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M. W. Felton

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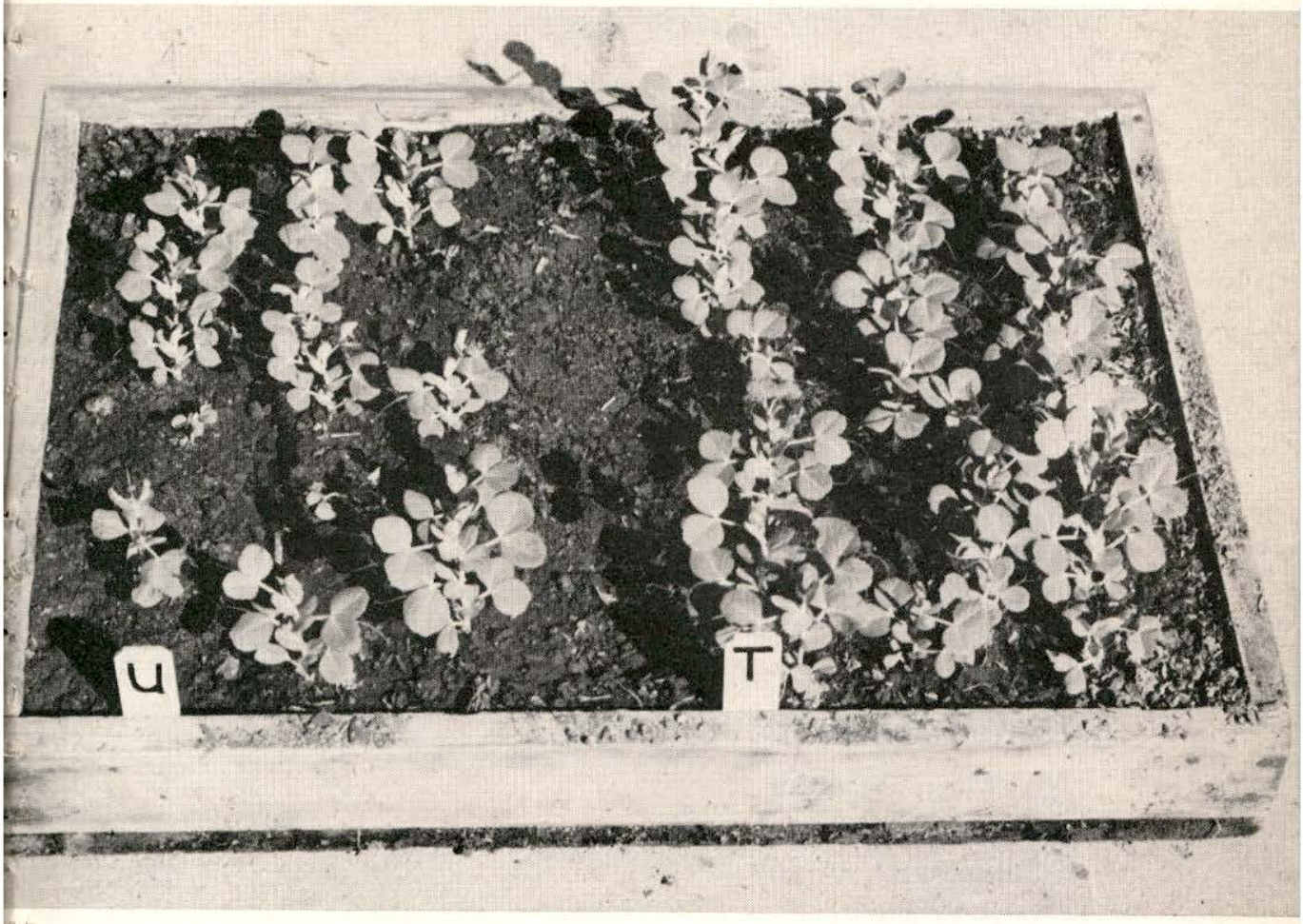

Seed treatment (right) increases the stand and vigor of peas.

The Experiment Station
University of Nebraska College of Agriculture
W. V. Lambert, Director, Lincoln, Nebraska

CONTENTS

Seed and Soil Treatments for Vegetable Crops Grown in Nebraska

M. W. Felton [1] and J. E. Livingston [2]

WHY SEEDLINGS DAMP-OFF

One of the hazards in growing vegetables is the poor stand frequently obtained. Often this is attributed to poor seed. Usually, however, the poor stand is caused by the attack of disease-producing organisms that live in the soil or are carried on the seed. This is particularly true when weather conditions at planting time are unfavorable for the rapid emergence of the young seedlings. Many of the vegetables grown in Nebraska are planted very early in the spring so the crop will mature before the hot weather of summer. These early-planted seeds often encounter cold, wet soil conditions that are not favorable for the rapid germination of the seed and emergence of the young seedlings. On the other hand, cold, wet soils favor the development of numerous seed-borne and soil-borne organisms that attack the seedlings, causing damping-off and death. Tests conducted during the past four years at the Nebraska Agricultural Experiment Station have shown that when seeds are planted in cold, wet soils, better stands of vigorous seedlings are generally obtained when the seeds are treated before they are planted.

VALUE OF SEED TREATMENT

Seed treatment materials are used primarily as "seed protectants" and "seed disinfectants" and both serve as insurance against disease. Seed disinfectants are usually applied as liquids to kill disease-producing fungi and bacteria that overwinter on or inside the seed. These organisms produce blights, spots and rots on the leaves and fruits. Potatoes, tomatoes, peppers, eggplant and cabbage are the principal crops for which disinfectants are recommended. The diseases of these crops for which seed disinfectants are effective are described in Nebraska Extension Circular 1801, "Vegetable Diseases in Nebraska." The most important are rhizoctonia and scab of potatoes, bacterial spot and canker of tomatoes, bacterial spot of peppers, black rot of cabbage and Phomopsis blight of eggplant. Several types of disinfectants may be used. They are discussed on page 16 of this bulletin.

Seed protectants are used to improve stands by controlling damping-off. Damping-off is caused by decay-producing organisms that are present in nearly all soils and on nearly all seeds. These organisms require only favorable

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[1] Formerly assistant plant pathologist, Nebraska Agricultural Experiment Station.

[2] Associate plant pathologist, Nebraska Agricultural Experiment Station.

TABLE 1. *Seed protectants recommended for treating vegetable seeds.*

Crop	Treating material					
	Arasan	Spergon	Cuprocide	Semesan	N. I. Ceresan	Zinc oxide
Cabbage, cauliflower, and other crucifers	x	x		x		
Carrots [1]		x	x			x
Corn (sweet)	x	x				
Cucumbers, melons and other cucurbits	x	x	x	x		
Eggplant	x	x	x			
Garden beets	x	x	x	x	x	
Lettuce [1]		x	x			
Lima beans	x	x				
Onions [1]	x			x		
Peas	x	x	x	x		
Peppers	x		x	x		
Snap beans	None					
Spinach	x	x	x			x
Tomatoes	x	x	x		x	

[1] Seed treatment recommended only for early plantings.

weather conditions to attack the young seedlings. Damping-off is particularly serious in flats and hotbeds. It also causes considerable loss of seedlings in the garden, especially with such crops as peas, cucumbers, melons, spinach, beets and lima beans.

TABLE 2. *Crops for which seed disinfection is recommended.*

Crop	Treating Material
Cabbage	Hot water Corrosive sublimate
Eggplant	Hot water Semesan
Peppers	Hot water Semesan
Potatoes	Semesan Bel Formaldehyde
Tomatoes	New Improved Ceresan Corrosive sublimate

Seed protectants are inexpensive and available in a powder form that is easy to apply. A little of the powder on the point of a knife blade can be added directly to the seed packet. The packet should then be shaken until the seed is completely covered with the powder. With larger quantities of seed a fruit jar makes a convenient mixing chamber. The seed can be planted immediately after treatment.

Many seeds now sold on the market have been treated. These should be used when possible. Otherwise, the materials listed in Tables 1 and 2 should be used for treatment.

Seed treatment should not be considered as a substitute for good horticultural practices, such as planting viable seed, rotating the crops in the garden, removing and destroying all old diseased plants, and using new or sterilized soil in the hotbed. For best results all of these practices, including seed treatment, should be used in conjunction.

Tables 1 and 2 list the crops on which seed treatments have been tested at the Nebraska Agricultural Experiment Station and the materials used.

SEED TREATMENT CHEMICALS

Protectants

A NUMBER of chemicals satisfactorily prevent seed decay and seedling rots. Arasan and Spergon are the most recently developed seed treatment materials. They are organic chemicals that can be used safely on all vegetables even in excess amounts. This makes them preferred for small lots of seed where it is difficult for the average person to measure out definite quantities of the treating material. Cuprocide, Semesan, New Improved Ceresan and zinc oxide are satisfactory seed treating materials but each contains some metallic element that contributes to its toxicity. The amount of these materials applied to the seed must be regulated according to the manufacturer's recommendation. Otherwise they may cause injury and give a reduced rather than an improved stand. Semesan and New Improved Ceresan both contain mercury and are thus classed as mercurials. Cuprocide contains copper, and zinc oxide contains zinc.

Disinfectants

Of the disinfectants recommended corrosive sublimate, Semesan, and New Improved Ceresan are mercury compounds. Corrosive sublimate (bichloride of mercury) is *very poisonous* to humans and animals if taken *internally* and must be carefully handled. Formaldehyde contains 37 to 40 per cent formalin and is used principally in the liquid form. Formaldehyde dusts are available and are used chiefly by mixing with the soil in the compost pile for soil sterilization.

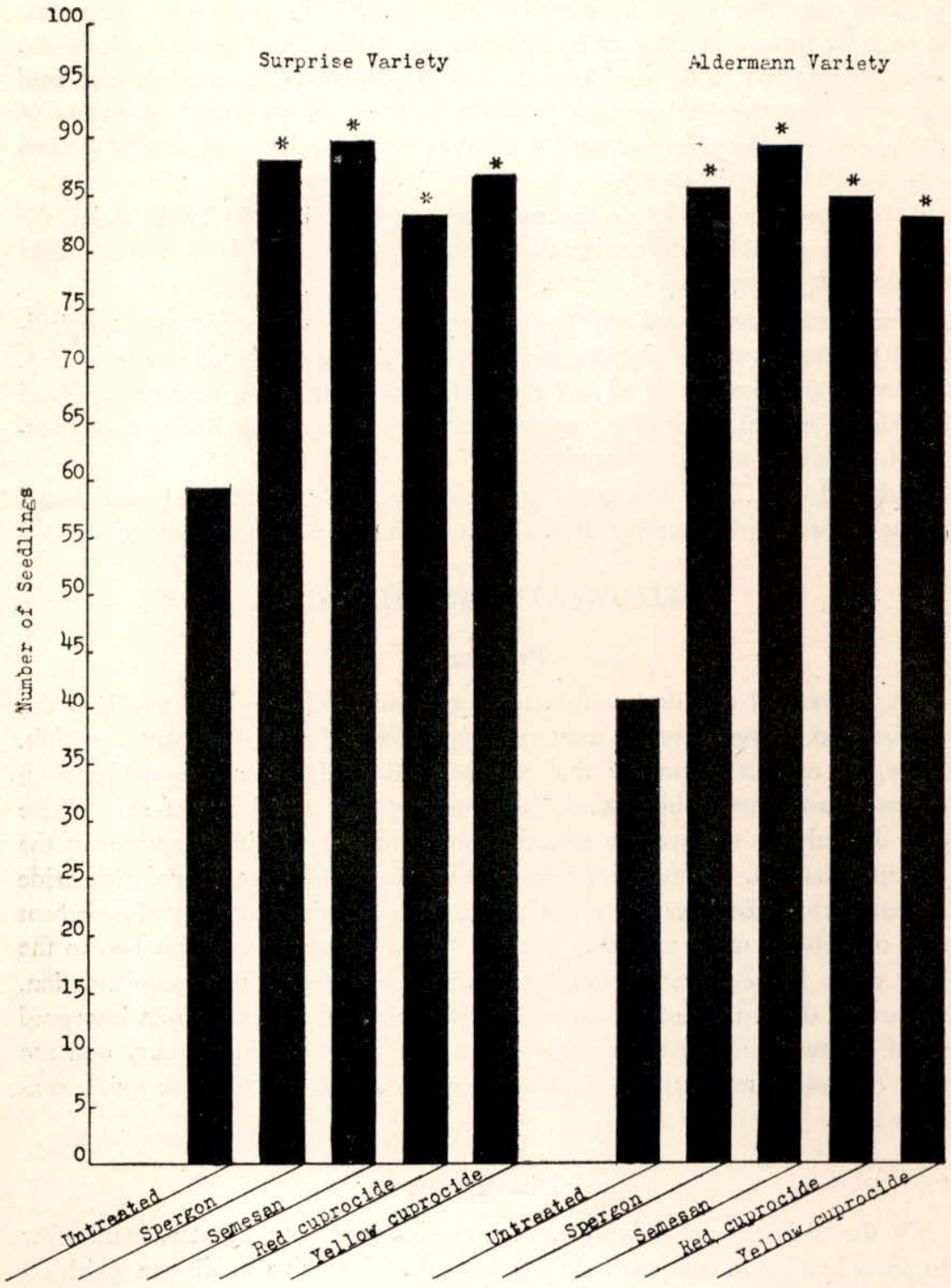

FIG. 1.—Average number of pea seedlings which emerged following various seed treatments. There were five replications of each treatment, with 100 seeds per replication. Asterisk at top of column indicates significant increase over the untreated plot.

DISEASE-FREE SEED

PLANTING DISEASE-FREE seed is obviously one of the best ways to avoid disease. Unfortunately, the average grower cannot know whether the seed he is buying is free from disease. With some vegetables, such as tomatoes, dry or field beans and potatoes, it is possible to buy certified seed. It is very desirable to use such seed when possible. Certified seed comes from fields that have been inspected by competent persons and found to be free from serious seed-borne diseases. Some diseases, such as bacterial blight of beans and the virus diseases of potatoes, cannot be controlled by either seed protectants or disinfectants. Thus the only control is to use seed that has been certified as free from disease. Even certified seed should be treated with one of the seed protectants to avoid damping-off caused by soil-borne organisms.

WHEN TO USE SEED PROTECTANTS

Peas, early smooth. The early smooth seeded peas, represented by Alaska, are quite resistant to seed decay and benefits from seed treatment are not always evident. In only two out of six tests covering three years did marked increases in both yield and stands of early smooth peas follow the use of seed protectants. In one case where treatment gave increased stand and yield, early planting was followed by an extended period of wet, cold weather, the interval between planting and emergence exceeding four weeks. However, the cost of treatment is so low that the grower can hardly afford not to avail himself of the insurance provided by seed protectants. Arasan, Cuprocide, Semesan and Spergon are recommended. Under some conditions a distinct stunting has been observed in rows treated with Semesan, although seed decay was quite effectively prevented.

Peas, wrinkled seed types. Most of the popular garden varieties, such as Little Marvel and Laxton's Progress, belong to the wrinkled seed class. These varieties are more susceptible to seed rot and consequently benefit to a greater extent from seed protectants than the early, smooth seeded types, particularly when planted early in cold soils. Under eastern Nebraska conditions seed treatment has improved stands in six out of seven tests using wrinkled seed varieties. The accompanying charts (Figures 1 and 2) illustrate the results from a test in 1942 where the benefits were particularly marked. The results of seed treatments on wrinkled seeded peas during three seasons (1942-44) certainly justify the use of seed protectants by the commercial vegetable producer as well as the home gardener.

Based on evidence obtained in several years' tests in Nebraska and other states, the following materials are recommended for wrinkled seeded peas in order of preference: Spergon, Arasan, Semesan and Cuprocide.

Lima beans. In Nebraska the lima bean has been found to benefit consistently from seed treatment. The practice of early planting to avoid the

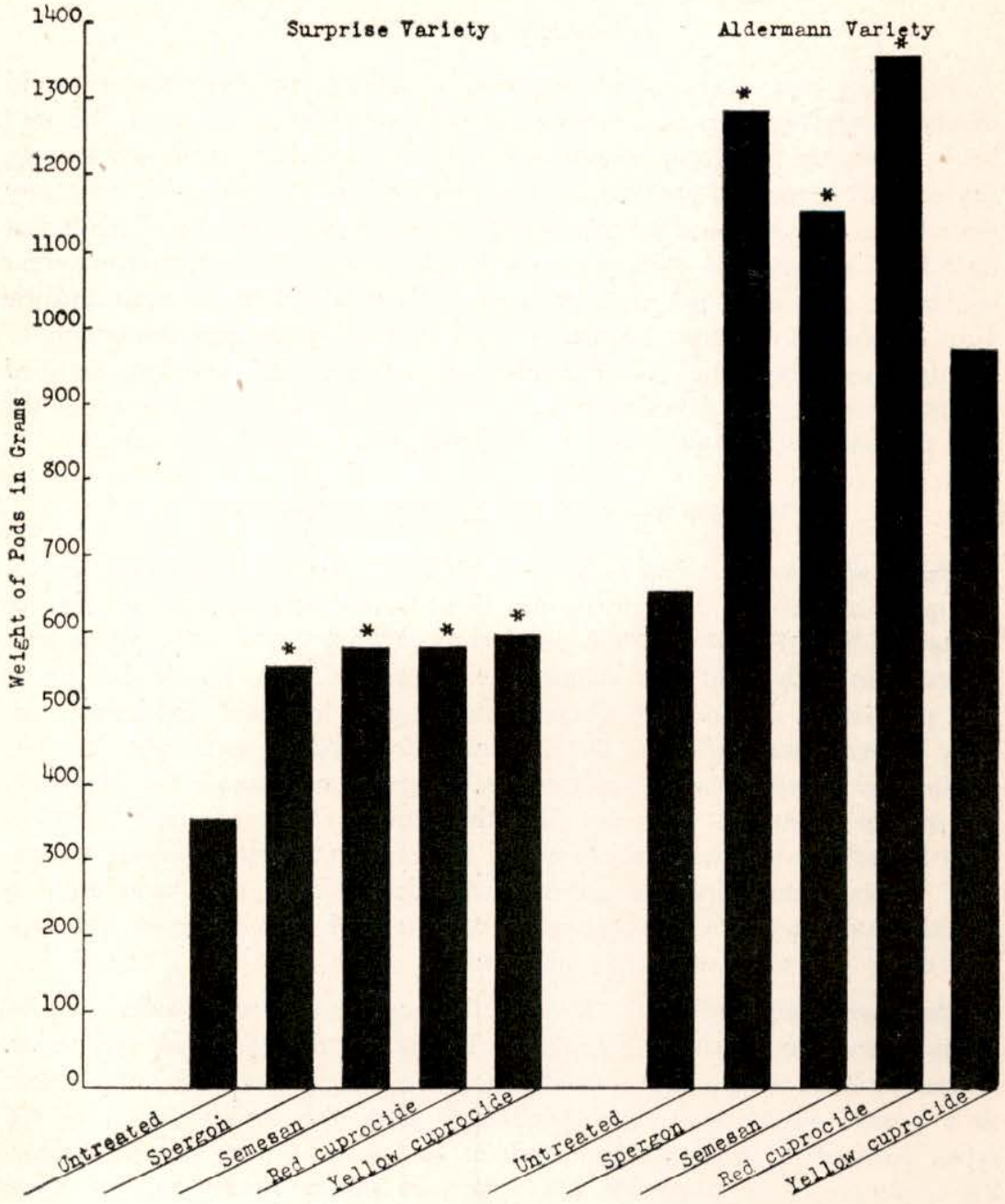

FIG. 2.—Average yield of pods obtained when pea seed was treated before planting. There were five replications of each treatment. Asterisk at top of column indicates significant increase over the untreated plot.

high temperatures of July and August has resulted in below-optimum temperatures for germination, resulting in frequent failure. Under these circumstances, seed treatment has given the best results. Through the use of viable seed and the proper seed proctectant, good stands may be assured.

Tests on lima beans in 1943, 1944 and 1945 clearly indicate the desirability of using one of the two new materials, Spergon and Arasan. The results of the 1944 test are illustrated in Figure 3. Spergon has consistently given

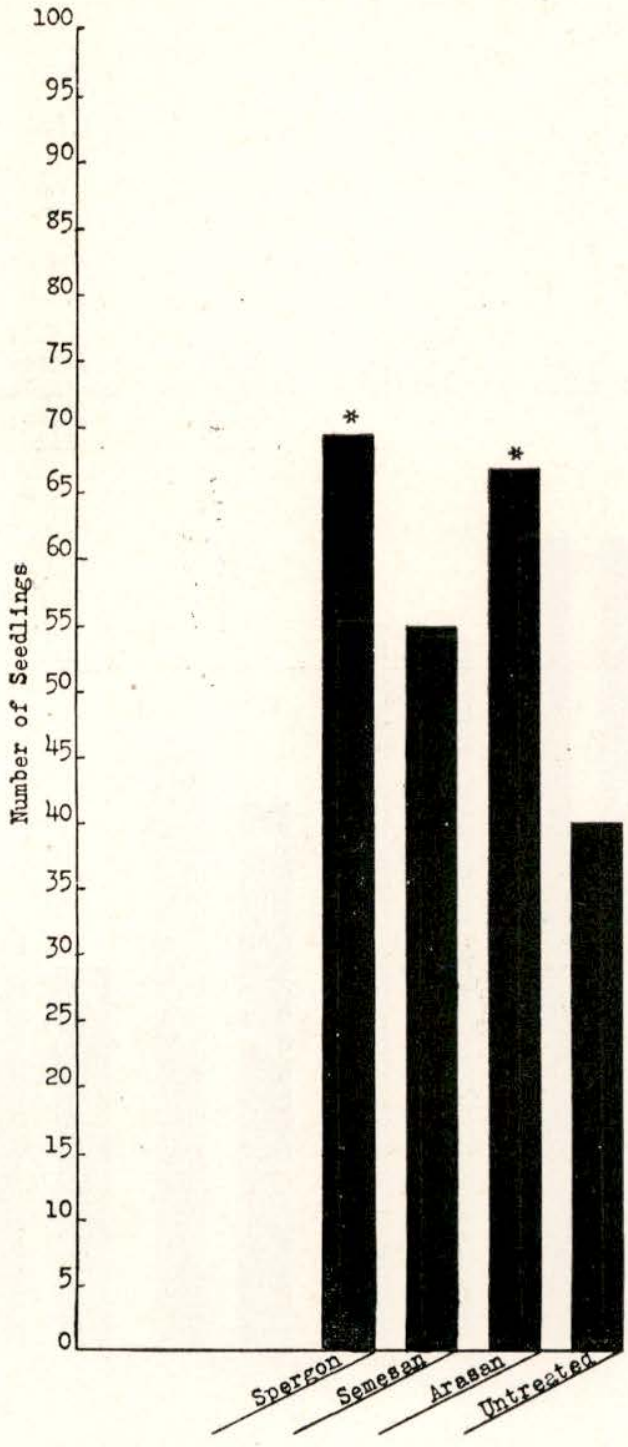

FIG. 3.—Average number of plants obtained from planting 100 seeds of Henderson Bush lima beans following treatment. Asterisk at top of column indicates significant increase over the untreated plot.

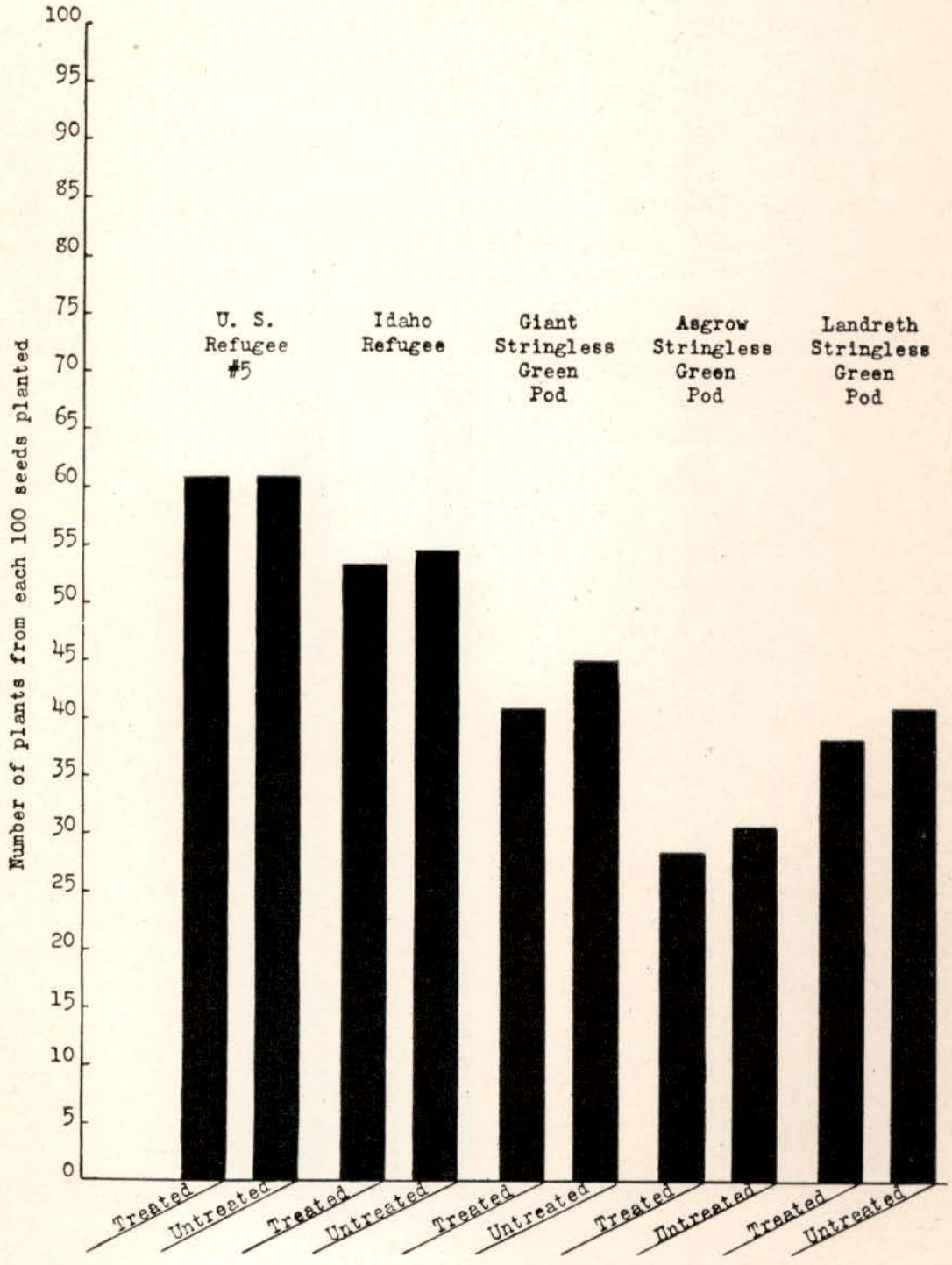

FIG. 4.—Average number of plants obtained from planting seed of different varieties of snap beans after treatment with Spergon.

slightly better results than Arasan and both have been definitely superior to Semesan. Spergon and Arasan are recommended for lima beans at the rates specified by the manufacturer.

Snap beans. Green and wax garden beans failed to benefit from seed treatment in tests conducted in 1942, 1943 and 1944. Semesan, Cuprocide, Arasan and Spergon were used in these experiments. With the possibility in mind that certain varieties might respond to seed treatment where others did not, Giant Stringless, Asgrow Stringless Green Pod, Landreth Stringless Green Pod, Idaho Refugee and U. S. Refugee were compared under conditions which resulted in an average germination of 46 per cent. Seed treatment gave no increase over the untreated check (Figure 4).

More important than seed treatment for snap beans is the selection of carefully threshed disease-free seed to aid in the control of bacterial blight. This disease is carried inside the seed and is not controlled by any known seed treatment. The use of certified seed or seed from western areas where blight is not a problem is recommended.

Garden beets. In two years' tests garden beets have responded very favorably to seed treatment, particularly in early plantings when conditions for germination were unfavorable. Later in the summer when temperatures were high, results were less favorable. Tests involved a variety of materials but most of the evidence relates to Yellow Cuprocide, Arasan and New Improved Ceresan. Arasan and New Improved Ceresan gave slightly better stands than Cuprocide. In an earlier test Semesan and Spergon gave excellent results. In Figure 5, the results from a seed treatment test planted on May 1, 1944, are graphically pictured. Comparable results were obtained by applying Arasan at three different rates, thus demonstrating the wide latitude of effectiveness available in the newer materials. Arasan, New Improved Ceresan, Semesan, Cuprocide and Spergon can be recommended for garden beet seed with assurance of improved stands.

Cabbage, cauliflower, radishes, turnips. Ordinarily little trouble is experienced in obtaining satisfactory stands with the crucifers. Members of this family produce vigorous, fast-growing seedlings quite tolerant to cold soils, and consequently little benefit can be expected from seed protectants. However, with seed lots of doubtful vigor or following hot water treatment (described on page 17) it is advisable to treat with Semesan, Spergon or Arasan.

In seedbeds some loss from damping-off usually occurs following emergence. This can be reduced by careful watering (preferably only in the morning of sunny days). Soaking all the soil in the flat so as to make frequent watering unnecessary helps keep the soil surface and plants dry as much of the time as possible. In addition, the application of a fungicide such as zinc hydroxide or Arasan to the surface of the soil will help reduce damping-off. Never use materials containing copper on crucifers since copper is extremely toxic to members of this family.

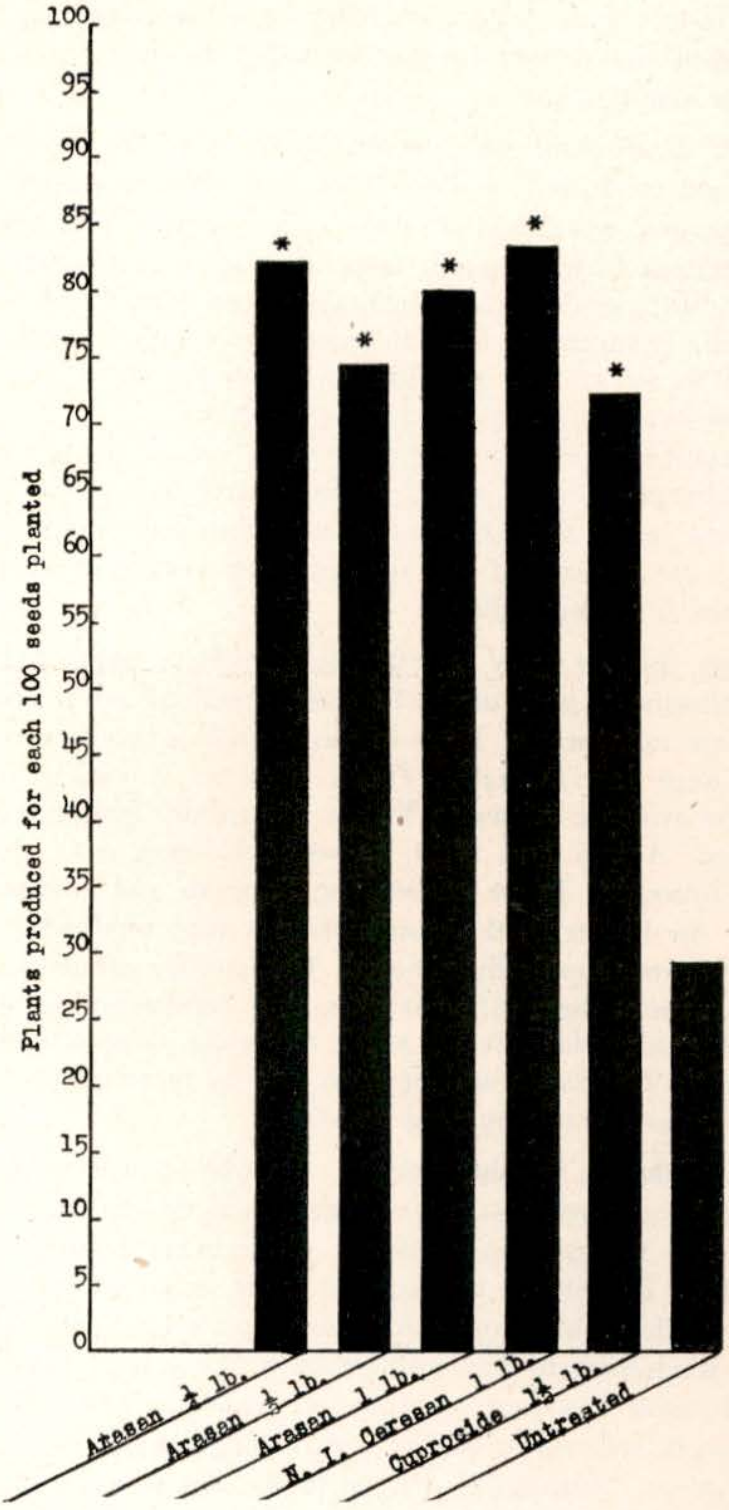

FIG. 5.—Emergence of garden beet seedlings following seed treatment at varying rates of application of different materials per bushel of seed. Asterisk at top of column indicates significant increase over the untreated plot.

Black rot, one of the diseases of cabbage, cauliflower and broccoli, which is frequently troublesome in Nebraska, is carried within the seed and cannot be controlled by the ordinary seed protectants. A special treatment, either hot water or corrosive sublimate, is necessary. These treatments are described on pages 17 and 18.

Carrots. Seed treatments ordinarily are necessary only on early planted carrots. Beneficial results have been reported with Spergon, zinc oxide and Cuprocide.

Temperature, moisture and the mechanical condition of the soil are usually the determining factors in relation to stands. In eastern Nebraska it is frequently necessary in midsummer to provide some sort of wind and sun protection for the young seedlings, in order to obtain satisfactory stands for fall harvest. These late plantings escape injury from the carrot weevil.

Sweet corn. While sweet corn has not benefited consistently from the use of seed protectants, the low cost should certainly justify treatment as a means of insurance, particularly on early plantings or with damaged seed. In three of five tests stands were improved under eastern Nebraska conditions. In only one of the five tests was yield appreciably increased. When benefit occurred, either conditions for germination were poor or damaged seed was employed. It has also been noticed that fewer weak seedlings occur when treated seed is used.

The results from the 1943 test using Golden Cross Bantam are illustrated graphically in Figure 6. Arasan and Spergon gave significant increases in yields. However, where moisture is a limiting factor increased stands are not necessarily followed by increased yields. Seed treatment does *not* control smut in sweet corn.

Cucumbers, melons. While recent experimental work on these crops is lacking in Nebraska, results from other states indicate that favorable responses may be expected from seed treatment of cucumbers, cantaloupe and watermelons. Several materials have proved effective and at present one material cannot be recommended over another. Spergon, Arasan, Semesan and Cuprocide have all effectively increased stands in these crops.

Eggplant. Eggplant seed germinates rather slowly, requiring moderately warm soil. Treatment of the seed with one of the dust materials frequently, but not always, improves the germination and the resulting stand.

Phomopsis blight is a seed-borne disease that frequently causes serious damage to the foliage and fruit of eggplant in eastern Nebraska. Disinfecting the seed with corrosive sublimate controls the disease but often injures germination. On the other hand, the hot water method has been used successfully in other areas. This consists of soaking the seed in water held at 122° F. for 25 minutes. When dry, the seed should be treated with Cuprocide dust at the rate of 2½ ounces to 15 pounds of seed.

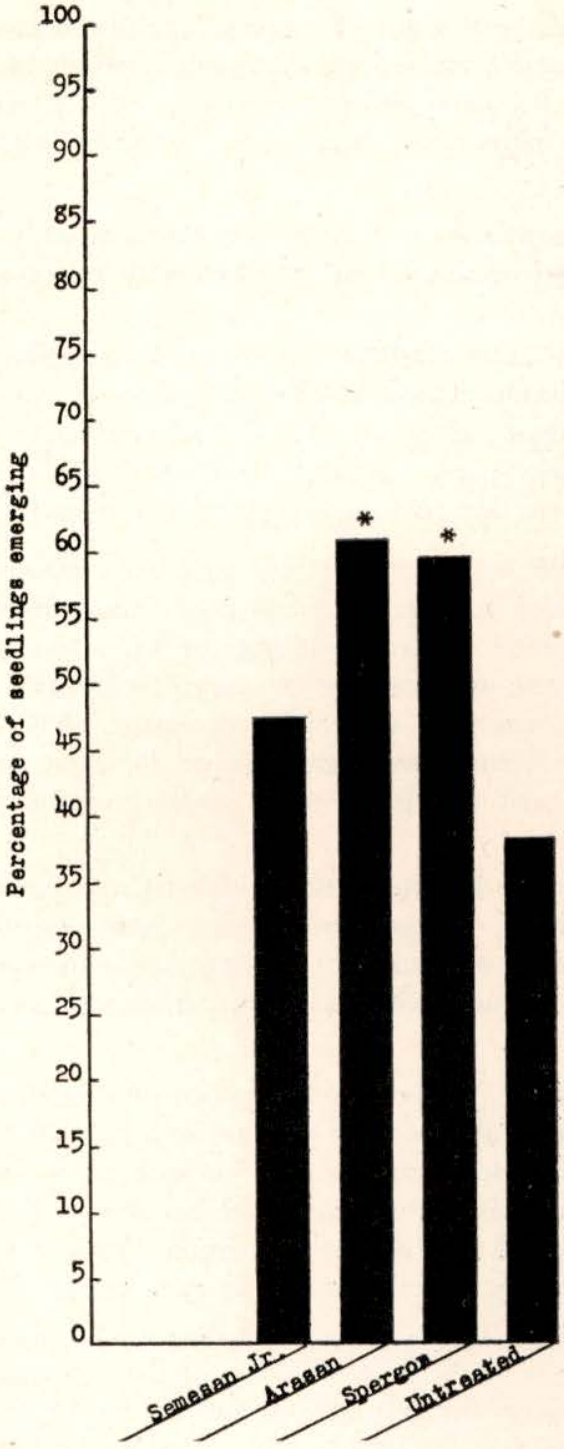

FIG. 6.—Average emergence of seedlings of Golden Cross Bantam sweet corn following treatment with different materials. Asterisk at top of column indicates significant increase over the untreated plot.

A small sample of seed should be treated and tested for germinability before treating the entire lot. Seed lots apparently vary in their susceptibility to injury.

Lettuce. Lettuce seed requires very shallow planting and yet a sufficient covering of soil to insure adequate moisture for germination. Seed treatment has improved stands where moisture was adequate but under Nebraska conditions a reduction in stands has been observed when treated seed is planted in dry soils. Seed treatment can be recommended for early planting or for seedbed plantings when adequate moisture can be supplied. Cuprocide and Spergon appear to be the most effective materials.

Onions. Onions seldom show clearcut benefits from seed treatment and then differences are not great. However, the low cost of treatment may well encourage growers to take advantage of the degree of insurance offered by several materials. Arasan and Semesan have given favorable results in other states. These would be of greatest value on early plantings. Treatment of onion sets is not recommended.

Onion smut has not been of importance in the truck areas in Nebraska, so its control is of little concern here. If the disease is found, specimens should be submitted to the Plant Pathology Department of the University of Nebraska and control measures will be suggested.

Peppers. In limited trials at Lincoln, Arasan and Cuprocide have improved stands of several varieties of pepper. Semesan usually gives improved stands although it occasionally causes some injury resulting in a stand reduction. Arasan has given the most favorable results with no indication of injury.

The importance of bacterial spot in commercial plantings of peppers in eastern Nebraska makes the disinfection of seed very desirable. Semesan is a satisfactory seed disinfectant when used as a liquid soak according to the directions on the package. Hot water treatment (25 minutes at 125° F.) followed by Cuprocide (½ ounce to 3 pounds of seed) after the seed has dried, has been widely recommended. A small quantity of seed should be treated and tested for germinability before subjecting one's entire supply of seed to either of these treatments. Seed lots vary in susceptibility to injury and only lots of high viability should be used.

Spinach. In the only test on spinach (1942) Cuprocide, zinc oxide and Spergon all produced significant increases in stand, Cuprocide being the most effective. More recent tests in other states have indicated Arasan to be another good material for spinach. Seed treatment of spinach is a worthwhile practice.

Tomatoes. While little trouble is ordinarly experienced in obtaining satisfactory stands of tomato seedlings, the use of seed protectants has nevertheless usually given improved stands. Cuprocide, Arasan, Spergon and New Improved Ceresan have been very effective.

The common occurrence of several seed-borne diseases in Nebraska makes seed disinfection desirable. Tomato seeds are much more resistant to mercury injury than pepper or eggplant and either mercuric chloride (corrosive sublimate) or New Improved Ceresan can safely be used. Some stunting and retardation of growth may be evident if treatment is made immediately before planting. The tomato seed should be immersed in a solution of New Improved Ceresan (1-1200 for 5 minutes) or mercuric chloride (1-3000 for 5 minutes), then rinsed and dried. See page 17 for detailed instructions. The hot water treatment is also very effective.

SEED DISINFECTION

THE SEED PROTECTANTS discussed in the first part of this circular are primarily used to prevent damping-off. They *do not* control the numerous foliage and fruit diseases that occur on vegetables. Most of these diseases are caused by bacteria and fungi that are found in or on seeds from infected plants. The elimination of seed-borne inoculum, particularly in those diseases where it is a principal source of infection, is of major importance. For their control it is necessary to use a seed treatment that acts as a disinfectant by killing the organisms on the seed. Various chemicals are used as disinfectants. The problems involved and the methods are discussed here briefly.

The destruction of disease-producing organisms may be accomplished by the use of chemicals or heat. The seed can also be killed by these processes, so the problem is to kill the bacteria and molds without causing appreciable injury to the seed. This is sometimes difficult.

With diseases where the organism is carried on the outer seed coat the chemical disinfectants are quite successful. Corrosive sublimate (mercuric chloride), copper sulfate, Semesan and formaldehyde used as liquid soaks are commonly employed for seed disinfection. Since diseases and seeds vary in their susceptibility and resistance, respectively, to these treatments, it is necessary to follow carefully the recommendations for each kind of seed. There is no over-all treatment. Chemical disinfection is limited to those diseases where the organism is carried on or near the surface of the seed. A discussion of these diseases may be found in Nebraska Extension Circular 1801.

Heat provides the only effective means of reaching and killing organisms beneath the seed coat. The hot water treatment, the common method of supplying heat, is limited to those instances where the seed is appreciably more resistant to heat than is the organism involved. Frequently the margin between death of the fungus and death of the seed is not wide, necessitating strict observation of temperatures and time limits. The hot water treatment is highly effective when properly carried out.

The professional vegetable grower will find one of the following methods of seed disinfection quite valuable in helping to produce disease-free transplants year after year.

Hot Water Treatment

The use of heat, as in the hot water treatment, is the most versatile means of disposing of seed-borne organisms. However, the narrow tolerances demanded for successful treatment make it a very exacting process. Even under the best of conditions germination is usually lowered. Old or weak seed should never be treated with hot water. It is a wise precaution to treat and test a sample before subjecting an entire lot of seed to the treatment. When carefully carried out, it is a most dependable treatment against seed-borne organisms and the only effective measure against the organisms carried within the seed.

The hot water treatment calls for seed of high viability, a water bath in which a constant temperature can be maintained, and an accurate thermometer. The temperature must not go more than 2 degrees above or below that recommended and can be regulated by adding hot water. Both the time interval and temperature must be rigidly followed if the disease-producing organisms are to be destroyed without injury to the seed. The use of direct heat on the container should be avoided.

The seed is placed in a loose cloth bag and immersed in the water for the required time, then cooled and dried as quickly as possible. The following chart indicates the proper hot water treatment for various seeds.

Hot Water Treatment Chart

Crop	*Temperature*	*Time*
Tomatoes	125° F.	25 min.
Peppers	125° F.	25 min.
Eggplant	125° F.	25 min.
Cabbage	122° F.	30 min.
Cauliflower	122° F.	20 min.

A seed protectant should be applied after the seed has dried. Do not use Cuprocide on cabbage or related plants. Arasan and Spergon are very satisfactory and safe to use.

Corrosive Sublimate (Mercuric Chloride)

Corrosive sublimate is very effective against organisms on the surface of the seed. Treatment must be made at room temperature in non-metallic containers, such as wood, glass, earthenware or enamelware. The chemical may be dissolved in a small amount of hot water and then added to the correct volume of cool water. The solution loses its strength with each treatment and should be replaced. Following treatment, which should be carefully timed, the seed should be washed and quickly dried. Corrosive sublimate may be obtained at the drug store in 7½-grain tablets or in larger bulk quantities. The directions for using corrosive sublimate should be carefully followed, thus reducing the danger of injuring seed germination.

The following measures provide the concentrations most commonly used:

1–1000
1 oz. in 7½ gallons of water or
1 tablet (7½ grains) in a pint of water

1–2000
1 oz. in 15 gallons of water or
1 tablet (7½ grains) in a quart of water

1–3000
⅓ oz. or 1 teaspoonful in 8 gallons of water or
1 tablet (7½ grains) in 3 pints of water

Precautions. Mercuric chloride is very poisonous. Carefully dispose of the treating solution. Do not expose hands and arms unnecessarily to the treating solution. Seed disinfected with mercuric chloride should be protected from damping-off with Cuprocide, Spergon or Arasan. It is advisable to disinfect and test a small quantity of seed for germinability before subjecting large lots of seed to disinfection.

Mercuric Chloride Treatment Chart

Crop	*Concentration*	*Time*
Tomatoes	1–3000	5 minutes
Cabbage	1–1000	20 minutes
Cucumbers	1–1000	5 minutes
Peppers *	1–2000	2 minutes
Eggplant *	1–2000	5 minutes

* Frequently causes injury. Semesan as a liquid treatment seems to be less toxic and is preferred for these two crops. See recommendation accompanying product.

Copper Sulfate

Copper sulfate appears to be a very effective seed disinfectant for certain crops. It can be used on tomato seed following the hot water treatment. It is also a satisfactory treatment for pepper seed which is very susceptible to the mercurial compounds. The following treatments are recommended:

Tomatoes: Soak in solution of bluestone (copper sulfate), 2 oz. in 1 gallon of water for 1 hour. Then dry.

Peppers: Presoak in water for 5 to 6 hours. Soak in bluestone, 1½ oz. in 1 gallon of water for 5 minutes.

SOIL TREATMENT

SEED DISINFECTION is only the first step in disease control and the advantages gained may be immediately lost by planting seed in infested seedbeds. In addition to the common damping-off fungi, various other organisms which attack plants may be harbored in seedbed or propagation soil. These include

the fusarium wilts of tomatoes and cabbage, the slime mold causing club root of cabbage, the Verticillium attacking eggplant as well as many of the common foliage diseases which live over the winter on dead stems and leaves. The close proximity of plants in the seedbed furnishes ideal conditions for development and spread of these diseases which are then carried into the fields on the transplants. The seedbed is a critical point in plant disease control.

The use of virgin soil in hotbeds and cold frames is a practice of long standing but even soil from woods or uncultivated areas may carry troublesome quantities of weed seeds and damping-off organisms. Where extensive operations are conducted the annual replacement of seedbed soil becomes a costly item. Thus, more attention is being given to methods of soil sterilization or disinfection. Proper soil treatment has the additional advantage of eliminating weed seeds, insects, and nematodes.

Heat has long been used in soil sterilization in the form of live steam, dry heat and hot water, each with certain advantages but all being inconvenient to use. As a result, chemical treatments are becoming more and more widely used. When facilities are available for supplying large volumes of steam or hot water, as in greenhouses, the heat treatments of soil are strongly recommended. However, where such equipment is not available, chemical treatments offer many advantages.

Sterilization of small quantities of soil may be accomplished by baking in pans or flats in the oven for at least an hour. If a fairly large quantity of soil is to be sterilized, a medium-sized potato should be buried in the center of the soil and the soil left in the oven until the potato is baked.

Sterilization with formaldehyde is the oldest and most used method. One tablespoonful is used for a flat of soil 20 x 14 x 3 inches deep or 2½ tablespoonfuls for 1 bushel of soil. The formaldehyde is diluted four or five times with water and applied by spraying on the soil while mixing. Then the soil is covered for 24 hours, after which it is allowed to air at least 24 hours before planting. After the seeds are sown, the soil should be thoroughly watered. If the soil mixture is high in organic matter, a slight increase in the amount of formaldehyde may be justified.

Several commercial preparations, such as Larvacide, D-D, and Dowfume G, give partial sterilization of the soil. They are not as effective as heat or formaldehyde for killing disease-producing organisms. Their primary value is in killing nematodes.

In addition to the use of seed and soil treatments, certain practices that are usually considered only in connection with production may be adopted to serve as very important aids in preventing injury by diseases. Such practices include the use of viable seed, thorough preparation of the seedbed, adequate cultivation, and application of fertilizers.

November 1948 (5M)