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SEED POTATOES
SELECTION AND DISINFECTION

by
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Blackleg— A seed-borne bacterial disease

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SUMMARY

1. Poor seed and diseases are partly responsible for low yields of potatoes in Arizona. The best seed potatoes should be used for planting and seed tubers should be disinfected.

2. Home-grown seed that is equal or superior to imported seed can be produced. To select and increase disease-free, high-yielding strains of potatoes, a seed-plot should be established on every farm on which potatoes are commercially grown.

3. Only the cleanest certified seed potatoes should be planted to start the seed-plot and the tubers should be disinfected. Either the tuber-unit or the hill method should be used in the seed-plot. Both methods are described.

4. The seed-plot should be given extra care in the matter of fertilizing, cultivating, and irrigating. Several inspections should be made during the growing season. Diseased and otherwise undesirable plants should then be removed and destroyed.

5 Seed pieces should not be dropped and left exposed in the field during planting operations, nor should they be planted in dry soil. Attention should be paid to the effect of depth of planting on extent of disease.

6. Potatoes for seed should be dug by hand, carefully selected, and stored in labelled, clean sacks. Only the choicest, healthy, unblemished, uninjured tubers which are true to varietal type and selected from hills with a maximum yield of marketable potatoes should be saved for seed.

7. The seed potatoes should be stored in a well-ventilated house in which the temperature can be held between 35° F. and 40° F. The storehouse should be disinfected or fumigated before use. Directions are given for disinfecting and fumigating storehouse.

8. Seed pieces sometimes refuse to sprout promptly after planting, are attacked by organisms, and rot in the ground. The inactivity or "sleeping" condition is called dormancy. A trial formula is given for hastening the sprouting of seed potatoes.

9. Several treatments are described for disinfecting seed potatoes. Mercury-containing disinfectants are strong poisons when taken internally. Unused disinfecting solution and unused treated potatoes should be deeply covered with soil.

10. Badly sprouted seed potatoes are often injured by disinfectants. When proper storage facilities are not available for maintaining low temperatures, seed potatoes may be treated before storing by the standard mercuric chloride method.

SEED POTATOES

SELECTION AND DISINFECTION

J. G. BROWN AND R. B. STREETS

The average yield of potatoes in Arizona for the 10-year period, 1919-1928, is 74 bushels per acre (1). This yield is the lowest in the Mountain States with the single exception of that of New Mexico. Although the climate of Arizona is not ideal for potato culture except at the higher altitudes (2), poor seed and the prevalence of potato diseases have as much, or more, to do with the low yield. Both factors are within the possibility of control. Careful selection of clean seed potatoes and the general use of disinfectants should result in increased yields and the saving to the State of part of the money annually spent for imported potatoes. Large yields of potatoes are possible only when good, clean seed is used.

SOURCES AND SELECTION OF SEED POTATOES

Seed potatoes used in Arizona are home-grown, imported directly from other states, or purchased on the market.

Home-grown Seed

There is evidence that home-grown seed potatoes can be produced that do better in our potato districts than imported seed. Potatoes grown in the Duncan district have been used for seed in Pima County with outstanding success. No doubt the results obtained from the use of the Duncan seed are due in large measure to the selection and disinfection of the seed potatoes and the rogueing of fields which have been practiced in that district for several years. Repeated selection, disinfection, and rogueing of potatoes constitute a valuable means for eliminating many potato diseases.

The farmer who selects seed potatoes from his own fields should give attention to the size and shape of the tubers. A minimum diameter of 1⅞ inches and a maximum weight of 12 ounces are standard in several states for selecting seed for certification. Although small potatoes selected from thrifty hills in the field

produce satisfactory crops, those left after grading are often poor stock.

Irregularities in the shape of seed potatoes may indicate disease. Spindle-shaped and pointed tubers are indicative of a virus disease known as spindle-tuber. Irregular tubers should be discarded. Bruised, cut, cracked, and hollow tubers, also those with internal discolored spots, should not be used for seed. The selected potatoes should be handled carefully and not like bags of coal.

Imported Seed

Certified seed potatoes have been proved to be best. In one report giving the results of more than 11,000 comparative tests in 27 states, certified seed showed an increase of 46.4 bushels to the acre over the yield from uncertified seed.

The certification of seed potatoes in the different states producing them is usually done under the supervision of the state department of agriculture or the college of agriculture and experiment station. Most states require at least two field inspections of the growing crop besides the final inspection of the harvested tubers.

In order to pass inspection the potatoes from a given field must be of one variety, free from dirt and foreign matter, from frost injury, excessive sunburn, second growth, growth cracks, insects, and mechanical or other injury. No late blight, powdery scab, or potato wart is allowed. Only slight to moderate infections with scab, rhizoctoniose, stem-end discoloration and spindle-tuber are permitted. The size of the seed potatoes offered for sale is specified.

The purchaser of certified seed potatoes should make sure that the certification is made under the authority of the state in which the potatoes are produced. The original tag of the state inspector should be found on each sack of potatoes. Some so-called "certified seed" bears only the tag of the producer, and only the guarantee of the producer is back of the seed.

Finally, all certified seed potatoes are not equally good. Occasionally a shipment, which should never have been certified, appears to "get by" the inspectors. The purchaser of certified seed should make clear in his correspondence with the producer or the potato growers' association with which he deals that the potatoes must be exactly as advertised and must comply with the state rules of certification. Whenever choice seed is obtained, the name of the producer should be advertised among local growers for future patronage.

Market Seed

Seed potatoes purchased on the market from supplies offered for sale for food are a gamble. They may introduce mosiac and one or more of the many other diseases to which the potato is susceptible. Even if the potatoes were originally free from disease the frequent and careless handling of food stocks usually results in bruised tubers which may be infected with one or more of the storage rots. Seed pieces from such tubers are inferior.

Having selected the seed potatoes, preferably the best certified seed available if the grower is starting a program for the improvement of his crop, the next step is the increase of the seed.

INCREASING THE SEED

The seed plot is an excellent means for eliminating diseases and otherwise improving seed potatoes, as well as for increasing the seed. A seed plot should be established on every farm where potatoes are grown commercially. The plot should be located at a distance of at least 300 feet from other potato fields, on the best soil adapted to potatoes, and on soil in which no potatoes have been grown for the preceding 5 years. The soil should be fertilized and the crop carefully cultivated. The area of the plot should be one-tenth to one-seventh that of the potato acreage of the farm which the plot is to supply with seed. The best results in improving the seed will be obtained by using either the tuber-unit method or the hill method.

The Tuber-Unit Method

If the tuber-unit method is followed each tuber is cut lengthwise, stem-end to seed-end, into four seed pieces. Each seed piece is planted in a hill so that one tuber plants four hills. The hills from each tuber are marked by driving down a 2-foot stake in the row where it is out of the path of the cultivator. The first series of four hills with its stake is followed by a second series of four hills and so on until the tuber-units are planted. Each stake is numbered for reference at harvest time. One hundred and fifty to 200 tuber-units should be started the first year.

At harvest time the tubers from each tuber-unit are weighed and placed in a bag labelled with the number of the unit, weight of the tubers, and date of digging. From each of the best units 10 potatoes which are free from disease and typical for variety, are selected to plant in the seed plot the next season. The 10 tubers thus selected are placed in a bag and properly labelled. Each unit the next season will contain 40 hills. By

the third season the best yielding strains should stand out. At that time there should be enough seed tubers in each desirable strain to plant a large seed plot. Having thus established a desirable high-yielding strain, it is necessary in the future only to rogue out diseased and off-type plants. Seed potatoes left over each year after selection for planting the seed plot are used in planting the commercial field.

The Hill Method

Selection of disease-free, thrifty, heavy-yielding strains by the hill method is similar to the selection by the tuber-unit method. One seed piece is planted in each hill. During the growing season the thrifty, healthy plants are staked. At harvest time the selected staked hills are separately bagged and labelled. Potatoes which have descended from different seed pieces are not mixed in planting. This method takes longer to obtain a quantity of seed potatoes, but the selection is closer and the results are better. The accompanying diagram (Fig. 1) makes this method clear.

Rogueing

Rogueing means the removal of diseased and otherwise undesirable plants. Inspections of the seed plot should be made at intervals of 2 weeks during the growing season. At this time the plants are gone over one by one, and all weak, diseased, off-type plants are destroyed. At least one inspection should be made by a trained pathologist. Such an inspection can be provided by the Department of Plant Pathology without cost to the farmer. Selection is a valuable means for obtaining disease-free as well as high-yielding strains, and the seed plot is a much better way than selection from the field. The seed plot is especially valuable in eliminating virus diseases, which cause "running out" or degeneration of potatoes, a trouble formerly attributed to conditions of the soil, temperature, and other environmental conditions.

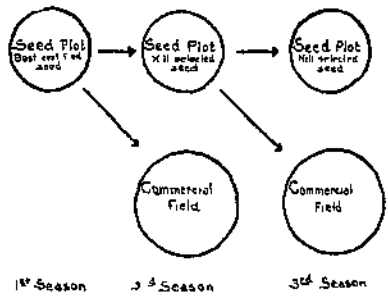


Fig. 1. Diagram showing method of maintaining and improving seed stock by use of isolated seed plot.

DISINFECTION OF SEED POTATOES

Reasons for Disinfection

Even the best seed potatoes on the market usually are more or less infected with black scurf; frequently they also carry common scab and blackleg.

Black scurf is caused by a fungus called *Rhizoctonia solani*. This fungus forms on the surface of potato tubers small, blackish bodies which are termed sclerotia. The sclerotia can remain alive on the stored tuber and infect the young plant from the seed piece. They look like spots of dirt, but they do not rub off. Plants grown from infected seed pieces produce few or no potatoes of marketable size; often they produce many small tubers. Rhizoctonia may kill the sprouts on the seed pieces, attack the stem and cause a dry rot of the tubers. In the field Rhizoctonia thrives under temperatures that favor the vigorous growth of the potato plant (3). The fungus is bad in both acid and alkaline soils.

Fig. 2.-Black scurf (Rhizoctonia) sclerotia of various sizes; aptly described as "the dirt that won't wash off."

Common scab, another fungus disease, is caused by *Actinomyces scabies*. The scabs which give the common name to the disease, start at the breathing pores of the tuber as small, brown specks. Later the specks enlarge and become rough and corky. They may even cover the surface of the tuber. Scabby potatoes present an uninviting appearance on the market and making thick peeling necessary. They also lose more water in storage than clean, smooth potatoes (4). The scab fungus grows will under temperatures prevailing in Arizona during the potato growing season. Its growth is favored by alkaline or neutral soils and discouraged by acid soils. Only fertilizers which have an acid reaction in the soil should be used on potato fields.

Blackleg is a bacterial disease of potatoes resulting from an infection with *Erwinia atrosceptica*. It causes a soft decayed spot in the stem-end of the tuber. When the skin is removed from an

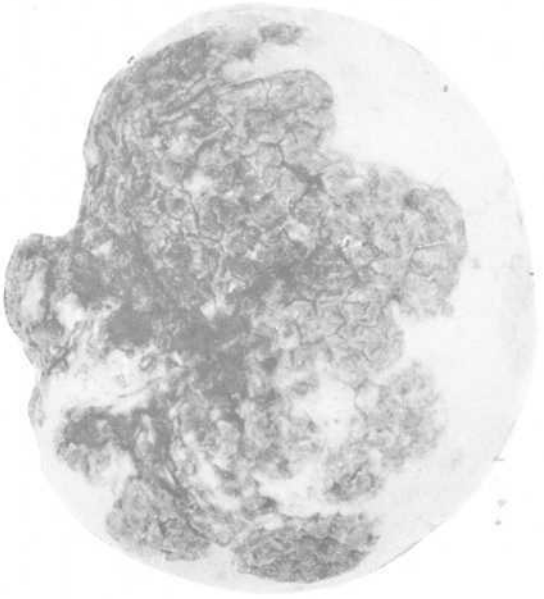


Fig. 3. Common scab. Caused by Fungus (*Actinomyces scabies.*) Scabs start at the breathing pores of the tuber as small, brown specks. Later the specks enlarge and become rough and corky.

infected spot, the flesh becomes reddish and then black. The rotten spots may spread and form large "scores" or, lesions. When a seed piece which is diseased with blackleg is planted it

Fig 4. Section of potato tuber showing rot caused by blackleg organism.

either decays or else the bacteria spread from it to the young plant and cause rotting and blackening of the tap-root and lower or basal part of the stem. (Fig. 5) Potato plants may be dwarfed or killed by the disease. Low temperatures and high humidity favor the disease which is bad in the irrigated sections of Arizona. Since the germ survives the winter in Michigan (5), it is probably able to survive in Arizona. It can do this only

Fig. 5. Potato stem showing blackleg, a seed-borne bacterial disease.

when it is protected in the tuber. For this reason the practice of leaving the crop in the field over winter, which is sometimes followed in Arizona, is a bad one.

The proper disinfection of seed potatoes kills the parasites on the surface of the tuber unless the infections are numerous and far advanced. It does this without injury to the tuber. Disinfection does not reach the parasites which cause deep-seated

diseases, such as Fusarium rots. It may not greatly increase the yield where treated seed potatoes are planted in fields in which black scurf, scab, and blackleg diseases have been bad in preceding potato crops. Even in this case seed potatoes should be treated, for the parasites carried on the tuber are often more active than those left in the soil by preceding potato crops, especially after the parasites have remained inactive in the soil during the winter months, and the hot, dry fore-summer.

Rotation of crops should be practiced in combination with seed-potato treatment. In Arizona, potatoes should not follow potatoes, cotton, or beans. The Rhizoctonia which attacks cotton (causing soreshin) and bean plants is also active on potatoes. Resistant varieties of potatoes would make disinfection unnecessary, but no varieties have been found to be sufficiently resistant to the above-mentioned diseases to make them of value commercially. Disinfection which may be made very effective unless the soil is seriously infested, is a cheap insurance against surface-borne diseases.

Equipment

(a) Vessels for measuring, mixing, and dissolving chemicals, scales, and thermometer.

Disinfecting solutions containing mercuric chloride attack metal, therefore only wooden, earthen, glass or enameled vessels can be used. Use a glass measure, graduated in ounces to measure acid. A scale weighing in ounces is desirable when the powdered crystals of mercuric chloride are used. The crystals may be weighed out in proper amounts, according to the size of the container, by a druggist. When a hot treatment is to be used on the seed potatoes an accurate thermometer is necessary. Special heating apparatus is also advisable.

(b) Vessels for holding the disinfectant.

Wooden barrels of 50-gallon capacity are useful for disinfecting small quantities of seed potatoes. A battery of three barrels (Fig. 10) will keep two operators busy when the 5-minute treatment is applied. More barrels will be needed for longer treatments in order to save time., For large quantities of seed potatoes a tank is more economical of time.

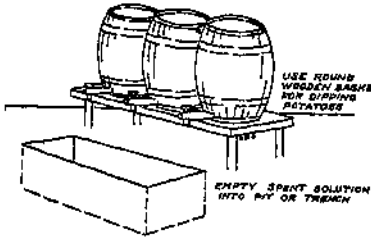


Fig. 7 Convenient arrangement of barrels for treating small amounts of seed-potatoes.


MATERIALS NEEDED
16 OZ.
4 QTS.
HOT WATER
FIRST
WEIGH MERCURIC CHLORIDE
(TABLETS ARE MORE CONVENIENT,
AS NO SCALE IS NEEDED.)
TABLETS
POWDER
SECOND
DISSOLVE MERCURIC
CHLORIDE IN HOT WATER
4 QTS.
HOT WATER

Two types of tanks are illustrated in Figures 8, 9, 10. The larger tank is capable of handling a wagon-load of seed potatoes at one time. This tank which was built by the potato growers in

Fig. 8. Community seed treating plant which has served the Duncan district (Greenlee County) for the past four years. See Fig. 9 for details of construction.

the Duncan district, is constructed of cement. The location of the tank is advantageous. Water runs by gravity into the top of the tank and the waste disinfecting solution flows out by grav-

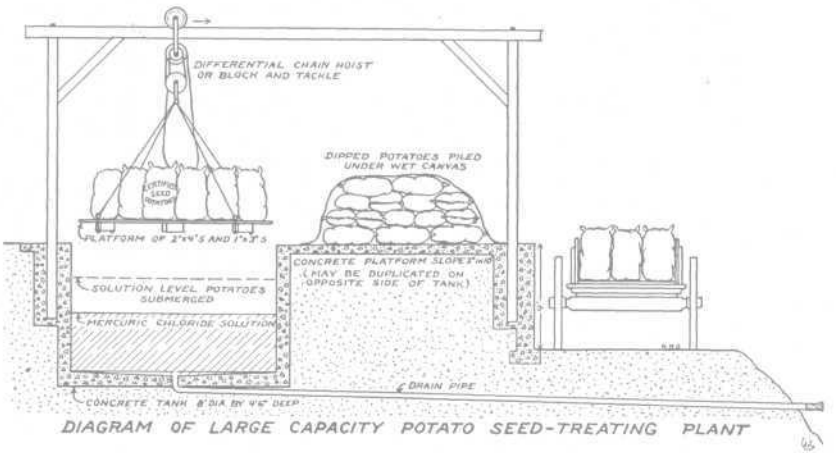


Fig. 9. Seed-potato treating plant large enough to serve an entire community. Handling of tubers is accomplished with minimum of time and labor.

ity from the bottom at the opposite side. No lifting of potato sacks from or into the wagon is necessary. The platform around the tank is below the level of the wagon-bed on one side and above the level of the wagon-bed on the opposite side. The treating platform is constructed of heavy wooden slats. When the sacks of potatoes are in place the platform is lowered into the tank by means of a block and tackle until the disinfecting solution covers the sacks; at the proper time it is raised by the same means.

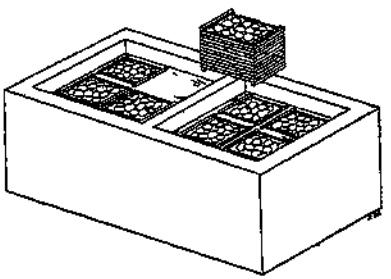


Fig. 10. A rectangular tank of reinforced concrete or wood painted with asphaltum paint is desirable where potatoes are dipped in slat crates. (After Wis. Agr. Expt. Sta. Bul. 331, Fig. 4.)

The flat tank will also handle large quantities of seed potatoes. It is designed primarily for treating potatoes in crates. The tank is loaded with filled potato crates when it is first ready for use, then enough water is measured and placed in the tank to bring the water-surface an inch or two above the crates. The crates of potatoes are now removed and the water level is marked with a streak of paint. Then the water is drained from the tank and the latter is filled up to the paint mark with the disinfectant. Thereafter, when new disinfectant is needed the proper amount necessary to cover the crates can be made up quickly by using the paint mark as a guide.

(c) Containers for the seed potatoes.

Crates are regarded as more satisfactory containers than sacks for treating seed potatoes, especially when small quantities of potatoes are to be treated. The crates take up less disinfectant and make unnecessary numerous handlings of the tubers in which bruises are likely to occur. Potatoes may be cut into seed pieces directly from the crate, whereas, sacks of potatoes must be dumped before cutting. However, when large quantities of potatoes must be treated it is quicker and handier to immerse the tubers in sacks.

Disinfectants

There are many ways of treating seed potatoes. Only the methods which appear to be more highly regarded by pathologists are discussed in this publication (6). Among these are the New Zealand, 5-minute, acidulated mercuric-chloride treatment; the standard mercuric-chloride treatment; the hot mercuric-chlo-

ride treatment; the cold formaldehyde treatment; the hot formaldehyde treatment; treatment with disinfecting dusts.

Close attention should be given to the directions for using the several chemical treatments described in the following paragraphs. Poor results obtained from the use of disinfectants in the attempted control of surface-borne diseases of potatoes frequently can be traced to carelessness or unsound judgment in making or applying the treatments.. In one actual case in which the farmer complained of loss resulting from the use of mercuric chloride, the quantity of the chemical given in the formula had been doubled; in another case, the seed potatoes were treated for 1½ hours instead of 5 minutes as clearly stated in the directions; in still another case another acid was substituted for the hydrochloric acid called for by the formula.

The use of a quantity of disinfecting solution for too many potatoes is another mistake which causes poor results. The repeated immersion of potatoes weakenes the disinfectant, especially the mercuric-chloride solutions. Finally the disinfectant is not strong enough to kill the fungi carried on the seed. Potatoes carrying soil reduce the strength of the disinfectant quicker than clean seed, and sacked potatoes quicker than crated ones. Unsatisfactory results are often obtained when sprouted seed potatoes are treated.

Methods

THE NEW ZEALAND 5-MINUTE ACIDULATED MERCURIC-CHLORIDE TREATMENT

This treatment is a modification of the standard mercuric-chloride treatment, which was first described by G. H. Cunningham (7) of New Zealand. It has been extensively used in Greenlee County, Arizona, for 4 years, where it has entirely replaced the older methods because of its convenience and effectiveness.

(a) *Advantages.* The time required for treatment is reduced from 1½ hours for the standard mercuric-chloride treatment to 5 minutes. One man provided with simple and inexpensive equipment can treat a ton of seed potatoes in an hour. The treatment has proved more effective in controlling disease than the old mercuric-chloride method.

(b) *Formula.* The solution of mercuric-chloride is made more active by the addition of hydrochloric (muriatic) acid. The formula is:

Water	20 gallons
Mercuric chloride (corrosive sublimate)	2 ounces
Concentrated commercial hydrochloric acid	16 ounces (1 pint)

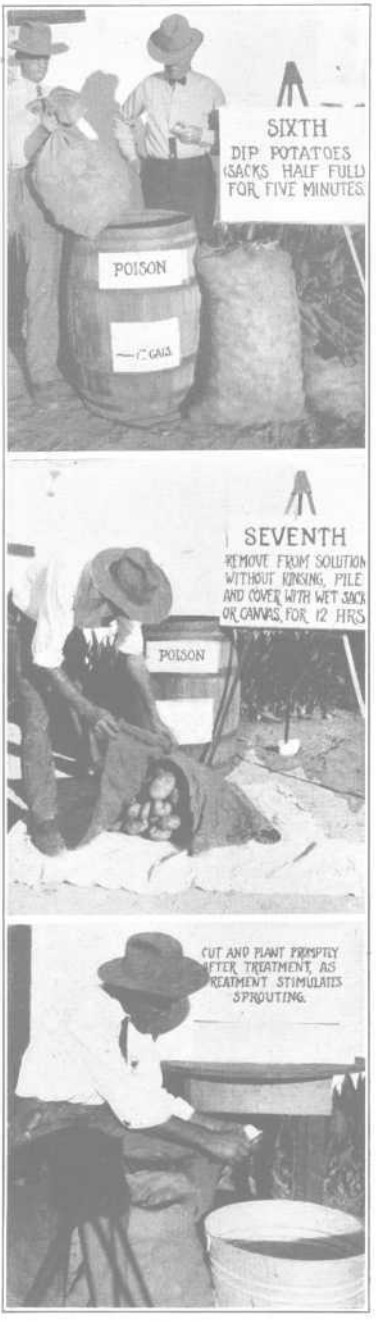
(c) *Preparation*

(1) Dissolve 2 ounces of mercuric chloride in 1 gallon of hot water in a non-metallic vessel. Mercuric chloride dissolves slowly in cold water but goes into solution readily in hot water. Stir the solution with a wooden paddle.

(2) Measure 19 gallons of cold water into a 50-gallon wooden barrel. pour into this the dissolved mercuric chloride and stir with a wooden paddle.

(3) Measure 16 fluid ounces (1 pint) of hydrochloric acid, put it into the solution in the barrel, and thoroughly stir the contents of the barrel with a wooden paddle. Set aside a few ounces of the unused solution in a jar for comparison later with the strength of the used solution..

(d) *Application*



(4) Immerse the seed potatoes for 5 minutes. Move the container in the solution (see paragraph on containers) in order to drive off air bubbles.

(5) Remove the container with the treated tubers, drain, and cover the potatoes with wet sacks or canvas over night, or at least for 12 hours. The solution on the potatoes remains active while the tubers are wet.

(6) After every fourth lot of potatoes is treated, test the used solution with blue litmus paper; if the pink color given by the used solution is paler than that given to the paper by the unused solution (previously collected in a jar), add 4 ounces of acid to every 20 gallons of solution and test again. In this way restore the acidity of the solution to the original acidity. Also add ½ ounce of mercuric chloride dissolved in hot water. Discard the used solution and make a new solution after 12 lots of potatoes have been treated.

THE STANDARD MERCURIC-CHLORIDE TREATMENT

The standard mercuric-chloride treatment has long been used for disinfecting seed potatoes. Its main disadvantage is the long time required for its application.

Formula

Water ..... 30 gallons
Mercuric chloride ..... 4 ounces

Preparation

(1) Dissolve 4 ounces of mercuric chloride in 1 gallon of hot water in a non-metallic container, meanwhile hastening the solution of the crystals by stirring with a wooden paddle.

(2) Measure 29 gallons of cold water into a 50-gallon wooden barrel or other suitable non-metallic container, add to this the dissolved mercuric chloride from (1) and stir well. Mark on the barrel the level of the solution for convenience in restoring the original volume and in making new solution. For receptacles larger than barrels use the same proportionate amount of mercuric chloride to water.

Fig. 13. The solution is poisonous and should be kept out of reach of children and livestock.

Application

Seed potatoes are immersed for 1½ to 2 hours, then drained and immediately dried for storage, or cut and planted. Some pathologists advise the treatment of seed potatoes before storage in order to avoid injury to the sprouts. In Arizona most potato growers buy seed potatoes just before planting, so this program would be impossible. Attention is also called to the practice of pre-soaking the seed potatoes in water for 12 hours before treatment with mercuric-chloride solution, which shortens the time of treatment to ½ hour.

Each lot of seed potatoes treated weakens the mercuric-chloride solution. Dirty potatoes do this faster than clean ones. After treating each 4 bushels of seed potatoes add ½ ounce of mercuric chloride dissolved in 1 quart of hot water, then add enough water to bring the level of the disinfectant back to the height of the original volume, as shown by the mark on the barrel or tank. When the solution has become dirty discard it and use new solution.

Another way to compensate for the weakening of the mercuric-chloride solution is to leave the potatoes in the used solution for a longer period of time. The first lot of potatoes is given a soak of 1½ hours, the second 1¾ hours, the third 2 hours and the fourth 2¼ hours, after which the solution is discarded.

THE HOT MERCURIC-CHLORIDE TREATMENT

The main advantage of this treatment over the preceding one is a saving of time required for immersing the potatoes. On the other hand heating facilities must be provided, and there is danger of injuring the tubers by over-heating and of failure to kill the parasites because of under-heating.

Formula

Water	15 gallons
Mercuric chloride	4 ounces

Preparation

The disfectant is prepared in the same way that the standard mercuric-chloride solution is made, except that 15 gallons of water instead of 30 gallons make up the unit of volume.

Application

Potatoes are immersed in crates, wooden baskets, or sacks for 2 to 5 minutes. Care must be taken to keep the temperature of the disinfecting solution at 110°F. to 113°F. At temperatures below 110°F. Rhizoctonia (black scurf parasite) and Actinomyces (scab parasite) may not be killed, while above 113°F. the tubers may be injured. After treatment the potatoes are handled as described for the standard mercuric-chloride treatment.

THE STANDARD FORMALDEHYDE TREATMENT

This treatment has been used since 1897. The advantages of formaldehyde over mercuric chloride are that it is less poisonous, does not corrode metals, and is somewhat less expensive. In the experience of some pathologists it is less effective than mercuric chloride in controlling Rhizoctoniose. For this reason the cold formaldehyde treatment is no longer extensively used in many potato districts.

Formula

Water	30 gallons
Formaldehyde	1 pint

Application

Seed potatoes are immersed in wooden or metal containers, or in sacks, for 2 hours. When soaked for the requisite time the potatoes are removed and covered for 1 hour. No additional cover is necessary when the potatoes are treated in sacks.

THE HOT FORMALDEHYDE TREATMENT

The hot formaldehyde treatment is effective for combating surface-borne parasites. Its advantages are low cost and saving

in time, besides those mentioned for cold formaldehyde. Its advantage is the necessity for arranging a special heating apparatus in order to maintain a safe temperature.

Formula

Water	15 gallons
Formaldehyde	1 pint

Application

The disinfectant is kept at 124° to 126°F. and the potatoes are immersed in wooden or metal containers, or in sacks, for 2½ to 3 minutes, then removed and covered for 1 to 6 hours. If the temperature falls below 124°F. the parasites on the tubers may survive; if it rises above 126°F. the tubers may be injured. The level of the treating solution should be maintained by adding fresh solution from time to time.

Access to a steam boiler is almost necessary if a constant temperature is to be maintained, unless a treating machine is purchased. A steam coil placed in the tank or treating vat makes comparatively easy the maintenance of a constant temperature. A standard thermometer should be placed in the disinfecting solution and care should be taken to keep the temperature constant at the top and bottom of the tank by stirring.

ORGANIC MERCURY COMPOUNDS

The treatment of seed potatoes with organic mercury compounds is still in the experimental stage. According to Gratz (6) who has reviewed the most recent publications of the Experiment Stations of the United States, only two states definitely recommend the use of organic mercury compounds and three suggest either the new compounds or the old standard formula, while 27 use the cold corrosive sublimate treatment. In some cases the organic mercury compounds give greater yields but inferior control of disease as compared with the standard treatments.

Some organic mercury compounds are used in the form of dust and others in solution. Usually the solutions recommended by the manufacturers consist of 1 pound of organic mercury compound to 2½ gallons of water, and this amount of solution is sufficient to treat 12 to 15 bushels of potatoes. The tubers are treated whole or after they are cut into seed pieces. Directions for treating come with the package and should be followed carefully. In comparing the results obtained from the use of organic mercury compounds with those from standard treatments amount of disease in the crop should be considered as well as the yield.

Organic mercury compounds are poisonous and the precautions given below for mercuric chloride apply to them.

Precautions

Mercuric chloride and disinfecting solutions containing mercuric chloride are *poisonous* (Figure 13) when taken internally.

Care should be taken in handling both the powdered and tablet forms of the chemical and the solution. Used disinfecting solution and rinse water should be run into a deep pit which is filled with soil when the treating process is complete. Similar disposal of unused treated seed potatoes is necessary. Vaseline or some other form of grease may be used to protect the hands from possible irritation by the solution.

Only *wooden, glass, granite, porcelain, earthenware,* and *cement* vessels should be used for containers for the disinfecting solution containing mercuric chloride, and wooden crates and baskets and coarse cloth sacks for the potatoes to be treated in such solutions. Either metal or non-metal containers may be used in the formaldehyde solution.

Sprouted seed potatoes are likely to be injured by practically all disinfecting solutions. Seed potatoes should be treated before they are stored, otherwise the temperature of the storehouse should be low enough to keep the potatoes dormant.

Dirty potatoes weaken the disinfecting solution much faster than do clean ones. Loose dirt may be removed by using the hopper shown in Figure 14. The seed tubers should be thoroughly cleaned with a spray of water before they are treated.

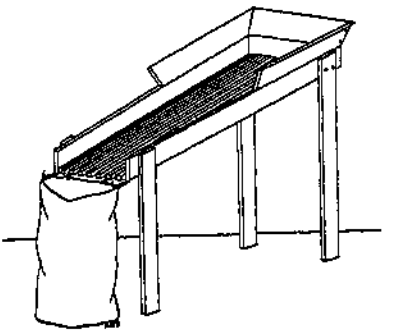


Fig. 14. Loose dirt can be removed from seed tubers by running them over a sacking hopper. (U. S. D. A. Farmers' Bul. 1639.)

Seed potatoes should be treated before they are cut into seed pieces, for the freshly cut surfaces are subject to injury by the disinfectant. Unless the potatoes are to be cut for planting when disinfection is completed, the tubers should be surface dried and stored in new or disinfected sacks. The disinfectant continues active so long as the potatoes are wet and may seriously injure the seed.

CUTTING THE SEED PIECES

Hand-cutting of the seed pieces is better than machine-cutting, for it permits the proper selection of "eyes" and the discarding of diseased potatoes. Faster work can be done when the operator is equipped with the cutting bench described by the United States Department of Agriculture (8). This bench can be made on the farm. Its essential parts are a bin which feeds the potatoes to the cutter and a fixed knife against which the

draws the tuber. Since the knife should be disinfected frequently we suggest a modification which permits the quick changing of knives. A slot into which the knife-handle fits is provided with a screw having a winged head and bearing upon the knife-handle when the knife is in position. Extra knives are kept in a pail containing 5-percent formaldehyde solution, and the knives are exchanged every time a diseased tuber is cut.

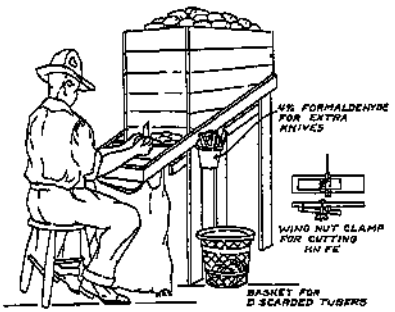


Fig. 15. A convenient cutting bench lightens task of preparing seed. (Modified from U. S. D. A., Farmers' Bul. 1639.)

The operator at the cutting bench should be careful to detect internal discolored spots in the potatoes. Small brown spots in the wood-bundle ring may indicate infection with rot, wilt, or other organisms. All potatoes with discolored spots, hollow heart, and black heart should be discarded. As they are cut the seed pieces should be placed in a clean container. By "clean" is meant freedom from contamination with parasitic organisms. If sacks are used they should be new or properly disinfected.

Some potato specialists advise the cutting of seed pieces a week or longer before planting, and the greening and sprouting of the pieces by exposure to light. Somewhat subdued light is used. The pieces are dusted with fine sulphur or gypsum to hasten drying and prevent decay.

DORMANCY

Some trouble with seed potatoes has been experienced by growers in Arizona, especially in the southern part of the State, in getting seed pieces to sprout promptly after planting. Seed potatoes imported from the North sometimes remain dormant or in a "sleeping" condition until the usual time for sprouting in the North. Thus seed planted in February or March may fail to sprout until late April or May. The pathologist is interested in this dormancy, for it affords an opportunity for fungi to attack the pieces in the soil and to rot them.

Certain chemicals break the dormant period of the seed potato and stimulate sprouting. Twenty-two years ago McCallum (9) of this Station listed several such chemicals, including ethyl bromide, carbon tetrachloride, ammonia, gasoline, ethylene chloride, and bromine. Since then Denny (10) and others have worked with a long list of chemicals and have obtained

fine results with several. Among these are ammonium, sodium, and potassium thiocyanate. Under favorable conditions treatment with sodium thiocyanate gave 100 percent sprouting in seed pieces of dormant tubers of the Bliss Triumph variety. It appears that the use of such a seed treatment for dormancy should be good insurance against poor stand caused by late sprouting and rotting.

None of the treatments for dormancy have been tried on a commercial scale, but the thiocyanates have worked so well in Denny's laboratories that we believe they merit a practical trial. Farmers who wish to treat seed potatoes for dormancy are advised to prepare only enough seed pieces for a few rows. The treated seed pieces should be of the same variety as untreated ones used for comparison, should be planted the same day and in the same way. The Irish Cobbler variety, extensively planted in Arizona, reacted favorably in laboratory tests.

Formula

Water	27 gallons
Ammonium thiocyanate	27 ounces

Smaller quantities should be made in the same proportion of thiocyanate to water.

Application

The seed pieces are immersed for 1 hour in the treating solution at a temperature between 59°F. and 86°F. After treatment they are drained and planted without rinsing.

PLANTING

Sanitary Measures

Seed pieces should be handled in such a way that re-infection with parasitic fungi and bacteria will be avoided. Clean containers for the seed have been mentioned. If used crates, baskets, or sacks must be utilized, they should be first disinfected with 4- or 5-percent formaldehyde. The hoppers of planters should be washed with the same disinfectant. After sorting potatoes the hands should be washed in disinfectant before treated seed tubers and seed pieces are handled.

Long Exposure of Seed Pieces

In furrow and hill planting with the hoe, seed pieces are sometimes dropped long before they are covered. This is bad practice. It has recently been found that the seed-corn maggot carries the bacterium which causes the blackleg disease of potatoes (11). The adult insect lays its eggs upon or near the seed pieces so that infection becomes easy, and one of the diseases for which the seed tubers were treated gains entrance. Seed

pieces should be covered with soil immediately, not left exposed.

Depth of Planting

The depth of planting of seed pieces in relation to attack by the black-scurf fungus, *Rhizoctonia solani,* has been studied in the New Jersey Station (12). Seed pieces were planted 1, 2, and 4 inches deep. The sprouts from the shallow-planted pieces were cleanest. The results were 48.5 percent clean sprouts for the 1-inch planting, 32.9 percent for the 2-inch planting, and 20.7 percent for the 4-inch planting. It is not known that these results apply in Arizona. They are mentioned in order to call attention to a detail that should be watched by the farmer. A record of the depth of planting and the results for each potato crop should be kept. Every potato crop should be studied as an experimental crop by the grower and notes taken so that a permanent record will be possible.

Dry Soil

Poor results from planting seed potatoes in dry soil have sometimes been attributed to seed treatment or to disease. The seed bed should be in good tilth. Seed potatoes, especially treated seed, should not be planted in dry soil.

HARVESTING

Seed potatoes should be dug by hand and selected as previously described. Careless handling results in serious loss from rots. If the seed potatoes are placed directly in crates in the field and stored as harvested, much bruising will be avoided and loss from storage diseases averted. After tubers are selected for planting the seed plot next season, the remaining tubers may be stored for planting the commercial field the following year.

STORAGE OF SEED POTATOES

Facilities

The seed for use next planting season should be properly stored. In some cases cold storage facilities may be available in the warehouses of nearby towns or cities. The room used should be well ventilated and have a controlled temperature not below 35°F and never above 40°F. Potatoes in sacks should be placed on a false floor, and the sacks so arranged that air currents may pass over and between them as well as under them. If potatoes

have been stored in the room before, the latter should be thoroughly disinfected before it is used.

Storage Houses

There are several satisfactory types of storage house for potatoes, but the most adaptable to conditions in Arizona are the cellar or dugout type, the adobe, and the insulated wooden storage house. The details of the storage unit can be varied to suit local conditions, provided that the two fundamental principles of proper storage are satisfied; (1) insulation against fluctuating temperatures so that even low temperatures (35-40° F.) will protect tubers against freezing and sprouting; and (2) ventilation to prevent the accumulation of moisture and carbon dioxide, and to insure necessary oxygen. Storage houses above ground should be provided with top and bottom ventilators which can be opened and closed according to existing temperatures. The adobe storage house* for sweet potatoes described in Arizona Agricultural Experiment Station Bulletin 106 is adapted to white potatoes. For potatoes a heater is not needed except in locations at higher altitudes in the State.

Disinfection of the Storage House

The disinfection of the potato house is very important, for fungi and bacteria which cause decay of potatoes live in the soil and refuse left from previous storage. After a thorough cleaning the store room may be disinfected with either copper sulphate (bluestone, blue vitriol) solution or with formaldehyde solution. The copper sulphate solution is made by dissolving 1 pound of the sulphate in 10 gallons of water; the formaldehyde solution by dissolving 1 pint of commercial formaldehyde in 10 gallons of water. Either solution is preferably sprayed on floor, walls, and ceiling, for spraying is easier, quicker, and more likely to result in satisfactory penetration into crevices and corners than when a brush is used.

Fumigation of the Storage House

Fumigation with formaldehyde gas may be practiced when the storehouse can be tightly closed. After the house is cleaned the floor should be sprinkled with hot water in order to humidify the air. Treatment is more effective when the temperature of the

*Other houses adapted to potato storage are described in Michigan Agricultural Experiment Station Special Bulletin 146, 1925; Wash. Agr. Exp. Sta. Bul. 193, 1925; U. S. D. A. Farmers' Bul. 847, 1930.

air in the room is above 50°F. For every 1,000 cubic feet of space in the room, 23 ounces of potassium permanganate and 3 pounds (3 pints) of formaldehyde are required. The permanganate is placed in a large open vessel which is floated in a pan or tub of water. When the room is sealed, except the door through which the operator must leave, the formaldehyde is poured from a wide-mouthed jar upon the potassium permanganate. Fumes will rise at once, and care must be taken not to breathe them. The operator must work quickly and leave immediately after the formaldehyde has been added to the permanganate. The room should be kept closed for at least 24 hours. At the end of that time it should be thoroughly aired. Then it is ready for the potatoes.

Although seed potatoes may be stored in crates, sacks, or bins, crates are best adapted to proper aeration. The crates also make sorting easier. Two or three times during the winter, oftener if necessary, the potatoes should be inspected and decayed tubers should be destroyed. Before planting, seed potatoes should receive a final sorting. At this time decayed tubers are destroyed and those with long sprouts are discarded.

Summary of Treatments

Formula	Treatment†	After-treatment	Advantages	Disadvantages
New Zealand acidulated mercuric chloride				
Water ..... 20 gal. Mercuric chloride ..... 2 oz.* Conc. Hydrochloride acid.....16 oz.	Immerse 5 min.	Drain, pile and cover with wet sacks or canvas 12 hrs. or more	Better disease control Quicker & easier Stimulates sprouting	
Standard mercuric chloride				
Water ..... 30 gal. Mercuric chloride ..... 4 oz.*	Immerse 1½-2 hrs. or pre-soak in water 12 hours and treat ½ hr.	Drain and dry		Time-consuming
Hot mercuric chloride				
Water .....15 gal. Mercuric chloride ..... 4 oz.*	Immerse for 2-5 minutes at 111-113 deg. F.	Drain and dry	Time of treatment shorter	Difficult to maintain temp.; too low—no control;—too high—injury to tuber.
Standard formaldehyde				
Water .....15 gal. Formaldehyde (40%) ..... 1 pt.	Immerse 2 hours	Drain and cover for 1 hour	Somewhat less expensive	Time-consuming. Less effective for black scurf
Hot formaldehyde				
Water .....15 gal. Formaldehyde (40%) ..... 1 pt.	Immerse 2½-3 min. at 124-126 deg. F.	Drain and cover 1 to 6 hours	Somewhat less expensive	Same as hot mercuric chloride

*Dissolve in 1 gallon hot water.

†Wash dirty potatoes before treating—it saves disinfectant.

APPENDIX

Chemical Supplies

SOURCE OF CHEMICAL SUPPLIES

Local drug stores and seed houses usually can supply the chemicals necessary for disinfecting seed potatoes. Orders should be placed early enough so that the dealer will have time to purchase the chemicals from the wholesale house if necessary. The following companies carry disinfectants and the addresses are given for the convenience of those who are unable to purchase chemicals locally.

California Spray-Chemical Company	Los Angeles, California
General Chemical Company	Los Angeles, California
Mallinckrodt Chemical Works	St. Louis, Missouri
Sherwin-Williams Company	Los Angeles, California

COST OF CHEMICALS

The retail prices of chemicals used for disinfecting seed potatoes vary with the quantity purchased and with the fluctuation of the chemical market. The prices given below are only approximate.

Chemical	Price 1 lb.	Price per lb. 5 lb. lots	Price per lb. 25 lb. lots	Price per lb. 60 lb. lots	Price per lb. 100 lb. lots
Copper sulphate	$.20-.25	.15-.20	.10-.15		.09-.12
Hydrochloric acid	$.65-.79	30		7.80-9.00	3.50-10.00
Mercuric chloride	$2.70	2.18-2.24	1.80-2.10		
Formaldehyde 40%	.06	.45			
Potassium permanganate	.70	.40	.36		

Blue litmus paper is sold in books of 25 strips at $.05—.10 per book.

Weight and Measure Equivalents

	English units	*Metric units*
Weight		
	15 grains	1 gram
	1 ounce	28.35 grams
	1 pound (Av.)	454 grams
Capacity	1 ounce	30 c.c. (ml.)
(liquid)	1 pint (16 oz.)	473 c.c.
	1 quart	947 c.c.
	1 gallon	3,785 c.c.
	7.5 gallons	1 cubic foot

Capacity of Cylindrical Tank

Diameter X diameter (in feet) X .7854 (approximately three-fourths) ÷ 7.5—capacity in gallons.

Antidote for Mercuric Chloride Poisoning

If poison is swallowed induce vomiting with warm mustard water or other emetic, or use stomach pump. Then give plenty of white of egg, milk, castor oil, or table salt. *Call a doctor.* Two to 5 grains of dry powder are sometimes fatal if absorbed by body.

Amount of Spray per Acre:

For control of foliage diseases of the potato (principally early blight in Arizona) two or more applications of Bordeaux Mixture 5-5-50 should be applied beginning when plants are 6 to 8 inches high. At this time 75 gallons per acre will cover the foliage. Later sprayings will require 100 to 125 gallons per acre on account of increased area of foliage to cover. Bordeaux Mixture must be made properly to be effective. Write for instructions.

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