UNIVERSITY OF IDAHO
College of Agriculture

PRODUCING
THE IDAHO POTATO

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IDAHO Agricultural
Extension Service

Bulletin 367
February 1962

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ACKNOWLEDGMENTS

With appreciation, the author acknowledges the aid of Experimental Station and Extension Service personnel of the University of Idaho in preparation of this bulletin.

Published and distributed in furtherance of the Acts of May 8 and June 30, 1914, by the University of Idaho Agricultural Extension Service, James E. Kraus, Director; and the U. S. Department of Agriculture, cooperating.

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Richard E. Ohms

INTRODUCTION

The grower who knows the nature and habits of the potato under normal conditions of growth and storage can best give his crop the necessary environment to improve his yield and income. This is especially true concerning the potato because it is sensitive to environment during growth and is perishable during storage.

STAGES OF GROWTH

The seasonal life history of the potato plant may be divided into three periods; (1) rapid plant growth during which every practice should promote vigorous and healthy development, (2) plant maintenance and rapid tuber development, (3) plant decline during which the tubers are maturing and enlarging at a decreasing rate.

Rapid Vine Growth. Vegetative growth is affected by temperature, day length and fertility. Day temperatures over 80° F. and night temperatures over 73° F. are usually most conducive to vine growth. Long days favor vine growth; short days favor tuber growth.

Rapid Tuber Development. There is no direct relationship between a vine's flowers and its tuber-set. The same environment that promotes flowering also usually promotes tuber development. An infection of rhizoctonia, a soil-borne disease of potatoes, often causes profuse flowering in a potato field. When this occurs, the yield and quality will be poor.

The potato tuber is an enlarged portion of an underground stem called a stolon. Tubers develop when the potato plant has more carbohydrate than it needs for growth and respiration. Tuber-set and development depend to a great extent upon temperature, day length, and nutrients. Tubers develop most rapidly when day temperatures are above 68° F. and night temperatures below 57° F. At high temperatures tuber formation is possible only to a limited extent during short days; at low temperatures, tubers can be formed during long and short days.

Vine Decline and Tuber Maturing. During this phase, the tuber growth rate decreases and the tubers start to mature. After the tubers start this phase the potato requires less water. Production emphasis then should be on maturity to increase cooking and storage quality.

SOIL TYPE

Potatoes can be grown on many different types of soil. They prefer such medium textured soil as a silt loam with good structure, good moisture-holding capacity, and a plentiful supply of

available plant nutrients. Organic matter is necessary for good structure in a soil. It is desirable to plow under green manure, plant residues, or barnyard manure before planting potatoes. There is some danger from scab when plant residues are present during tuber development.

ROTATIONS

A successful crop rotation must maintain good production and at the same time make money for the farmer. In planning a good rotation, the soil-building, weed-control, insect- and disease-control influences of a rotation must be considered as well as labor and equipment requirements of the crops and crop value in relation to production costs. The decision on what crops to grow in the rotation is complicated, and much depends on the grower's preference. The potato grower must weigh all the above factors.

Soil Building Features. A good rotation includes the return of crop residues to the soil. These residues are a source of plant nutrients and the cheapest means of improving the soil's physical condition. When the soil structure is improved, the land is easier to work, there are fewer clods at harvest, and the soil will better absorb and hold water. **In general, plant nutrients can be added cheaper through commercial fertilizers and the physical condition of the soil improved with least expense by returning crop residues such as grain stubble.**

Disease Controlling Features. A sound crop rotation and proper sequence of crops in the rotation is often the most practical and least expensive means of "living with" certain potato diseases. Early blight, verticillium wilt, eumartii wilt, scab, and rhizoctonia are all influenced by the crop rotation. Generally—from a disease standpoint—planting potatoes on the same field for 2 years in succession is poor practice. An ideal rotation calls for potatoes on the same land every fifth year.

Verticillium wilt and eumartii wilt can be partially controlled by preceding the potato crop with a legume green manure plowed down in the fall. Some evidence shows that a small-grain crop with its straw returned to the soil decreases the severity of rhizoctonia. There is some danger of scab if the straw is decomposing during the time the tubers are developing. The foliage disease "early blight" can be controlled to some extent by planting potatoes in a field only after all old potato vines or leaves have been plowed under and have decomposed.

Because sugar beets build up a highly pathogenic type of rhizoctonia, potatoes following sugar beets in a rotation is bad practice.

No one rotation will aid in controlling all diseases. Should one of the diseases mentioned become a limiting factor in potato production, then a rotation offering some control becomes sound man-

agement. For further information on potato diseases see the **Disease Control Section** in this bulletin.

Insect Controlling Features. Crop rotation may or may not reduce the population of soil-inhabiting insects. Infestations of wireworms, leather-jackets, seedcorn maggot, and white grub can be reduced by incorporating an insecticide into the soil between each two crops of the rotation.

Weed-free alfalfa provides little food for wireworm larvae. Numbers of this pest decrease each succeeding year alfalfa remains on the infested soil. Fields of clover, cereal crops, grass-legume mixtures and weedy alfalfa provide abundant larval food, and wire-worm populations increase when these crops are present on the soil. Leaf-feeding potato pests are generally good flyers. Their presence in a potato field is not influenced by crops grown the year before. For further information about insect pests of potatoes see the **Insect Control Section.**

Weed Controlling Features. Any good rotation will to some extent control weeds. Alfalfa and row crops generally allow for cultural weed control. Weeds in small grains and peas are best controlled by chemicals. Weeds reduce yields through their competition for moisture, sunlight, and plant food and may allow build-up of potato diseases and insects.

Disease and insect controlling properties of a rotation can be nullified to some extent if weeds are present. For example, pig weed will build up rhizoctonia. Thus, if pig weeds are allowed to grow in a grain field, rhizoctonia-controlling properties of the grain will be less effective. As previously mentioned, if an alfalfa field becomes weedy, the wireworm-controlling feature of alalfa is decreased. For further information on weed control see the **Weed Control Section.**

FERTILITY

A proper balance of available nutrients for the potato results in high yields of quality tubers. Either a lack of or excess of a nutrient may cause decreased yields and poor quality tubers.

In Idaho, nitrogen and phosphorus are nutrients most often lacking in potato production. When nitrogen is lacking, a low yield and early maturity results. A lack of phosphorus may result in decreased yields, tubers of low solids, poor net on the tuber, easily injured tubers, and poor storing tubers. Potassium is not usually a limiting factor in Idaho's potato production.

Excess nitrogen and potassium will decrease yields, increase malformed and knobby tubers, and result in tubers with poor net and low solids. Excess phosphorus will not cause harmful effects, but adding phosphorus over amounts required for plant growth will **not** counteract the harmful effects of excess nitrogen or potassium.

It must be remembered that a balanced soil fertility is only one of many factors that effect high yields and quality tubers.

Amount of water and time of watering, disease control and insect control must be carefully programmed and executed if maximum efficiency is to be had from applied fertilizers.

Fertilizer Guide. The correct soil fertility must be maintained to produce a good crop of potatoes. Table 1 is a guide for determining the nitrogen practice to be followed. As shown, amounts to be applied depend on the soil's cropping history and yield expected. **Phosphate and potash levels of the soil can best be determined by a soil test available through your county agent's office.**

Table 1.—Fertilizer guide based on previous crop and soil tests.

Expected Yield (100 lb. sacks per acre)	Following a row crop or non-legume green manure		Following Alfalfa Crop Removed		Following a legume green manure, 1 ton or air-dry hay per acre plowed under		Following grain or grass, stubble removed		New land just cleared from sagebrush	
	N	P_2O_5*	N	P_2O_5*	N	P_2O_5*	N	P_2O_5*	N	P_2O_5*
300**	100	80	60	80	40	80	120	80	100	80
400**	140	120	100	120	80	120	160	120	140	120

* Rates of P_2O_5 shown in table are for soils having a medium level of available phosphorus.

**Unless 300-sack yields are being obtained, do not use the rates for 400-sack yields. Modify rates shown above by the following factors:

1. Reduce nitrogen rates 4 lb. per acre and P_2O_5 rates 2 lb. per acre for each ton of good manure applied.
2. Apply an additional 20 lb. of nitrogen per acre for each ton of grain straw returned to the soil.
3. If soil test indicates low level of P_2O_5, increase rates 40 lb. per acre. If soil test indicates high level of P_2O_5, decrease rates 80 to 120 lb. per acre.

Fertilizer Application. If worked into the soil, commercial fertilizers applied in the fall are preferred on most soils suitable for potato production. On extremely sandy soils, spring applications of nitrogen are recommended. Application of fertilizer before plowing is a good method of getting fertilizers into the soil.

Little evidence exists to indicate a benefit of one particular form of nitrogen or phosphorus over another. Work all fertilizers into the seed bed when making a broadcast application. When fertilizer is banded, make the application at planting time. Banded fertilizers are best placed 4 to 6 inches at the side of the seed piece and 2 to 3 inches below it. The higher the nitrogen rate, the farther one should band from the seedpiece. For further information on potato fertilization consult University of Idaho Bulletin 281, "Fertilizer Studies on Russet Burbank Potatoes in Southern Idaho."

PREPARING THE SEEDBED

Soil Tillage. Plow-depth varies with the type of soil and the type of organic matter to be returned to the soil, but a depth of 8 to 10 inches is usually enough. The seedbed should be tilled to the depth plowed. Fall plowing in most cases is preferred to spring plowing as it allows more time for breakdown of crop residues. Freezing and thawing during the winter improves soil structure. Some growers prefer to crown alfalfa in the fall and plow in the spring.

Where the soil has been fall plowed, spring harrowing as soon as the surface is dry helps eliminate clods and save moisture. **Avoid working the soil when it is either too wet or too dry.** This will reduce the number of clods that cause bruising at harvest.

Moisture. The seedbed should be moist and mellow at the planting depth when the seed is planted. Sub-soil moisture to 2 or more feet below the surface is desirable. **Never plant in a dry seed bed.** A pre-planting irrigation either in the fall or spring prior to planting is usually necessary under Idaho's climate. **Proper soil moisture in the seedbed provides better sprouting and promotes healing of the cut seedpiece.** When potatoes are planted in dry ground, severe losses often occur due to seedpiece decay. For further information on irrigation see the **Irrigation Section.**

PLANTING

Plant Certified Seed. Planting certified potato seed eliminates many disease hazards threatening the commercial grower. Compared to non-certified seed, certified seed is the best insurance that there will be a marketable crop at harvest time. Certified seed is the best insurance that potatoes can be grown in the field in the future. Certified seed is the best basis for high yield and top quality. Do not substitute with "year out" or other "cheap" seed. For further information on certified seed see the **Disease Control Section.**

If the seed has not started to sprout, warm it for 10-15 days at 50-60° F. prior to planting.

Seed Size, Cutting, and Handling. Whole seed or "single-drop" is highly desirable for planting, but not nearly enough of this kind of seed is available. Consequently, most seed must be cut.

Large seed pieces are recommended. Seed pieces between 1½ and 2 ounces weight insure strong, healthy hills with three to four stems per hill. Seed of this size usually assures good germination and provides the plant with a generous food reserve during the first weeks of growth. Cut seed so that a minimum of new surface is exposed. Blocky pieces are preferred since less cut surface is present for soil fungi to gain entrance to and decay the seed piece. A 1½-to-2-ounce seed piece helps prevent knobby tubers.

Cut seed may be "cured" if not immediately planted. Best healing takes place at temperatures between 45° and 55° F. in a humid

atmosphere with air circulation. Under these conditions the cut surface usually heals in 7 days. After that, the seed can remain in storage until the warming-up period prior to planting.

This curing process results in a **suberin** layer over cut surfaces. The suberin layer is a protective layer which reduces moisture loss as well as entrance of disease organisms. Cut potatoes often dry at the surfaces. This drying is not suberization.

In most of Idaho, seed is cut within a few days of planting. Good stands can come from freshly cut seed since soil conditions of moisture and temperature are usually such that suberization takes place in the soil.

Proper handling of seed from storage to planter is of utmost importance. A cellar is a good place to cut the seed. If the tubers are warmed to 50° F. or above, there will be less mechanical damage. Protect seed from sun and wind. Cover trucks with a tarp when hauling and handling seed in the field. This applies to cured as well as freshly cut seed whether or not it has been treated.

If rain or mechanical breakdown stops planting operations, put the seed in a damp cellar, close the door, and follow the procedure given above for curing cut seed.

Seed Treatment. Successful seed treatment provides a chemical coating over the cut surface and prevents invasion of rot organisms common in Idaho soils. The suberized surface of a properly healed seed piece resists the invasion of the rot-producing organisms, and does **not** require chemical protection.

When planting is made in a dry or cold seedbed, seed treatment may be beneficial. If it is necessary to treat seed then, it is important that the treating operation be done according to the chemical manufacturer's recommendations. When the treating solution becomes weak or dirty from excessive soil, disease can actually be spread in the treating operation. **Unless treating is done correctly, do not treat at all.**

If seed treatment is necessary, Captan, Phygon, and Semesan Bel. are effective. Streptomycin may be added to enhance the bacterial killing properties of Captan and Phygon. For further information on potato seed treatment see University of Idaho Bulletin 329, "The Influence of Seed-Piece Treatment on Disease Control and Yield of Russet Burbank Potatoes."

Planting Operation. If acreage permits, delay planting until the soil is warm enough (50° F.) for good sprouts. Dry soils increase seedpiece decay. Wet, cold soils slow growth and increase rhizoctonia.

Both "assist-feed" and "picker" planters do a good job when properly adjusted. Better stands usually follow use of the "assist-feed" type. Tractor speed must allow the planter to place the seedpieces at the desired spacing and depth.

Best distance between potato hills depends somewhat on soil fertility. On fertile soil, a distance of 9 inches between hills with 36 inches between rows is considered good. Greater distances result in large tubers and a high percentage of knobby ones. Spacing at 12-14 inches is usually suitable if there are few "skips" and where verticillium wilt, early blight, or water shortage may be limiting factors.

Seed is usually planted from 4-6 inches **below the soil surface.** Deep-planted seed will result in fewer green-end tubers at harvest. A pack wheel behind the planting shoe insures a close contact between soil and seedpiece and thus provides adequate moisture for suberization and sprouting. Often the ridge left by the planter is levelled off before the potato seedlings emerge. This allows more rapid emergence and early weed control.

CULTIVATION

The purposes of cultivation are to kill weeds and to prepare the field for irrigation. Unless cultivation accomplishes one of these purposes, stay out of the field. Late cultivations with shovels or disks set too deep or too close to the row prune away important feeder roots. For further information on weed control see the **Weed Control Section.**

A low, flat hill with square shoulders is usually desirable for the potato row. This type of hill, coupled with deep planting and mellow soil, reduces the number of green-end tubers, allows better moisture control, and keeps tubers cool for better quality.

IRRIGATION

Proper irrigation is one of the most critical factors in producing high yields of quality potatoes. A lack of moisture during the early stages of tuber set and development results in malformed tubers. Excessive irrigation late in the season may result in water-rot and delayed maturity. This causes low solids and more harvest injury. For further information on irrigation see University of Idaho Bulletin 246, "Irrigation of Russet Burbank Potatoes in Idaho."

The soil moisture level at the seedpiece is the key to proper irrigation. When this moisture level drops to 65 percent available moisture, it is time to apply water. Use the "feel test" to determine this level. If you do not know how to determine the 65 percent level consult your county agent.

Make sure the seedbed at planting time is moist and mellow at the planting depth. The soil must be moist 2 feet below the soil surface. Do not plant in a dry seedbed.

Irrigation prior to planting may be necessary to provide suitable soil moisture at planting time. This can be done in fall or spring.

For proper moisture at planting time, the "feel test" should show 65 percent available moisture at the soil level where the seedpiece will lie.

The potato's water requirements can be divided into three periods—first irrigation after planting, growing-season irrigation, and last irrigation.

First Irrigation After Planting. An early irrigation increases the number of tubers per hill and lowers the percentage of malformed tubers. Under Idaho's conditions, the soil moisture level will usually dictate that this irrigation be applied within 30 to 40 days after planting. Do not allow soil moisture to go below the 65 percent available moisture level.

It should be kept in mind that this first irrigation must be light. To avoid over irrigation, irrigate every other row and run the water in furrows made by the tractor tires. A "furrow-slicking" cultivator may also be used to advantage. Allow the water to run in the furrow until it soaks over to the seedpiece.

Under sprinkler irrigation, adjust pressure and nozzle size to apply water no faster than it will go into the soil. Allow sprinklers to run until the water soaks down from 1 to 1½ feet.

Growing-Season Irrigations. As the tubers develop, they are less and less easily affected by water. Irrigate when moisture reaches the 65 percent-available-moisture level at the seedpiece. If

the water supply is short, reduced moisture after July 20 is not so harmful as a lack of water earlier in the season.

Some practices that may help apply the correct amount of water for maximum yield and quality are:

1. Plant and make furrows so the seedpiece is below the bottom of the irrigation furrow.
2. If water penetrates rapidly, irrigate alternate rows and change rows every-other irrigation.
3. Allow water to soak to the seedpiece.
4. Make "U"-shaped smooth, slick furrows on soils that absorb water readily.
5. Do not apply water by sprinklers any faster than it will go into the soil at the end of the irrigation period. At the end of this period the soil should be soaked down 2 feet.
6. Consult your county agent for basic irrigation rules.

Last Irrigation. The potato plant will use from 1 to 4 inches of water the last 20 to 30 days of the growing season. By stopping irrigation 20 days prior to the average date of the first killing frost, the solids content of the tuber increases, water rot decreases, and harvest injury and storage losses are reduced without decreasing yield and grade.

If the soil is dry, a light conditioning irrigation 1 to 4 days before harvest will mellow the soil for easier harvesting and fewer clods. A portable sprinkler system can be used to an advantage to apply this irigation.

DISEASE CONTROL

Potatoes are attacked by many disease-causing organisms. Since potatoes are vegetatively propagated, the organisms of many potato-plant diseases are present in tubers used for seed. These disease-causing organisms are either bacteria, fungi, virus, or nematodes.

Certified Seed. One cannot tell by looking at seed whether it is diseased or not. Idaho certified seed meets the requirements of good seed. Narrow tolerances are allowed for moderately serious diseases. No tolerances are allowed for such serious diseases as ring rot, eumartii wilt, and nematodes. Zero tolerance means that if a single infected plant or tuber is found during inspection by the Idaho Crop Improvement Association the entire seed lot is rejected from certification. Complete crop losses have resulted from planting "one year out" seed infected with ring rot, leaf roll, eumartii wilt, or nematodes. **Eumartii wilt and nematodes once introduced into a field's soil are capable of remaining there in the soil and inflicting crop losses from that time on.**

In order for seed to be certified, the seed must be sacked in new bags, the bags sealed, and labeled with a certification tag. The tag color designates the grade within the sack.

For seed to be certified it must be planted from seed winter tested in California plots and containing a low level of leaf roll or mosaic virus. There is one exception to this. When seed stocks come from another state they must be foundation stocks or approved by the Idaho Crop Improvement Association.

Foundation seed is under even more strict conditions and contains an even lower incidence of diseases than certified seed. The University of Idaho produces foundation seed at the Tetonia Branch Experiment Station under strict requirements so that a certified seed grower has a source of new seed if trouble befalls his own seedstock.

Before purchasing certified seed the commercial grower will do well to know the reputation of the seed grower and the integrity of the dealer and to look over field readings of the seed offered for sale. The Idaho Crop Improvement Association publishes these readings and makes them available through your county agent.

Sanitation. Two of Idaho's most serious diseases, **eumartii wilt and root knot nematode** can be spread by dirt on equipment and by tare dirt from beet dumps, potato cellars, and warehouses. Equipment used off your farm should be cleaned and steam sterilized before it is brought to or back to your farm. Do **not** bring tare dirt to your farm. Do **not** use potato sacks for seed if they have previously contained commercial potatoes.

Protection from Serious Soil Borne Diseases. If a grower wishes to continue to grow potatoes and avoid eumartii and nematodes, these three basic rules will almost eliminate chances of bringing them to his soil—

1. **Plant only certified seed.**
2. **Clean and steam-sterilize all machinery and equipment used off your farm.**
3. **Never bring tare dirt back to your farm.**

Ring Rot. Ring rot is a bacterial disease primarily maintained from season to season in infected seed. The bacterium does not over-winter in the soil but remains in dried slime and potato refuse on equipment that has been used to handle infected tubers. Certified seed will almost entirely eliminate any trouble with this disease. Observance of three rules will eliminate ring rot as a disease problem for the commercial grower.

1. Do not use seed known to be infected with ring rot bacteria regardless of how slight the infection. Plant only certified seed.

2. Do not use machinery, sacks, planters, or other equipment which may have been infested unless such equipment has been thoroughly cleaned with soap and water and steam disinfected.

3. Do not place a diseased crop in storage. Dispose of it at once. If storages become infected, clean cellars thoroughly and spray with a solution of copper sulfate at the rate of 1 pound to 10 gallons of water.

Blackleg. Blackleg is caused by a soil borne bacterium present in Idaho soils. The bacterium requires a wound in order to gain entrance into the potato plant. Blackleg is closely associated with seedpiece decay. To control blackleg, observe the seed-handling and -planting recommendations previously discussed in this bulletin.

Verticillium Wilt. The cause of verticillium wilt—commonly called 'early dying"—is a soil borne fungus. There is no real control known for it. The following cultural practices tend to reduce the severity:

1. Plant only certified seed grown at a cool temperature.
2. Maintain balanced soil fertility by using rotations of alfalfa or clover as well as applications of barnyard manure. To arrive at the proper fertilizer balance, follow the suggested guide previously discussed in this bulletin.
3. Do not follow potatoes with potatoes in the rotation.
4. Practice weed control in the rotation.
5. Irrigate lightly and frequently during the early and hot part of the season and less often during the later, cooler weeks.

For further information on Verticillium Wilt consult University of Idaho Research Bulletin 45, "Early Dying (Verticillium Wilt) of Potatoes in Idaho," and Extension Bulletin 350, "Potato Verticillium Wilt—Symptoms, Cause and Control."

Eumartii Wilt. A soil-borne fungus causes eumartii wilt. It spreads from farm to farm in infected seed, in tare dirt, or in contaminated equipment. Once introduced to soil this fungus cannot be eradicated. Eumartii can cause a complete crop loss due to tuber rot. For further information on eumartii wilt consult University of Idaho Extension Bulletin 345, "Potato Eumartii Wilt—Symptoms, Cause and Control." To control eumartii wilt—

1. If your farm is not infected—
   a. Do everything possible to keep infected seed from being planted. Plant only certified seed.
   b. Do not bring tare dirt back to your farm.
   c. Do not bring or allow any machinery, sacks, bulk trucks, or any other equipment to come onto your farm unless it is steam sterilized first.

2. If your farm is infected—

   a. Grow potatoes in the field no more than once in every 5 years.

   b. Grow sweetclover green manure preceding potatoes.

   c. Sell all culls to a starch plant.

   d. Plant certified seed.

Scab. The cause of common scab is a soil-borne fungus generally present throughout Idaho's potato-growing areas. The disease is one of the main reasons for growing the Russet Burbank variety in Idaho. The Idaho Rural suffered severely from scab; the Russet Burbank is somewhat resistant, but scab is again becoming important to the State's potato production. For further information on Scab consult University of Idaho Extension Bulletin 347, "Potato Scab—Symptoms, Cause and Control." For scab control follow these recommendations:

1. If a scab problem exists in a field, do not plant potatoes if there is un-decomposed plant residues present at the time when potato tubers are developing.
2. Maintain a good nutrient balance. Be careful not to apply excessive nitrogen or potassium. Maintain adequate phosphorus in the soil. To arrive at the correct balance of fertilizer rates, follow the guide previously presented in this bulletin.
3. Follow a crop rotation that includes non-susceptible grain and legume crops between potato crops. Control mustard weeds.
4. Plant potatoes or other susceptible crop in a field only once every 5 years.
5. Treat scabby seed with Semasan Bel.

Rhizoctonia. Rhizoctonia is caused by soil borne fungus native to Idaho soils. The fungus attacks the underground stem and stolons and causes a decrease in both yield and quality.

These control measures will help alleviate rhizoctonia severity:

1. Do not follow potatoes or sugar beets with potatoes.
2. Keep soil in the potato hill as loose as possible.
3. Avoid over irrigation.
4. Plant potatoes following a grain crop with the stubble returned to soil in the fall.
5. Practice good weed control in the rotation.
6. Avoid planting when soil temperatures are below 55° F.

Early Blight. Early blight is a foliage disease caused by a fungus that over-winters in old potato vines and leaves. The fun-

gus is present in most Idaho potato fields but only causes damage under sprinkler irrigation. For further information on early blight consult University of Idaho Extension Bulletin 346, "Potato Early Blight—Symptoms, Cause and Control."

Control of early blight is as follows:

1. Cultural control—
   a. Decrease the amount of a field's fungus by never following potatoes with potatoes in the rotation and by plowing under all old potato vines and leaves.
   b. Decrease the number of life cycles of the organism by irrigating according to soil moisture. Each sprinkling eliminated will eliminate one life cycle of the fungus.
2. Chemical control—
   a. Apply chemical control when leaves next to the ground contain one or more spots per leaf. Continue application between irrigation until August 20.
   b. Use Zineb or Maneb according to label directions. Complete coverage of the foliage is important. Use a spreader-sticker such as B 1956.
   c. Ground application is preferred to aircraft application. If ground sprayers are used, apply the chemical prior to irrigation. If the application is made by aircraft, apply the chemical immediately after the sprinklers are turned off so that moisture on the leaves can be used to spread the chemical over the leaf surface.

Virus Diseases. The common virus diseases of Idaho potatoes are leaf roll, mosaic, and calico. Generally, all virus diseases can be controlled by planting certified seed. In the potato field, viruses are spread from plant to plant by aphids.

Certified-seed growers should contact their county agent or a representative of the Idaho Crop Improvement Association for instructions on how to control virus diseases in certified-seed production.

Nematode Diseases. In Idaho two nematode diseases are important. Complete crop losses are possible due to tuber discoloration. The root knot and the potato rot nematode—once introduced into the soil—remain in the soil from that time on.

1. If your farm is not infested—
   a. Plant only certified seed.
   b. Do not return tare dirt to your farm.
   c. Clean and steam-sterilize all equipment before bringing it onto your farm.

2. If your farm is infested—

   a. Consult your county agent for control measures.

   b. Sell all culls to starch plant.

INSECT CONTROL

Many insects damage potatoes. Wireworms are general pests and require chemical control in many areas. The Colorado potato beetle is now widely distributed. Other insects are only important when conditions are favorable for their development. If potatoes are to be processed, the control of western potato flea beetle larvae may be necessary. Occasionally it is necessary to control other pests.

To get the desired results from chemicals, be sure the proper insecticide is selected and the proper amounts used. **Excessive dosages are costly and may lead to unlawful pesticide residues on the potatoes at harvest time.** (See page 22.) Be sure the application is timed to coincide with the particular pest's activities. In most instances, chemical control treatments are applied to prevent potato injury. When using any insecticide be sure that coverage is complete. Only this can bring satisfactory control.

Wireworms. Crop rotations or application of an insecticide to the soil will usually control wireworms. Alfalfa is the key crop in a rotation for their control. It provides little food for the wireworm larvae, and their numbers decrease after each succeeding year. The reverse is true when clover, cereal crops, and grass-legume mixtures are used in the rotation.

Thoroughly mixing 10 pounds of actual DDT or 5 pounds of actual aldrin or dieldrin per acre in the soil controls wireworms. Apply the insecticide evenly over the field by dusting or spraying. Disk, plow, and cross-disk the insecticide into the soil to a depth of 6 to 8 inches. One such treatment will kill the wireworms already in the soil and prevent reinfestation for about 8 years when DDT is used, and for about 5 years when using aldrin or dieldrin. DDT does not always kill all the wireworms the first season. Treating the soil with DDT between the other crops of the rotation will insure wireworm-free soil when the potatoes are planted. Immediate wireworm kill can be obtained by the use of aldrin or dieldrin.

White Grubs. Potatoes planted in fields recently broken out of sod or fields rich in humus may be subject to white grub attack. Effective control can be had by thoroughly mixing 10 pounds of actual DDT or 5 pounds of actual aldrin or dieldrin into the soil as outlined under "wireworms."

Leatherjackets. These are the larvae of large, awkward, slow-flying mosquito-shaped crane flies. They prefer to deposit their eggs in moist areas of fields with an abundance of organic matter. They attack growing tubers and cause injury similar to that of

white grubs. Thoroughly plowing and disking infested areas in August will prevent damage to crops the following season. Soil treated for white grub control is generally free of leatherjackets.

Seedcorn Maggot. The adult of the seedcorn maggot is a grayish-brown fly never more than 1/5 inch long and is particularly a problem during cool, wet springs. The flies are attracted to soil with an abundance of freshly decaying organic matter. Here they lay their eggs. The cream-colored larvae burrow tunnels into the potato seedpiece and may completely prevent sprouting. To prevent the seedcorn-maggot injury that occurs when the weather is cool and wet at planting time, delay potato planting until warm weather prevails.

Western Potato Flea Beetle. Flea beetle larvae live in the soil and feed on potato roots and tubers. They excavate tiny tunnels just under the skin of the potato tuber. Ordinarily, these tiny tunnels are removed when the potatoes are peeled. But in commercial process peeling, only the thin outer skin is removed. Then the tunnels remain on the potato and must be cut away by hand. Harrow 1 pound of actual aldrin or dieldrin into the top 2 or 3 inches of each acre of the potato field just as the plants emerge. This shows promise in preventing tuber infestation by flea beetle larvae.

False wireworms.

Long-horned borers.

Dryland wireworms. Several members of these three groups of insects show up in soil during the first and second years after removing sagebrush from the land. In the absence of their normal foodplants, these insects will feed on potatoes. To prevent injury, treat the soil as for wireworms.

Colorado Potato Beetle. The adult Colorado potato beetle usually appears on the potato foliage as it first emerges from the ground in the spring. Females of these plump yellow and black striped beetles are about 3/8 inch long and lay bright orange eggs in clusters on the undersides of leaves. They hatch into brick-red, hump-backed larvae which grow to be about 1/2 inch long and become orange in color. Some years there is a partial second generation. Both the adults and larvae are vigorous eaters and often completely defoliate the potatoes.

Since the adult beetles do not emerge from hibernation and migrate into the potato fields at the same time, the application of an insecticide is best delayed until the first larval feeding. Treat the plants with 1 pound actual DDT per acre as a dust or spray. A second treatment is sometimes necessary. Thorough coverage is essential for effective control. Thiodan, dieldrin or endrin can also be used.

Green Peach Aphid. Heavy aphid infestations occasionally occur in Idaho's commercial potato-growing areas and cause potato

leaves to curl, turn yellow or brown, and die. This can be prevented by applying 1 pound of actual thiodan or 9 ounces of actual endrin per acre. Other material such as malathion, parathion, demeton, or diazinon, may also be used. Thorough coverage is essential for effective control. Except for malathion, most organic phosphate insecticides are dangerous to handle and apply. Read and follow instructions on container labels.

Investigations to determine the relationship of green-peach-aphid activities to the spread of potato-leaf-roll virus are under way. Until this relationship is understood, the control of this aphid on potatoes to prevent the spread of leaf roll is not recommended.

Two-Spotted Spider Mites. The two-spotted spider mite in Idaho apparently includes several species of mites that have similar life cycles. Occasionally the mites migrate from freshly-cut hay fields to adjacent potatoes. Injured leaves become dry and leathery, turn red or brown in color, and often fall prematurely. Severe damage may be done in a short time. The mites can be controlled by applying 25 pounds of dusting sulfur per acre. Kelthane, parathion and trithion are also effective.

Other Insects. Where the control of the alfalfa looper, beet webworm, blister beetle, intermountain potato leafhopper, lygus bug, thrips, adult western potato flea beetle, or western yellow-striped armyworm seems necessary to prevent excessive leaf damage, apply 1 pound of actual DDT per acre as a dust or spray. Satisfactory control comes only with thorough coverage.

WEED CONTROL

A weed control program in all crops in the rotation is the first step to controlling weeds in potato fields. Weeds decrease yields through competition for water, nutrients, and sunlight. They cause difficulties at harvest and are involved in the buildup of certain potato disease organisms and insects. A combination of mechanical and chemical control measures may be necessary to control weeds in potatoes.

Mechanical. Three to four days before the potatoes emerge it is often a good idea to smooth out the ridge left by the planter. This allows more rapid potato emergence and accomplishes eary weed control. A harrow of the Melrose type will do an excellent job in controlling small weeds. Harrow teeth must not penetrate more than 1 inch into the soil. Deeper setting can damage the potato plant. Pull the harrow slowly through the field.

When the potatoes are a little larger, use cultivators to throw dirt over the small weeds in the hill and to kill weeds in the furrow. Be careful not to cut important feeder roots during the cultivation. Cultivate only to control weeds and to aid irrigation.

Chemical. The broadleaf perennials—Canada thistle, bindweed, and alfalfa—can be controlled prior to planting commercial

potatoes. Permit the weeds to grow in early spring. Spray with 2 pounds 2,4-D per acre, irrigate the same day, and wait 2 weeks before plowing or preparing the seed bed.

Bindwed and Canada thistle can be treated in the fall with 2,4-D 10 days before harvest if the potato vines are dead. **Do not use 2,4-D on potatoes grown for seed.**

Control quack-grass before planting potatoes. Allow the grass to grow to 4 inches, spray with 10 pounds of dalapon per acre, wait 4 days, plow, prepare seedbed, and plant. **Do not use dalapon when red-skinned varieties are to be planted.**

Some chemicals such as falone 44E, and alanap 10G show some promise in lieu of cultivation for annual weed control. Consult your county agent concerning use of these and other materials as pre- and post-emergence chemicals for potato weed control.

VINE REMOVAL

In Idaho, when frosts have been late or a grower wishes to harvest early, mechanical or chemical methods can be used to kill the vines. The time necessary to "set" the skin of potatoes varies with the kind of vine removal. If recommendations for last irrigation are followed, potatoes mature in 10 to 14 days after rotobeating, frost, or chemical treatment. The time can be reduced to 5 to 10 days if a vine puller or under-cutter is used. **After vine killing, use a roller to fill cracks in the soil to avoid light greening and frost spots on the tubers.**

Mechanical. In all types of mechanical methods, properly adjusted equipment is necessary to prevent uncovering or injuring tubers close to the surface. Mechanical vine-removal methods result in little stem-end discoloration.

Chemical. Many chemicals for killing potato vines are on the market. Some chemicals may cause stem-end discoloration. Do not use them. It is also important that any chemical used to kill vines leaves no residue on or in the tubers. If there is a residue there must be an accepted tolerance for the chemicals. Ammonium sulfate can be used to good advantage at the rate of 100 pounds dissolved in 100 gallons of water per acre. It does not cause stem-end discoloration and it has fertilizer value for the next crop.

HARVESTING

Increased potato acreages, labor shortage, and labor costs have brought advances in mechanical harvesting. Regardless of the harvesting method or type of machine used, most important is proper management to prevent harvest injury. For more information on harvesting consult University of Idaho Bulletin 218, "Injury to Russet Burbank Potatoes by Different Harvesting Machines." The following steps will help reduce damage to potatoes at harvest.

1. Apply a light irrigation to soften clods and to mellow soil for harvesting.
2. Rubberize digger chains, transfer and elevator chains on combines and pilers.
3. Maintain a cushion of soil from digger point to transfer chain.
4. Adjust speed so tubers do not roll on harvester or piler.
5. Do not use kickers or eccentrics on digger chain unless necessary.
6. Pad truck bed. If bulking, pad box and bed and pad the hopper on the bin piler.
7. Do not allow potatoes to drop more than 6 inches.
8. Always **place** potatoes. Do not throw them, whether it be into sacks, trucks, or bins.
9. Stress safety at all times.
10. Educate all employees on these nine points for potato handling.

STORAGE

The purposes of storing potatoes are: (1) to maintain the tuber in the most edible and salable condition during the winter months; (2) to provide a uniform flow of high quality tubers to the user throughout the winter and spring; and (3) to keep seed potatoes in good condition. Good storage prevents the development of rot, retards the growth of sprouts, and prevents excessive moisture loss. To arrive at these goals proper management means the control of temperature, humidity, and air circulation.

Storage management can be divided into three definite periods: (1) the wound-healing and -curing period; (2) the storage or holding period; and (3) the warming-up or grading and sacking period. Each has a particular function and must be carefully managed.

Wound-Healing and Curing Period. During this period, bruises and other wounds caused at harvest time heal over. The corky suberin layer that forms reduces danger of rot. The healing process takes place in about 3 days at 60° F. and 6 days at 50° F. It may not take place at all at 40° F. if relative humidity in the cellar is low. Slowly lower the cellar temperature until it reaches 38-40° F. in the first week of December. If water rot or field frost are present, a temperature above 50° F. after harvest can be quite harmful. Under these circumstances, reduce the temperature to 38° F. immediately upon completion of the harvest operation.

Storage or Holding Period. In general, the higher the temperature maintained during this period the higher the quality of the tubers for processing and fresh market. But higher storage temperature shortens the period that tubers can be kept without

sprouting and excessive shrinkage. Tubers can be kept for only 12 to 15 weeks at a temperature of 50° F. before they begin to sprout. But they keep 24 to 32 weeks without sprouting at 40° F. To store potatoes into April or May temperatures should be between 38° and 40° F., humidity 85 to 95 percent, and air movement of 10 cubic feet per minute per ton of potatoes.

Warming-up or Grading and Packing Period. Cold tubers are brittle and easily bruised and damaged during handling. Before removing potatoes from a cellar, warm them to 50° F. Closing the air vents and preventing the entrance of cold air into the storage is an easy way to raise the temperature. Heat from respiring potato tubers will be enough to raise the temperature if no cold air enters.

Recommendations for Potato Storage:

1. Clean the cellar of all refuse and old tubers. Spray the cellar with a solution of copper sulfate until the walls, ceiling, and floors are completely covered. Use a mixture of 10 pounds of copper sulfate to 100 gallons of water. Since copper sulfate has a corrosive action, thoroughly clean equipment after use.

2. Be sure the cellar has adequate insulation. A minimum of 6-inch, bat-type, mineral- or wood-wool insulation or 16 inches baled straw is recommended. A wet ceiling results from inadequate insulation.

3. Wet the cellar down each fall prior to the storage season. Soil of floors and walls should be moist but not muddy. **Do not place potatoes in a dry storage.**

4. Remove all tubers having cuts, serious bruises, water rot, or field frost. Undamaged tubers store well without much trouble. Damaged tubers require special care.

5. Cool the cellar slowly to 38° to 40° F. by the first of December.

6. Provide air movement of 10 cubic feet per minute per ton of potatoes during the healing period.

7. Keep the tubers at 38° to 40° F. in the storage during the holding period.

8. Maintain relative humidity of 85 to 95 percent in the cellar. If the humidity is lower than this, wet down the alleyway or pour water into air tunnels.

9. Have a positive air movement through the potato pile to provide a cooling effect and an exchange of gases. Air movement up to 10 cubic feet per minute per ton of potatoes can be used without dehydrating the tubers if the humidity is above 85 percent.

10. Warm the tubers to 50° F. before handling. Cold tubers are easily injured.

SPROUT INHIBITORS

At temperatures below 45° F. sugars accumulate in stored potatoes. The presence of sugar reduces processing quality. This appears in French fries and potato chips as an undesirable darkening of the products. Ideally the best temperature for stored potatoes is above 45° F. To store potatoes at this temperature it is necessary to use sprout inhibitors. Sprout inhibitors can be applied at the following stages:

In the Field. Maleic hydrazide will prevent sprouting if applied to still green potato plants. An application shortly after blossom fall gives good sprout inhibition. In the application, be sure to follow directions on the label.

At Harvest. Apply TCNB as a dust to potatoes as they are placed into storage. This chemcial has not received Federal Drug Administration tolerance at this date. Application for approval has been submitted.

In Storage. CIPC is an effective sprout inhibitor when applied after potatoes are stored. CIPC is applied through the ventilating air stream. A forced-air ventilating system that provides thorough air distribution is necessary. CIPC interferes with the healing process of the tuber. Do not use it until tubers are in the storage or holding period.

VARIETIES

The Russet Burbank variety predominates Idaho's potato production. A variety having other shape, skin, and cooking qualities would be questioned on the fresh market as an Idaho potato. With the expansion of potato processing in Idaho, production of another variety is possible. For further information on varieties see University of Idaho Bulletin 375.

These characteristics would be desirable in a variety:

1. Long russet type similar to the Russet Burbank.
2. Resistance to diseases verticillium wilt, leaf roll, rhizoctonia, eumartii wilt, early blight, and scab.
3. Reasonably high dry-matter content.
4. Narrow ranges of specific gravity and size.
5. Higher yields of U.S. No. 1's than Russet Burbank.
6. Insentitive to environmental factors of water, fertilizer, and temperatures.
7. Resistance to harvesting and handling injuries.
8. Store well.
9. Low sugar content and conditions easily.

ECONOMICS OF POTATO PRODUCTION

The cost of producing potatoes depends primarily on the yield per acre and number of acres produced. Here are 1958 data from 68 better managed potato farms in southeastern Idaho. They show that costs per unit decrease as acreage and/or yield increases. These data assume one-third of the farm acreage to be in potatoes. The unit cost does not include a charge for operator, family labor, or any return to investment.

Farm size, range in acres	60-120	121-200	201-280	281-400
Total cost per acre for potato production	$240	$224	$210	$196
Cost per cwt.				
175 cwt., yield	$1.37	$1.28	$1.20	$1.12
200 cwt., yield	1.20	1.12	1.05	.98
225 cwt., yield	1.07	1.00	.93	.87

The cost figures cannot be assumed to continue downward at the same rate for larger-sized farms as they do for these four typical-sized farms. Costs should decrease when farms are over 400 acres, but the rate of decrease should be less.

The size of farm and yield are very important factors in low costs per unit. Low costs are associated with:

1. Large acreage in one crop and large fields.
2. Properly timed irrigation and fertilization practices.
3. Well maintained machinery, conditioned well in advance of need.
4. Wise buying of all supplies and materials.
5. Close supervision of labor with care to hire workers suited for their jobs.
6. Closely consolidated operations that eliminate the need to move equipment and men long distances.

In Idaho, the most common causes for high production costs are:

1. Low yield per acre.
2. Acreage of potatoes low in relation to the farm's total size.
3. Depreciating equipment too quickly or trading it before optimum use has been gained.
4. Careless purchase of supplies and materials.
5. Overhead costs too high because of:
   a. too much insurance
   b. too elaborate spending for shop and equipment
   c. careless machinery practices resulting in excessive repairs and breakdowns
   d. poor supervision of labor or poor hiring practices
   e. excessive use of automobiles and trucks which is wasteful of labor and equipment.

OTHER BULLETINS ABOUT POTATOES BY THE UNIVERSITY OF IDAHO

A Guide for Fertilizing Idaho Crops, Ext. Bul. 325
A Study of Simulated Hail Injury on Potatoes, Exp. Res. Bul. 22
Early Dying (Verticillium Wilt) of Potatoes in Idaho, Exp. Res. Bul. 45
Estimating Hail Injury to Potatoes, Exp. Bul. 274
Fertilizer Studies on Russet Burbank Potatoes in Southern Idaho, Exp. Bul. 281
Fusarium Seedpiece Decay of Potatoes in Idaho and Its Relation to Blackleg, Exp. Res. Bul. 15
Influence of Seed-Piece Treatment on Disease Control and Yield of Russet Burbank Potatoes, Exp. Bul. 329
Irrigation of Russet Burbank Potatoes in Idaho, Exp. Bul. 246
Knobby Tubers, Ext. Bul. 349
Malformed Potatoes, Ext. Bul. 348
Marketing Potatoes for Consumer Approval, Exp. Bul. 0285
Mechanical Injury to Potatoes from Harvester to Consumer, Exp. Bul. 280
New Ideas in Packing Idaho Potatoes, Exp. Bul. 284
Packing Idaho Potatoes, Exp. Bul. 247
Packing 10-pound Sacks of Idaho Potatoes, Exp. Bul. 318
Potato Early Blight, Ext. Bul. 346
Potato Eumartii Wilt, Ext. Bul. 345
Potato Scab, Ext. Bul. 347
Potato Tuber Diseases, Defects, and Insect Injuries in the Northwest, Exp. Bul. 0274
Potato Verticillium Wilt, Ext. Bul. 350
Producing Early Gem Potatoes in Idaho, Exp. Bul. 262
Selecting and Breeding Potatoes for Field Resistance to Verticillium Wilt in Idaho, Exp. Res. Bul. 30
Shipping Idaho Potatoes in 50-pound Boxes, Exp. Bul. 303
Soil Fumigation With a Two-Bottom Two-Way Plow, Exp. Bul. 337
Stages of Potato Plant Growth—A Guide in Estimating Losses From Defoliation, Exp. Bul. 309
Storing the Idaho Potato, Exp. Bul. 0296

PESTICIDE RESIDUES: These recommendations for use are based on the best information currently available for each chemical listed. If followed carefully, residues should not exceed the tolerance established for any particular chemical. To avoid excessive residues, follow container label recommendations carefully with respect to dosage level, number of applications, and minimum interval between application and harvest.

THE GROWER IS RESPONSIBLE for residues on his crop as well as for problems caused by drift from his property to other properties or crops.