMENTS

Crop	Diseases Controlled	Method of Treatment
Flower seeds	Damping-off	Treat flower seeds to improve seedling emergence and to pro-
	Seed-rot	tect the young plants against damping-off. Suitable dusts,
		such as Semesan, Spergon, and Arasan are safe treatments.
		To small packets of seed, add a little dust on the point of a
		knife. Shake the package until the seeds are thoroughly
		coated. Screen off the excess dust. For larger quantities of
		seed, follow directions on the container.
Sweet peas	Damping-off	Use 1/3 teaspoon Arasan per pound of seed or 2 ounces per 100
	Seed-rot	lb. of seed.

General Recommendations for Control of plant diseases:

A variety adapted to the local climatic and soil conditions and of acceptable quality for home or market is the first essential in successful culture of any crop. (See vegetable varieties for Idaho gardens, Extension Circular 102.) *The use of disease resistant varieties* is the best means of controlling a number of diseases.

The best seed obtainable should be used. Seed should be true to name, high germinating, capable of producing vigorous seedlings, and *free from seed-borne pathogens*. As a safety measure, seeds of certain crops should be treated with hot water to assure freedom from these seed-borne diseases. Buy treated seeds whenever possible. Many of the vegetable seeds grown in the arid West are recommended since under these conditions there is a freedom from many seed-borne diseases. Idaho-grown vegetable seeds especially peas, beans, baby lima beans, corn, carrots, and onions are the best obtainable. Use Idaho certified potatoes as certification gives a practical guarantee that the seed is true to name and is free from certain dangerous pathogens. High-quality seed may be purchased from a grower or seedsman known to be competent and reliable or from a dealer handling top quality seed.

Use seed treated with a seed protectant. The treatment protects the seed against rot in the soil and against damping-off of seedlings and young plants. Untreated seed often gives adequate stands under favorable soil and temperature conditions, but conditions are not always favorable. Seed treatments are recommended because the cost of treatment is small when compared with the benefits received. Many treated seeds can be planted earlier without fear of their rotting in the ground. Request treated seed from your seed dealer as it will cost no more.

The seedbed should be well prepared and firm, and the seed should be evenly covered to the desired depth with loose soil. Seeds planted too deep are delayed in coming up, therefore are more susceptible to damping-off. Crusts formed over the seed by rain should be broken up to allow the plants to come up quickly, harden, and thus suffer least from damping-off and seed decay.

Transplants, sets, potato-tubers and similar propagative stock when used, should be disease free. Such plants are obtainable if grown from disease-free seed, in clean soil, and with surroundings free from a source of the disease of that particular crop. Even with such disease-free plants, it is still possible for the operator to infect them by handling with contaminated hands. Many destructive disease organisms may enter the garden soil on diseased propagation stock and become sources of diseases difficult to control. *Buy only clean, disease-free plants* from a reliable source or grow your own. The methods in this bulletin will serve as a guide to evaluate plants for purchase or for growing your own disease-free plants.

Crop rotation is effective in controlling a number of diseases. Nearly one-third of all vegetable-and-flower-disease control is accomplished by using no beds or fields where the same crop or related crops were planted the previous year.

Proper irrigation will reduce losses due to many of the diseases. Excessive irrigation or flooding weaken the plant's defense and

favor spread and growth of the organisms increasing losses due to rot and decay. Water carefully and avoid wetting the surface soil under the plant more than necessary. Deep rills are preferred to shallow rills.

Proper soil management fits with a crop rotation-soil-building-program with the use of green-manure crops, farmyard manure, proper use of crop residues and commercial fertilizers. These practices will aid in the control of certain important diseases.

Systematic sanitation against plant diseases should be carried out on every farm and garden. As a general rule, crop residues should be turned under as soon as the crop has been harvested. Many diseases perpetuate themselves as over-wintering structures in the plant parts. For this reason it is advisable to destroy diseased plants found in the garden, thus, making the residue safe to be used as a soil builder. *Sanitation includes weed control.* Remove the weeds that serve as overwinter sources of such major virus diseases as curly top, tomato mosaic, cucumber mosaic, lettuce mosaic, and yellow bean mosaic. Weeds should be controlled in the garden, along ditch banks, and in waste areas.

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These bulletins will help you fight diseases of your fruits, vegetables, and flowers. Write the Agricultural Mailing Room, University of Idaho, Moscow, for those you need. Your County Agent also has them on hand.

238 Bean Improvement and Bean Diseases in Idaho

254 Diseases of Potatoes in Idaho

262 Diseases of the Carrot Seed Crop in Idaho

274 Potato Tuber Diseases and Defects

110 Chlorosis of Plants in Idaho

96 Orchard Spray Recommendations for Idaho

Curative and Preventive Methods of Controlling
Fruit Diseases (Series)

I. Brambles, II. Bush Fruits and Grapes, III.
Strawberries, IV. Pome Fruits, V. Stone
Fruits, VI. The Value of Certification.

Have you a copy of the following bulletins? They will aid in your garden program—

52 Squash Bug Control, 104 Earwig Control, 182 Growing Strawberries in Idaho, 279 Idaho Recommendations for Insect Control, 110 Plants Need Food, 116 You CAN Grow Tomatoes, 95 Vegetative Propagation of Plants, 102 Vegetable Varieties for Idaho Gardens

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