BULLETIN NO. 274 MARCH, 1949

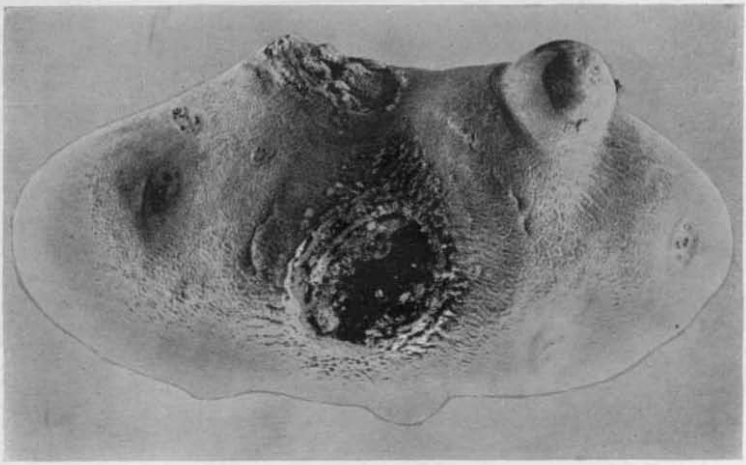
UNIVERSITY OF IDAHO

AGRICULTURAL EXPERIMENT STATION

Potato Tuber Diseases, Defects, And Insect Injuries in the Pacific Northwest

By

EARLE C. BLODGETT AND AVERY E. RICH



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Earle C. Blodgett

and

Avery E. Rich

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FOREWORD

THE PRESENT PUBLICATION is the result of a survey initiated in 1943 by the senior writer while he was employed by the Division of Mycology and Disease Survey, U. S. Department of Agriculture, and located at Moscow, Idaho, in connection with the Emergency Plant Disease Prevention Project. One of the grave threats to the food supply of the United States and of the world, during the war period, was the danger, through natural occurrence or by sabotage, of the spread of newly introduced or existing diseases. The duties of the survey personnel were to gain information on plant disease situations and to point out where control measures were needed. The official survey area included all of Idaho, the eastern counties of Washington and Oregon, and, by courtesy and availability, part of western Montana.

During the storage seasons of 1943-1944, 1944-1945, and 1945-1946 (in relation to similar work), several hundred visits were made to a great many potato storages and plants of all types and sizes. It was soon apparent that not all the disease problems encountered were commonly recognized. Thus, there was considerable confusion among growers, sorting crews, inspectors, and research and extension men regarding the names and causes of certain types of potato tuber rots or defects. Dictated by necessity that some common ground be sought, it became an established procedure to collect and photograph *all* the apparently different diseases and defects of potato tubers in the area covered. By the second season, considerable use was made of the photographs, and confusion gradually gave way largely to uniformity in terms and increased confidence in diagnosis. There have been numerous occasions in the past three years to refer again to many of the pictures and descriptions for assistance.

The diseases, defects, and injuries illustrated and discussed here constitute a complete list only in that these were the ones observed or known to occur in the area covered by the survey. All the photographs were taken by the senior writer unless otherwise noted. Most of the survey was involved with the Russet Burbank variety, but White Rose, Charles Downing (Idaho Rural), Bliss Triumph, and many new varieties in small amounts were observed. A definite attempt was made to group into natural types the various disorders and to list them in a general way according to importance. Many disorders are admittedly due to causes as yet unknown, and many are of very minor importance. Complete agreement may not be found on all items in the text and it may be stated frankly that revisions are desirable as additional information is available.

The junior writer assisted in preparing the manuscript and has contributed information on potato tuber diseases based on years of experience in the eastern states and in Washington.

To acknowledge justly all the assistance the writers have had on this bulletin is a very difficult but pleasant task.

The text on insect and related injuries, as acknowledged later, was prepared by Mr. B. J. Landis, Dr. H. S. Telford, and Mr. M. C. Lane. The identification or confirmation of the causal fungi in most cases was done by Dr. W. W. Ray and Dr. D. A. Preston, Oklahoma A & M College, Stillwater, Oklahoma.

A great debt is owed to Dr. C. E. Owens, Dr. Earl Anderson, and to Dr. C. W. Hungerford in particular, all plant pathologists who were the cooperators and counselors for the senior writer during the survey. They represented Oregon State College, The State College of Washington, and the University of Idaho, respectively. The writers are especially grateful to Mr. E. W. Whitman, Extension Agronomist (formerly Extension Potato Specialist), University of Idaho, for his advice and assistance with the survey. Dr. H. A. Edson and Mr. Paul R. Miller, in charge of the entire project, gave generously of their help.

A great deal of credit is also due Mr. John L. Toevs, formerly Superintendent of the Aberdeen Branch Station, Aberdeen, Idaho, for making available his wide knowledge of potatoes. Many others have assisted either directly in the survey, have critically read the manuscript, or have given encouragement. Special thanks are due the following: L. W. Nielsen, Leif Verner, J. M. Raeder, J. E. Kraus, H. C. Manis, Gerald Thorne, Glenn Ken Knight, R. D. Pelkey, J. E. Robertson, L. W. Boyle, Rex L. Blodgett, E. R. Bennett, G. W. Fischer, J. D. Menzies, M. R. Harris, R. L. Webster, D. H. Brannon, C. L. Vincent, S. B. Locke, and C. M. Wright.

Credit is also due to many County Extension Agents, warehousemen, growers, horticultural inspectors, and field men throughout the area covered.

It is hoped that this bulletin will prove as useful in its present form as the information was during the stages of accumulation. If it stimulates interest and results in accuracy and uniformity in diagnosis of potato tuber disorders and encourages efforts to correct these difficulties, it will fulfill its purpose.

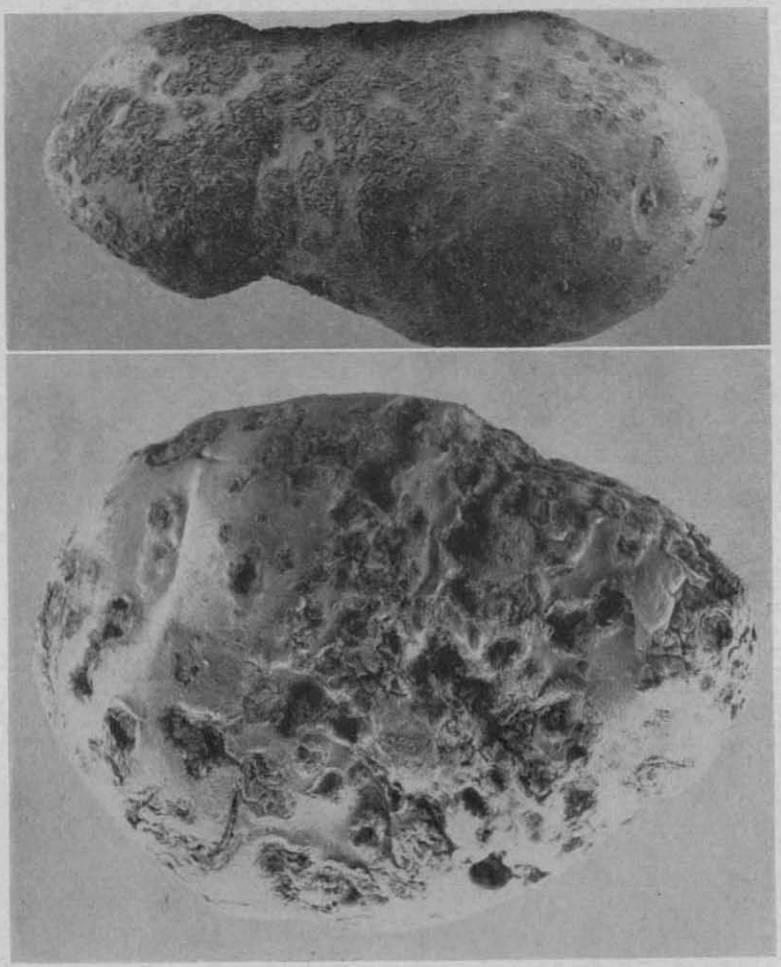


Fig. 1.—A-1. Common scab on Russet Burbank (above) and Chippewa (below). These illustrate the corky, or raised, and the pitted types.

I. SKIN DEFECTS

A. Parasitic

1. COMMON SCAB (bacterial)

CAUSAL ORGANISM: *Streptomyces* [*Actinomyces*] *scabies* (Thaxter) Waks. & Henrici.

DISTRIBUTION: Widespread, but usually confined to local areas and fields. A soil pH* of 5.5 to 7.5 favors the development of the disease. It rarely occurs on soils with a pH below 5.3 or above 8.0.

IMPORTANCE: It is often very severe on thin, smooth-skinned varieties. On Russet Burbank (Netted Gem), it is usually of very little or no importance but in some cases it is a grade-limiting factor. Affected tubers shrink excessively. Other organisms may also gain entrance through scab lesions.

SYMPTOMS: Common scab is generally characterized by raised corky areas, varying in size and shape and appearing much like terraces in miniature. The color is grayish-white to dark tan. On thin-skinned varieties, the scabby areas frequently are pitted or pocked, while in Russet Burbank they are usually raised. Thus the common terms associated with scab are *raised,* or *corky* and *pitted.* No true rot is associated with either type, and injury is rather superficial. In severe infections the shape and size of tubers may be changed. Common scab is sometimes confused with enlarged lenticels on Russet Burbank. An interesting but unusual symptom apparently associated with the disease has been noted on this variety in which a "corn" or bunion-like mass of tissue, perhaps the size of a pea, can be taken from underneath a rather inconspicuous lesion. The infected areas seem to be "corked off" from the healthy tissue. In the pitted type, the appearance suggests secondary injury by insects or other very small pests.

CONTROL:
1. Plant only scab-free or treated tubers in scab-free soil.
2. Long rotations omitting potatoes and sugar beets.
3. Resistant varieties (Menominee, Ontario, Cayuga, Seneca).
4. Alter soil pH. Acidifying soil with sulfur is sometimes effective but is not generally recommended because of its possible harmful effects on the soil or following crops.
5. Avoid the use of fresh manure, wood ashes, or lime. Manure should preferably be applied to some other crop in the rotation.

* The pH value is a common means of expressing the degree of acidity or alkalinity. A neutral soil has a pH value of 7.0. Acid soils have a pH value below 7.0, while alkaline soils are above 7.0.

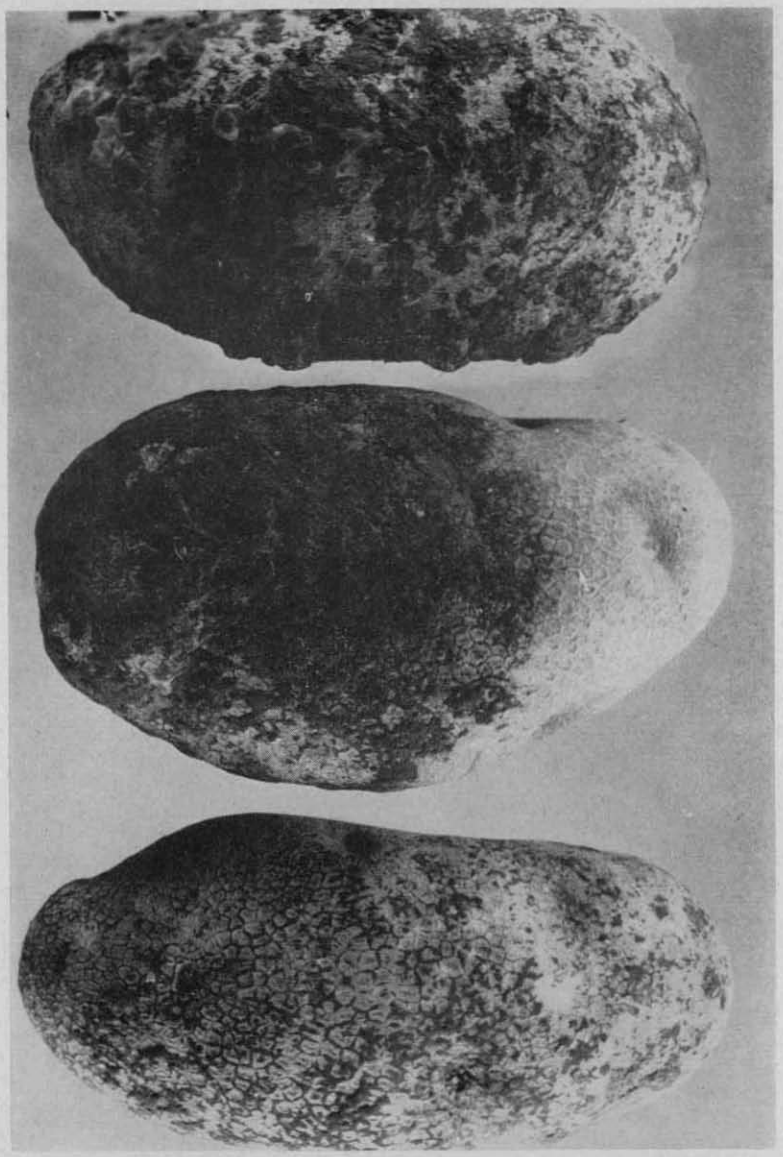


Fig. 1.—A-2. *Rhizoctonia,* showing mild to abundant formation of sclerotia on Russet Burbank.

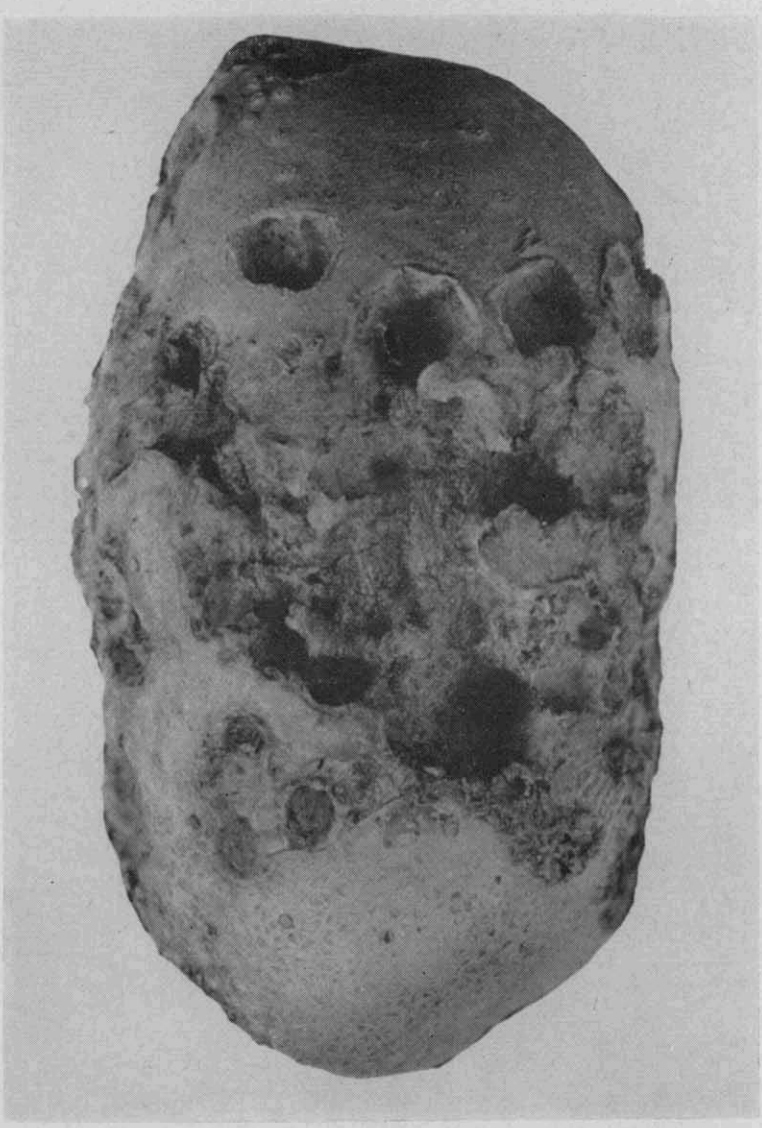


Fig. V.—7. Millipede injury to potato tuber. Note the shallow, irregular cavities. (Photo by W. A. Rawlins.)

V. INSECT AND RELATED INJURIES

7. MILLIPEDES

CAUSE: Long, slender, brown, many-jointed creatures known as thousand-legged worms, or millipedes.

DISTRIBUTION: Unknown. Of local interest in the Yakima Valley.

IMPORTANCE: Millipedes apparently enter potato tubers through lesions or abrasions made by scab organisms, soil insects, and other pests. They are probably secondary pests and are limited in their activities by the abundance of primary pests.

SYMPTOMS: From one to one hundred or more millipedes may be found partially concealed within a decaying tuber when it is removed from the ground. Although most numerous in decomposed tubers, individual millipedes attack apparently healthy tubers and also penetrate the sound portion of partly decayed tubers. The tunnels, less than one-sixteenth inch in width, are clean-cut, uncolored, and slightly larger than those produced by flea beetle larvae.

CONTROL: Soil treatment with insecticides or fumigants as recommended.

VI. MISCELLANEOUS DEFECTS

1. AERIAL TUBERS

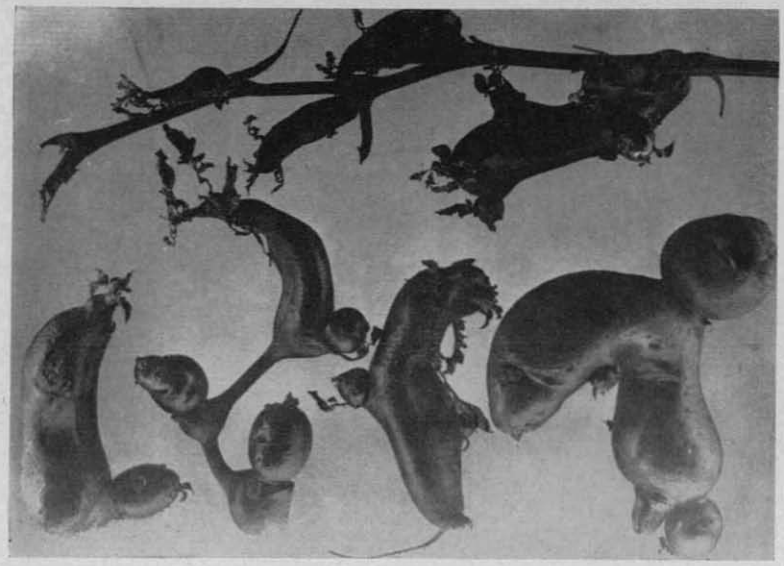


Fig. VI.—1. Aerial tubers from Russet Burbank. These are deep green, ill-shaped tubers borne on the stem above ground. Although usually small, they may attain several ounces in weight and assume odd shapes as shown.

CAUSES: Various; *Rhizoctonia,* viruses including current-season leaf-roll, late-breaking virus, and aster yellows, and probably other factors, such as insect and mechanical injury to portions of the lower stems. In the past, probably more aerial-tuber formation has been assigned to *Rhizoctonia* than was justified.

DISTRIBUTION: Widespread.

IMPORTANCE: The aerial tubers themselves are worthless. Factors which cause aerial tubers also reduce yield and quality of the crop.

SYMPTOMS: This condition is evidenced by the formation of one to several tubers in the axils of stems above ground. These tubers vary in size, are misshapen, and intense green in color. They may be closely confined to the area just above the ground or may occur in leaf axils anywhere on the plant.

CONTROL: Control *Rhizoctonia* and other diseases or factors which favor the formation of aerial tubers.

VI. MISCELLANEOUS DEFECTS

2. BIRD INJURY ("Chink" damage)

Fig. VI.—2. Bird injury to Russet Burbank. Note the type of injury to tissue as compared with that caused by white grub (V—3) and by rodents (VI—5).

CAUSE: Pheasants, sagehens, chickens.

DISTRIBUTION: General, but much more prevalent in the irrigated areas.

IMPORTANCE: Although the percentage is not great, the total loss is appreciable, especially in some fields.

SYMPTOMS: The injury is similar to grub damage except that birds usually attack only the exposed end of the tuber, and the deeper uneven marks are quite distinctive.

CONTROL: Type of culture, prevalence of birds, etc. are important factors which may be controlled to some extent. Tubers should be well covered with soil and harvested as soon as possible after maturity.

VI. MISCELLANEOUS DEFECTS

3. SPINDLE SPROUT (hair sprout)

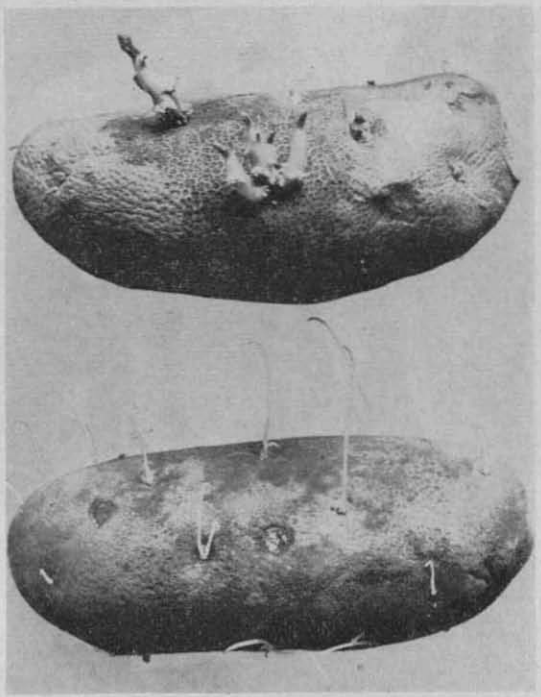


Fig. VI.—3. Spindle sprout on Russet Burbank tubers. (Photo by B. F. Dana.)

CAUSES: Probably due to various causes, such as viruses (leafroll or witches' broom) and physiological factors. It is frequently related to phloem damage. In some cases, spindle sprout has been attributed to adverse storage conditions.

DISTRIBUTION: Widespread; more serious in certain lots than others.

IMPORTANCE: Appreciable.

SYMPTOMS: Sprouts are abnormally long and slender. Seed pieces from such tubers give rise to extremely weak plants.

CONTROL: 1. Plant healthy seed.
2. Rogue diseased plants.
3. Provide favorable storage conditions.
4. Sort out affected tubers.

VI. MISCELLANEOUS DEFECTS

4. SPROUT TUBERS (blind tubers or potatoes without tops)

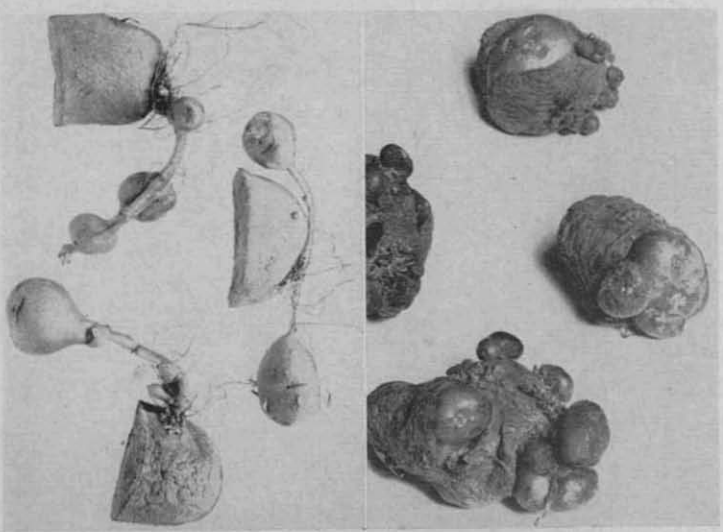


Fig. VI.—4. Sprout tubers produced by seed pieces after planting. (Photo by F. D. Heald.)

CAUSE: This is a non-parasitic trouble which is due apparently to an abnormally high concentration of cell sap in the "mother tuber" or seed piece. Dark storage at warm temperatures accompanied by removal of sprouts will produce this condition. Planting seed pieces in cold, dry soils seems to favor the development of sprout tubers.

DISTRIBUTION: Scattered; noted in several central Washington fields in 1948.

IMPORTANCE: Usually minor. Occasionally it reduces stands appreciably and thus reduces yields.

SYMPTOMS: One or more small, young tubers are formed on the end of short sprouts produced by tubers in storage or by seed pieces in the field without the formation of any leafy, aboveground plant.

CONTROL: 1. Storage at cool temperatures to prevent sprout development.

2. Avoid planting in cold, dry soil.

VI. MISCELLANEOUS DEFECTS

5. RODENT INJURY

Fig. VI.—5. Rodent injury on Russet Burbank. The type shown was caused by rats. Gophers and mice produce a similar injury.

CAUSE: Rodents, such as rats, mice, and gophers.

DISTRIBUTION: General. Gophers often cause injury before harvest and rat damage is frequently observed in storage.

IMPORTANCE: Usually minor, but sometimes serious. Gophers sometimes store potatoes in their runs. However, they usually cause more damage to growing plants than to the matured crop. Rats have a habit of making their winter homes in potato storage cellars, where they chew up considerable quantities of potatoes. Many tubers are gnawed sufficiently to make them culls although only small portions are actually eaten.

SYMPTOMS: Irregular holes or gouges in the tubers, usually showing characteristic teeth marks around the edges, are common.

CONTROL: 1. Poison baits.
2. Traps.

VI. MISCELLANEOUS DEFECTS

6. QUACK GRASS

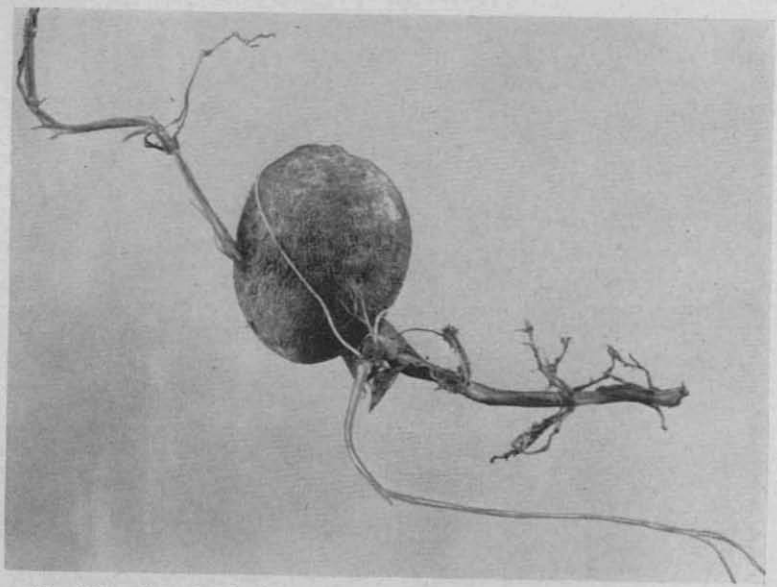


Fig. VI.—6. Quack grass injury to Russet Burbank. Note that the grass stolon has grown entirely through the tuber.

CAUSE: *Agropyron repens* (L.) Beauv. Mechanical penetration of tubers by the sharp growing points of the stolons.

DISTRIBUTION: Widespread.

IMPORTANCE: The amount of direct tuber injury is very minor; however, it is significant indirectly as it affects yield and ease of digging.

SYMPTOMS: The stolons of the quack grass plant grow into or completely through the tubers. There is usually evidence of the weed attached to the potato.

CONTROL: 1. Eradicate quack grass from fields to be planted to potatoes.
2. Proper cultivation.

SEED TREATMENT

CHEMICAL TREATMENT of seed potato tubers is frequently recommended for the control of common scab, *Rhizoctonia,* and various forms of seed-piece decay. However, its value is sometimes questioned. Undoubtedly, effective fungicides will control the organisms which are present on the surface of potato tubers, but the scab and *Rhizoctonia* organisms are often present in the soil and cause infection in spite of the use of disinfected seed. A dry type of seed-piece decay, due to *Fusarium* spp., often reduces stands and causes weak plants. Seed treatment reduces this type of injury, even though the organisms are often soil-borne.

Some of the common methods used for treating seed are as follows:

1. MERCURIC CHLORIDE (corrosive sublimate or bichloride of mercury); 4 ounces to 30 gallons of water. Soak whole seed 1½ hours. *Wooden* barrels or tanks should be used.
2. ACID-MERCURY; Dissolve 6 ounces mercuric chloride in 1 quart of commercial hydrochloric (Muriatic) acid, and add to 25 gallons of water in a *wooden* container. Treat whole seed for 5 or 10 minutes, then dry quickly or cut and plant immediately.
3. NEW IMPROVED SEMESAN BEL; This is a commercial preparation which is popular because it is used as a quick dip. One should follow directions given on the can.

The above materials are *poisonous* and *caustic.* Therefore they must be handled and used cautiously. Some of the newer varieties are injured considerably by one or more of the above treatments.

Several new organic compounds have been developed recently which show considerable promise for seed-treatment purposes. Zerlate, Dithane, Phygon, and Parzate are some of the materials which have given good results in limited trials. It is suggested that freshly cut seed be dipped for 1 minute in a solution of ½ lb. of Zerlate in 25 gallons of water. It is less dangerous and less injurious than the mercury compounds and it does not retard emergence. Wire baskets or wooden crates are convenient containers for dipping seed. Treated seed can be drained for a few minutes in a trough which will conduct the excess liquid back into the treating tank.

SPRAYING OR DUSTING

Sprays or dusts may be used to control early blight, late blight, flea beetles, Colorado potato beetles, aphids, and leaf hoppers. Dust is not as effective as spray when blight infections are severe. However, it gives satisfactory control of mild attacks when properly used. Dust is more adaptable, does not require water nor as much capital

outlay for equipment, and can be applied more rapidly than sprays. Dusting by airplane or helicopter is popular with some growers because it is fast and causes no mechanical damage. Neutral copper and copper-lime dusts are the most popular. DDT can be mixed with the former for control of insects.

Spray materials are cheaper than dusts, usually adhere better, give better control of serious outbreaks of disease, and can be applied any time of day. Homemade Bordeaux mixture is the most common spray material used. A 10-5-100 formula is suggested, and may be prepared by dissolving 10 pounds of copper sulphate (blue-vitriol) and 5 pounds of finely ground hydrated spray lime in 100 gallons of water. A stock solution of copper sulphate may be prepared by placing 50 pounds of the material in a burlap sack and suspending it near the top of a 50-gallon barrel of water overnight or until completely dissolved. A stock solution of lime is prepared by dissolving 50 pounds of lime in a 50-gallon barrel of water. Then each gallon of stock solution contains 1 pound of chemical. To prepare 100 gallons of Bordeaux mixture, 10 gallons of the copper sulphate stock solution (containing 10 pounds of copper sulphate) are placed in the spray tank, this is diluted with enough water to make nearly 100 gallons, then 5 gallons of lime water (containing 5 pounds of lime) is added, after which the spray should be well mixed.

A simpler method is to fill a 100-gallon spray tank about one-fourth full of water, wash 10 pounds of powdered copper sulphate (snow) through the intake strainer with about 50 gallons of water, make a creamy paste of 5 pounds of hydrated lime and water, and wash it through the strainer while constantly agitating the contents of the spray tank; fill the tank with water and apply the spray at once. DDT can also be added to this mixture for insect control. The spray should be applied as soon after preparation as possible, using about 300 pounds pressure, at least 3 nozzles per row, and about 100 to 150 gallons per acre, depending on the size of plants. This treatment should be repeated about every week when weather conditions are favorable for late blight or when early blight threatens.

Some new materials which show promise for blight control include Dithane and Parzate. It is easier to prepare solutions of these materials than to make Bordeaux.

Dusts should be applied at the rate of 25 to 35 pounds per acre, either in early morning or evening when the air is still and there is dew on the plants to make the dust adhere to them.

STORAGE

Proper storage is frequently mentioned as an important control measure for potato diseases and defects. The ideal temperature is around 40° F. Although potatoes can actually withstand temperatures as low as 28° F. for a limited time, such cold temperatures are undesirable. If the temperature remains near freezing for any length

I. SKIN DEFECTS

A. Parasitic

2. RHIZOCTONIA (fungous)

CAUSAL ORGANISM: *Rhizoctonia solani* Kühn [*Pellicularia filamentosa* (Pat.) Rogers].

DISTRIBUTION: Very widespread, perhaps more severe in old potato areas. Cool, wet weather favors the development of the disease.

IMPORTANCE: *Rhizoctonia* is regarded as one of the most important diseases of potatoes because of its direct effect on the young plant and resultant effects on tuber development. The stolons and roots may be girdled, causing poor stands and single-stemmed hills, sparse set or small tubers set high on the stems near the ground level. These conditions may cause tubers to be small and rough or large and knobby, many of which are "green heads." Aerial tubers are also frequently associated with this disease.

SYMPTOMS: *Rhizoctonia* on the tubers is identified by the presence of hard, black or dark brown bodies called sclerotia resting on the surface of the tubers. Frequently it is called "the dirt that won't wash off." The sclerotia vary in size from small specks to large masses nearly an inch across and one-fourth inch thick. Frequently the fungus is confined to a mild to severe netting or scurf, and often, even in extreme cases, only a portion of the tuber is affected. So far as observed, *Rhizoctonia* causes no extensive rot but may occasionally produce skin checking and a more or less superficial lesion, especially in soil very high in organic matter, and in conjunction with other organisms.

CONTROL: 1. Plant clean or treated tubers.
2. Long rotation systems are advisable, avoiding potatoes following sugar beets.
3. Shallow covering.
4. Late planting.

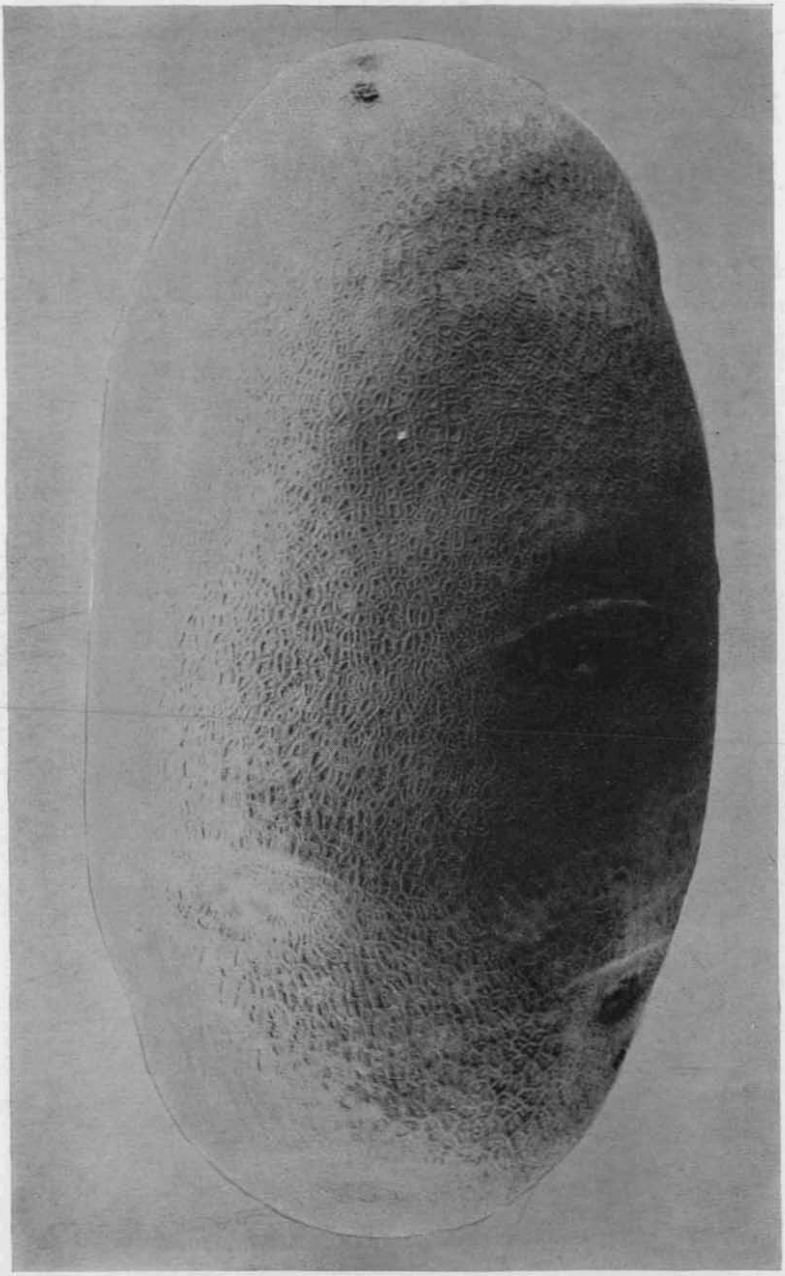
of time, some of the starch in the tubers changes to sugar, giving them an undesirable sweet flavor. Then there is always the danger that the temperature might drop, causing the potatoes to freeze and break down. A few frozen potatoes can damage many more by making them wet, nasty, and foul smelling. Temperatures above 50° F. are undesirable as they favor early sprouting, accompanied by excessive shrinking and shriveling, and promote the development of tuber rots. Unusually high temperatures may also be responsible for the development of blackheart.

Humidity is the second important factor in good storage. Condensation of moisture must be guarded against as it will result in rapid decay of wooden structures and will result in excessive tuber rots. On the other hand, air which is very dry will result in poor wound healing, excessive shrinkage and shriveling, and may cause air checking or cracking. A relative humidity of about 90% is most desirable.

In some areas where the air is dry and cool but not too cold, such as southern Idaho, pit storages have proved satisfactory and are the cheapest type to build. Temperature is regulated by natural ground temperature, air temperature, amount of straw and earth used as covering material, and sometimes by ventilators standing up through the covering materials. Humidity remains relatively constant at a satisfactory level in areas where this type of storage is adapted.

In areas where it is very cold or near the coast where it is humid, probably it pays to construct a permanent type of storage where the temperature and humidity can be controlled artificially better than can be done with most pit storages. Usually at least part of the structure is built below ground level. Concrete or wood, or a combination of the two, is the most common building material. Temperature and humidity are controlled by ventilation, fans sometimes being used for forced ventilation. Usually artificial heat is provided when needed. A few growers even store their crop in commercial cold storage.

Due to limited space, very little detail on potato storage can be given here. Therefore, it is suggested that U.S.D.A. Farmers' Bulletin 1986 be consulted for plans, list of materials, estimated cost, and other detailed information.



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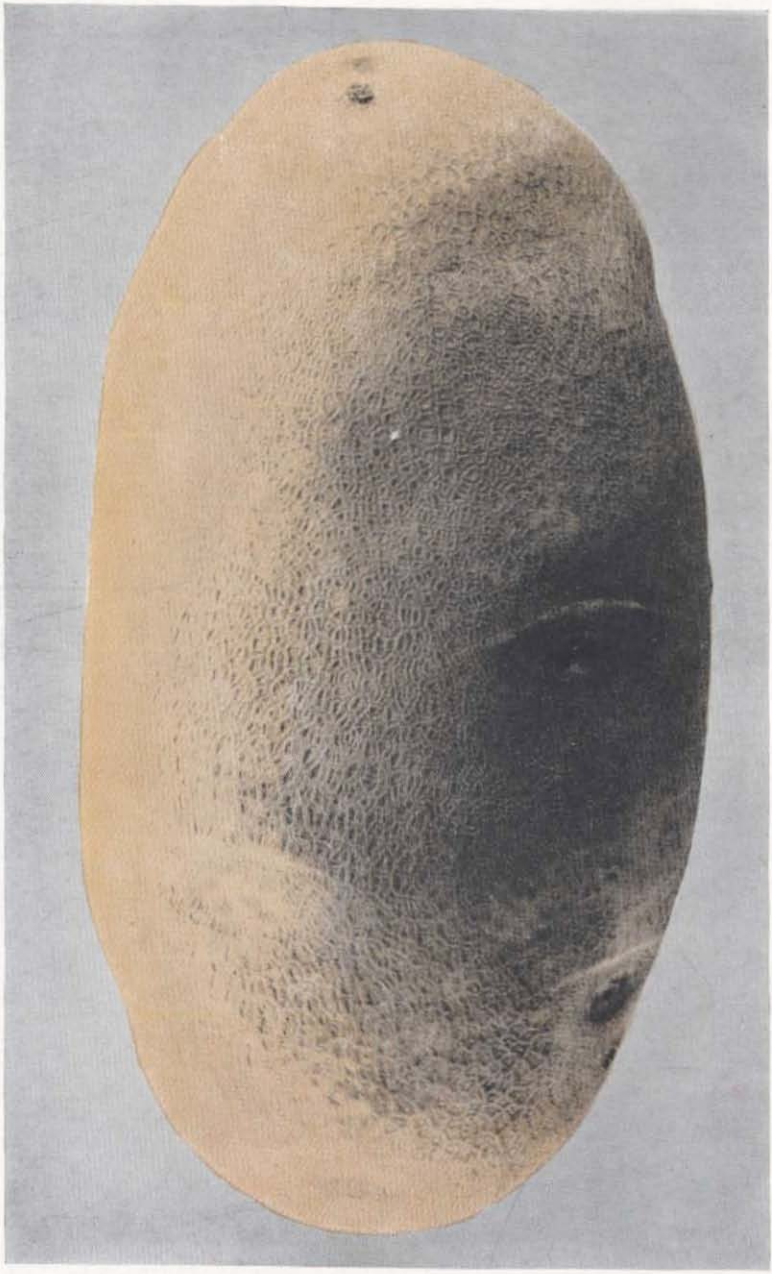

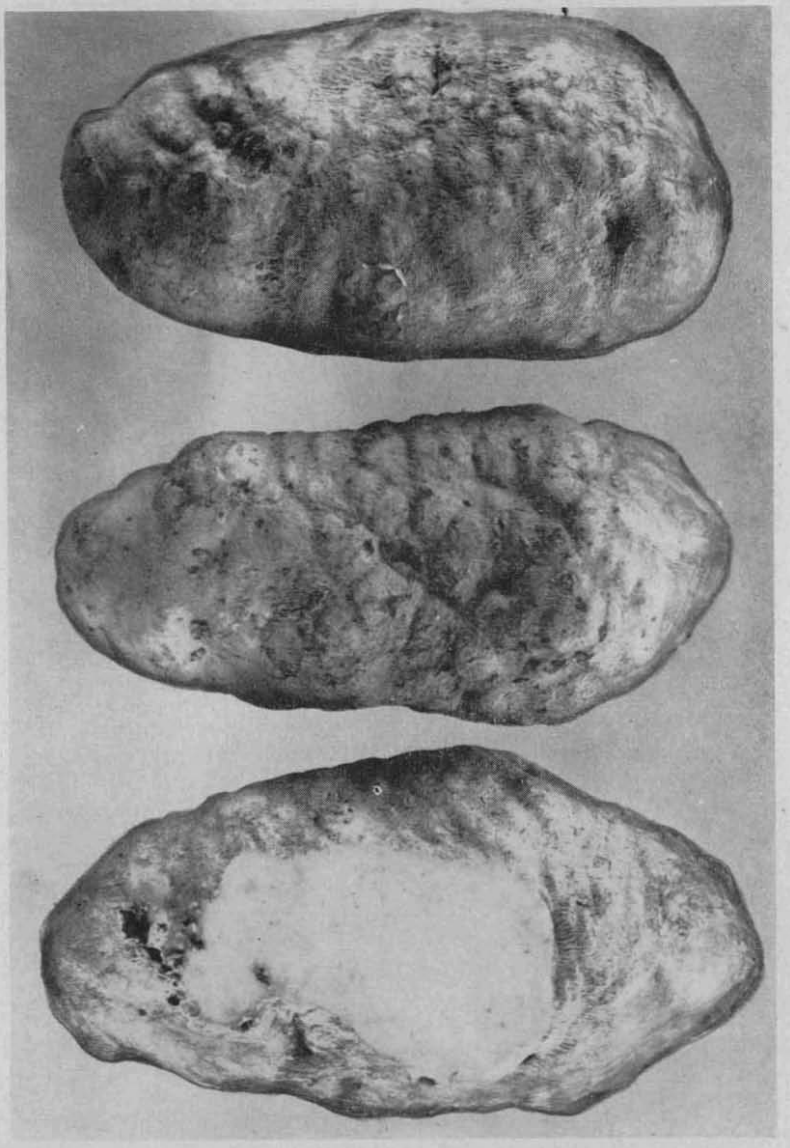

Fig. I.—A-3. Rootknot nematode injury on Russet Burbank tubers, showing the pebbly appearance on the surface and the brownish-yellow, discolored dots in the tissue.

I. SKIN DEFECTS

A. Parasitic

3. ROOTKNOT NEMATODE (nematode)

CAUSAL ORGANISM: *Heterodera marioni* (Cornu.) Goodey.

DISTRIBUTION: Scattered throughout all main potato-producing sections of the U. S. Reported in Idaho first in 1922 on potatoes in Canyon County and about 1935 in the Upper Snake River Valley near Fort Hall and Idaho Falls, and it has been known for many years in the Yakima Valley of Washington.

IMPORTANCE: Very serious. Cases are known where crops have been lost and the salability of farms definitely reduced.

SYMPTOMS: Infected tubers are pebbly in appearance with bumpy, uneven but firm skin surfaces. Both the size and shape of infected tubers are changed, resulting in dwarfed, odd-shaped potatoes frequently with "puffy eyes." The tissue under the raised areas may show numerous yellow to dull brown specks or blotches scattered through the flesh. In many severely infected tubers there are no external symptoms. After digging and handling, the raised areas appear to have no russeting and are smooth and shiny in appearance.

CONTROL: 1. *Do not use seed from infested farms.*

2. Other factors to consider are:

a. Avoid spreading soil from infested farms and fields by machinery, livestock, irrigation or drainage water, or from beet dumps or potato warehouses.

b. In a rotation, small grains and grasses for a three-year period reduce the population of nematodes.

c. Certain chemicals have shown promise as soil treatments. D-D and Dowfume are examples.

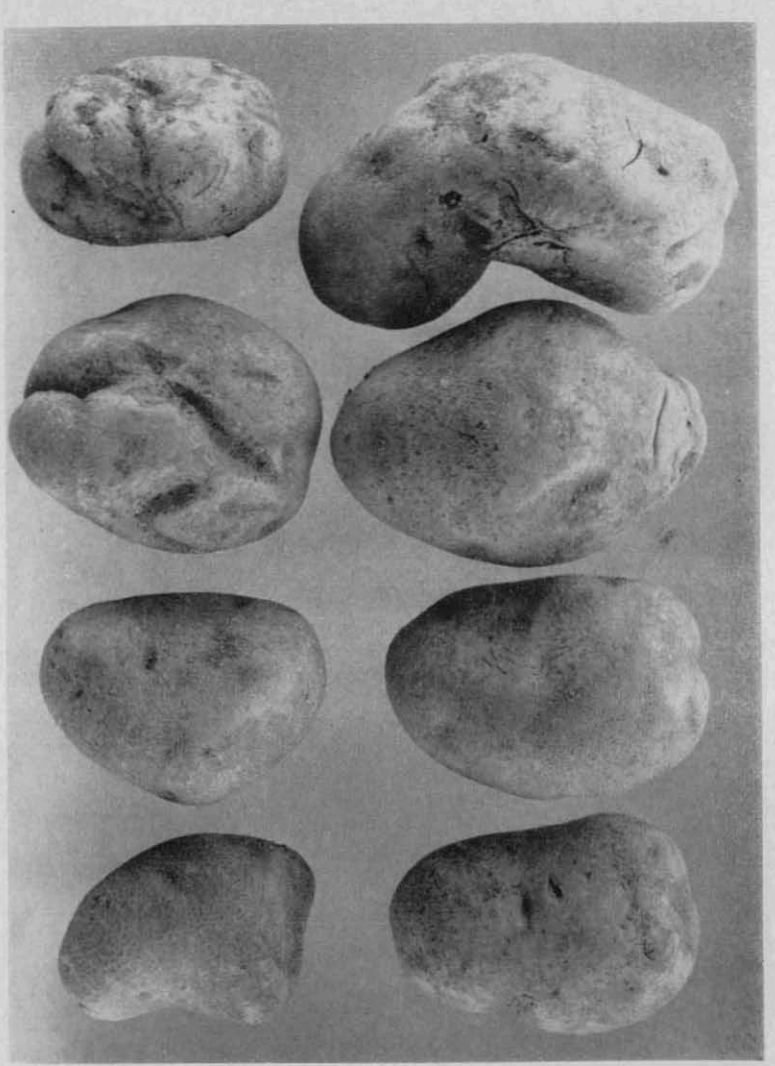

Fig. I.—A-4. Silver scurf injury on Russet Burbank tubers. Note the tendency toward square ends and malformation.

I. SKIN DEFECTS

A. Parasitic

4. SILVER SCURF (fungous)

CAUSAL ORGANISM: *Spondylocladium atrovirens* Harz.

DISTRIBUTION: Widespread.

IMPORTANCE: Slight; probably more than realized, however, due to loss of moisture and shriveling in storage.

SYMPTOMS: Silver scurf is characterized by a gray, smooth, leathery appearance of the skin, usually near the stem end of affected tubers and is more noticeable, because of a silvery sheen, when the tubers are wet. No rot occurs and damage involves reduction in size, malformation, and severe shriveling in storage. In most cases observed, severely affected tubers were small, slightly to severely misshapen, and russeting was less pronounced on russet varieties. Many tubers tend to be wedge-shaped or lopsided. It appears likely that infection in some lots has appreciably affected grade. The disease may spread in storage, especially under high humidity and temperature.

CONTROL: 1. Plant disease-free seed on clean land.
2. Harvest as soon as mature.
3. Keep storage temperature around 37° F. and relative humidity below 90%.

I. SKIN DEFECTS

A. Parasitic

5. POWDERY SCAB (fungous)

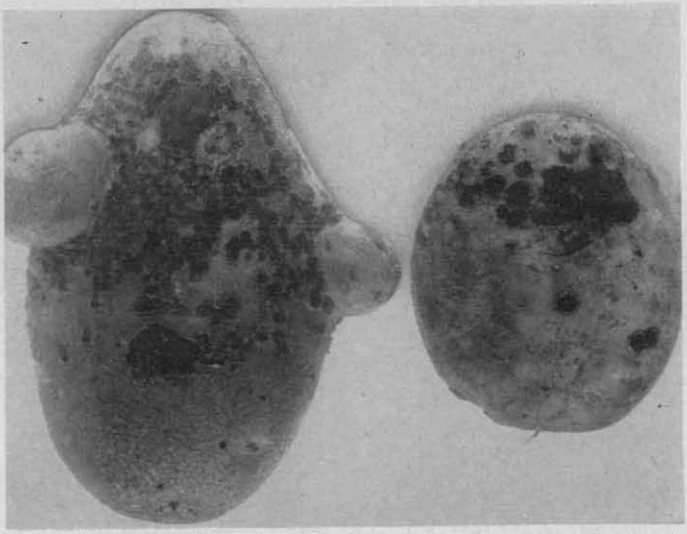

Fig. I.—A-5. Powdery scab on potato tubers, showing pustules filled with black spores. Note ragged edges of epidermis. (Photo by F. D. Heald.)

CAUSAL ORGANISM: *Spongospora subterranea* (Wallr.) Johnson.

DISTRIBUTION: Scattered. Reported from Washington, Oregon, Maine, and a few other northern states. Confined to cool, moist regions.

IMPORTANCE: Usually minor.

SYMPTOMS: Small raised pustules under the surface of skin, eventually enlarging and rupturing, exposing dark spore masses surrounded by ragged edges of epidermis. A dry rot sometimes occurs around the pustules.

CONTROL: 1. Plant only disease-free seed.
2. Rotation.
3. Sanitation.
4. Avoid poorly drained soil and the use of lime.

I. SKIN DEFECTS

A. Parasitic

6. VIOLET ROOT ROT

Fig. I.—A-6. Violet root rot on Russet Burbank potato, showing external dark fungus strands. (Photo by F. D. Heald.)

CAUSAL ORGANISM: *Rhizoctonia crocorum* (Pers.) DC. [*Helicobasidium purpureum* (Tul.) Pat.].

DISTRIBUTION: Reported from Oregon, Washington, and Nebraska. Probably present occasionally in other states.

IMPORTANCE: Minor.

SYMPTOMS: Surface of tuber partially covered with a dense, felt-like mass of fungous tissue, chocolate-color when dry, violet-brown when wet. The mycelial mat can be easily removed, exposing small dark spots on the surface of the tuber beneath it.

CONTROL: Seed treatment is not effective. Probably clean seed, rotation, and sanitation are the most important control practices known.

Fig. I.—B-2. Cuts on Russet Burbank tubers. The lower specimens show rather large slab cuts made by the digger, and the upper specimens, which are the same tubers, indicate the extent of the damage done by black rot, which often enters through cuts or other injuries. (See III-A-1.)

I. SKIN DEFECTS

B. Non-parasitic

2. CUTS

CAUSE: Principally due to digger cuts resulting from improper care in digging. Another frequent cause is clipping ends and second growths during the sorting and grading process.

DISTRIBUTION: General; digger cuts are often excessive in field run potatoes, and clipped ends are common in Standard and Utility grades.

IMPORTANCE: Potentially serious because grade is reduced and tuber rots are likely to follow, especially if clipped tubers are stored for long periods under conditions which are unfavorable for rapid suberization.

SYMPTOMS: Cuts on tubers are merely mechanical injuries suffered during digging or sorting. They may be slight cuts into the tuber or they may be lengthwise or crosswise slab cuts exposing large areas.

CONTROL: 1. Adjust digger so that tubers are not cut.

2. Good stands of suitably spaced, multiple-stemmed hills, with irrigation and cultural practices which maintain uniform growing conditions throughout the season, will help prevent knobby tubers and jelly ends and thus reduce the percentage of tubers to be clipped in grading.

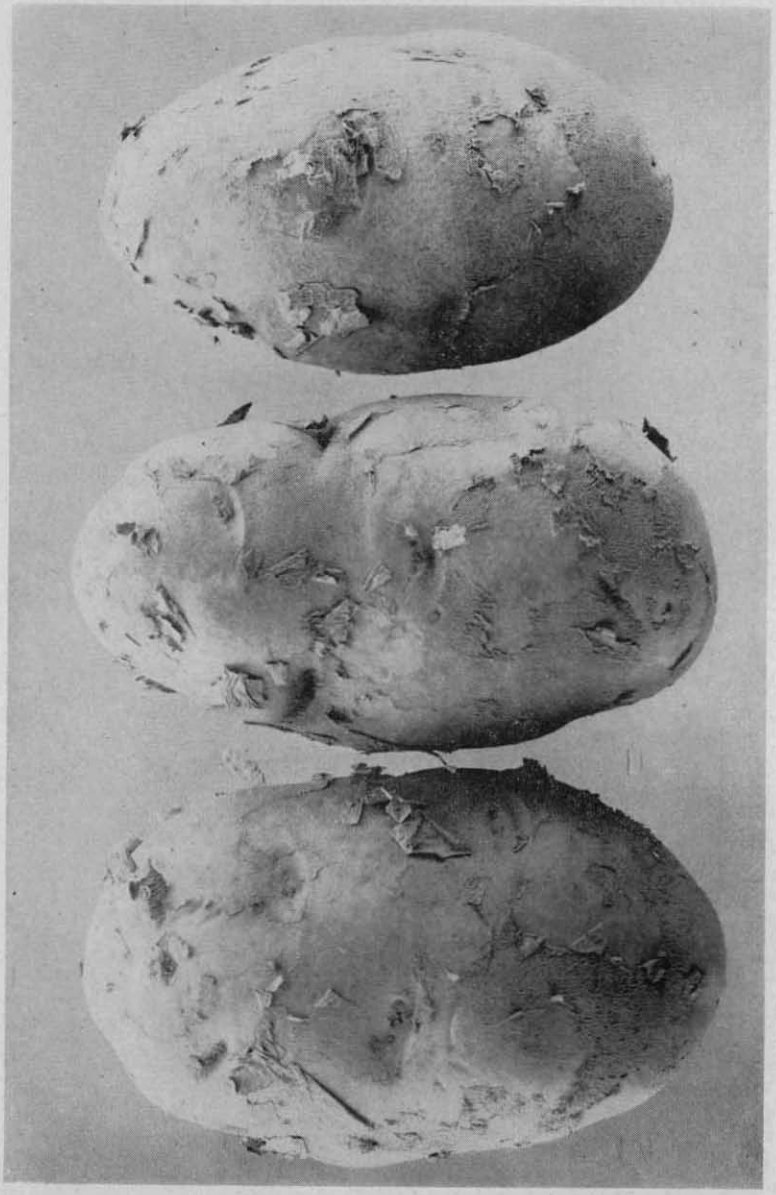

Fig. I.—B-3. Feather, on Russet Burbank tubers. Note remnants of outer skin which has become loosened in affected areas.

I. SKIN DEFECTS

B. Non-parasitic

3. FEATHER

CAUSE: Mechanical injury to outer skin of immature tubers.

DISTRIBUTION: General, especially in areas producing early potatoes or where late fall frosts necessitate digging immature tubers.

IMPORTANCE: Very great, since it affects markedly the keeping quality of the tubers. Feathered tubers shrivel badly, often scald and furnish entrance for rot-producing organisms.

SYMPTOMS: Feathered tubers may be slightly or severely affected and give the appearance of having the skin tissue scuffed, scaly, and broken, exposing the unprotected tissue. It is most commonly seen in the early dug, immature tubers, and is more prevalent on the bud end.

CONTROL: 1. Harvest tubers carefully.
2. For storage, harvest only mature tubers. Hasten maturity by withholding water, applying top killers, using mechanical means, or delaying harvest until after frost. Chemical top killers and mechanical devices may cause injury if improperly used.

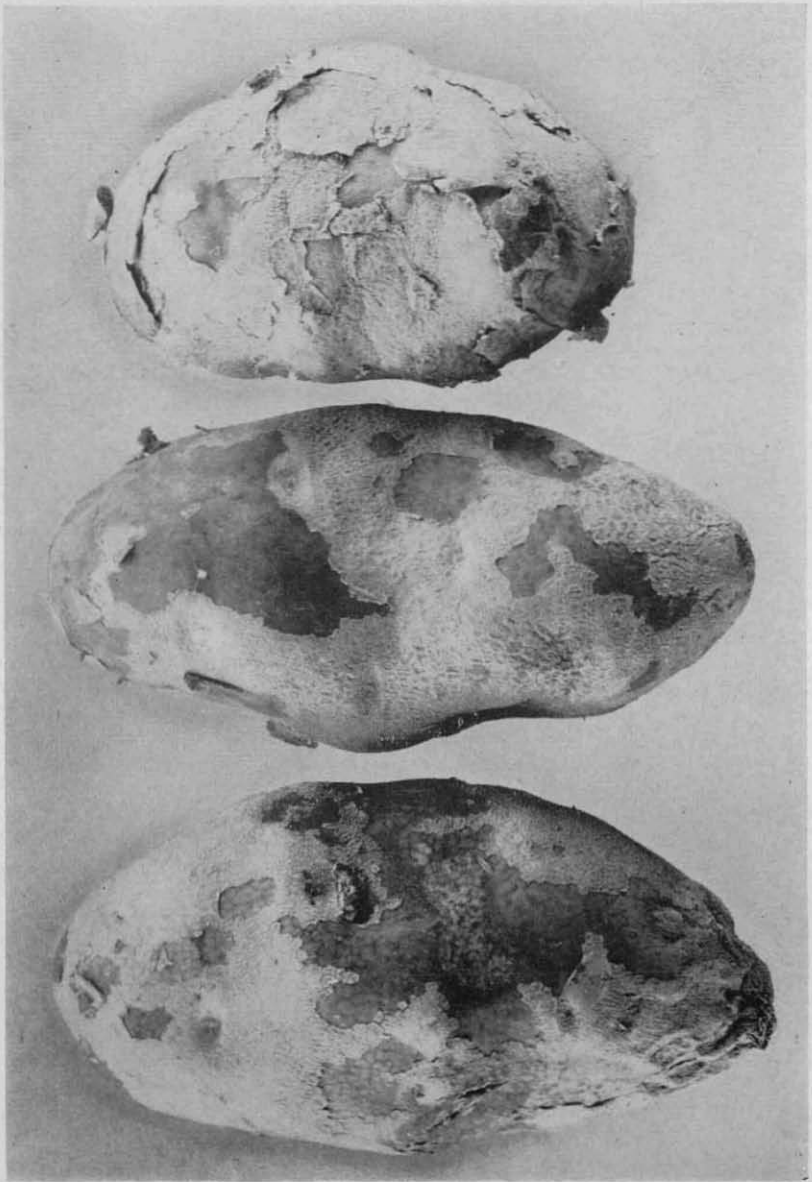

Fig. 1.—B-4. Feather and scald on Russet Burbank tubers. Note the discoloration on the scalded areas and the evidence of severe shrinkage of the tuber at the bottom.

I. SKIN DEFECTS

B. Non-parasitic

4. SCALD (following feathering)

CAUSE: The drying effect of wind and sun on immature tubers in which the outer skin has feathered or become roughened and scaly. Exposure to wind appears to be more critical than exposure to sun.

DISTRIBUTION: General. On individual tubers, scald is more severe at the bud end than at the stem end.

IMPORTANCE: Usually minor but occasionally very serious, depending largely on weather conditions and maturity when the tubers are dug. Most serious when potatoes are dug during windy weather.

SYMPTOMS: Frequently the tissue exposed by feathering is scalded and turns dark. In many cases the area becomes sunken and is followed by a rot which may be dry or wet but usually similar to black rot. Affected tubers turn green or yellow more readily and may shrivel badly. Frequently rot develops even where no further change in the surface is apparent. Scald may also favor *Penicillium* rot, particularly at temperatures near freezing.

CONTROL:
1. Do not expose harvested tubers to wind either before picking or in field sacks.
2. Use wind-proof or closely woven field sacks.
3. Store promptly. In windy weather, cover loaded trucks with canvas tarpaulin.
4. Avoid harvesting immature tubers.
5. Harvest only during mornings and late afternoons if weather is hot and windy.

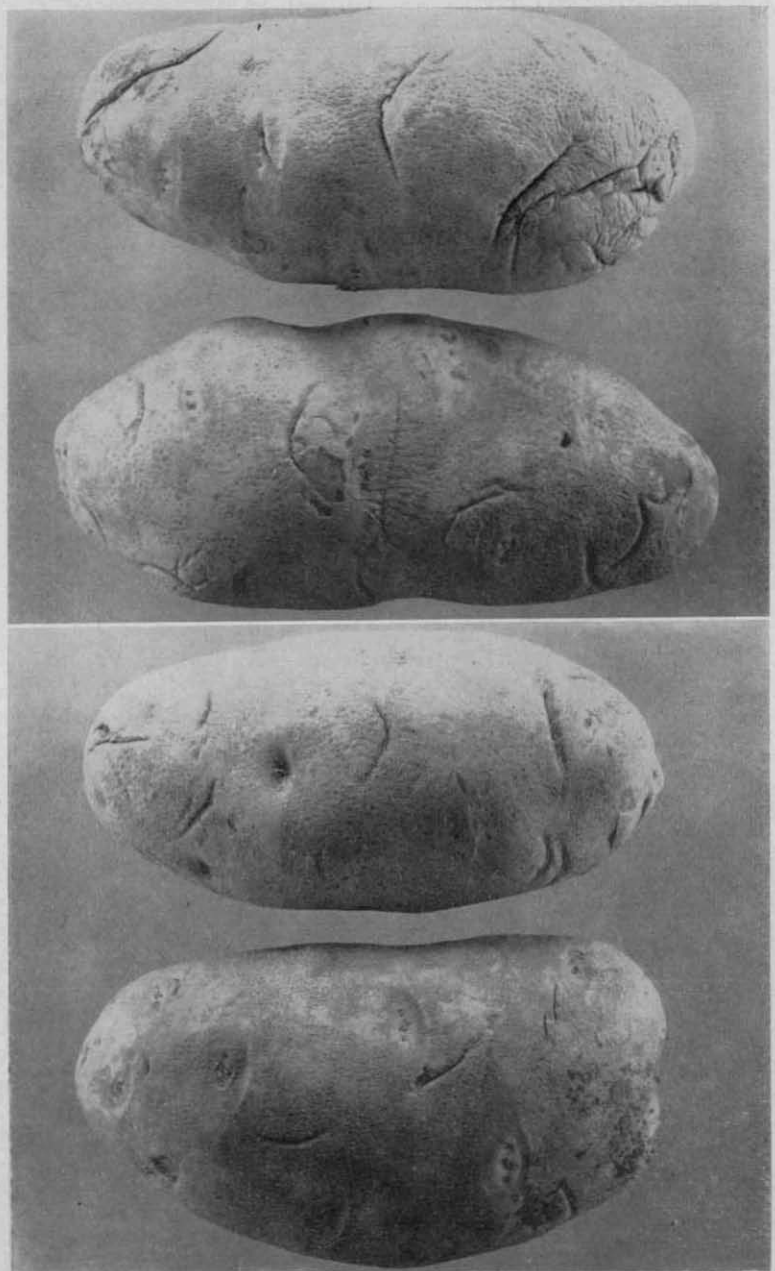

Fig. 1.—B-5. Storage or air checking of Russet Burbank tubers. The marks are often called "thumb-nail" cracks. Shrinkage accompanies this injury.

I. SKIN DEFECTS

B. Non-parasitic

5. STORAGE or AIR CHECKING ("thumb-nail" cracks)

CAUSE: Rough handling and excessively dry atmosphere often associated with sudden changes in temperature. Varieties differ greatly in their tendency to crack.

DISTRIBUTION: Rare in storage cellars unless relative humidity is suddenly reduced and tubers are handled roughly. Very common in potatoes on the market, especially in potatoes on display in grocery stores. Bliss Triumph potatoes are unusually subject to this condition.

IMPORTANCE: Very great in regard to appearance and keeping quality of potatoes in stores, and in some cases is confused with ring rot in sorting operations.

SYMPTOMS: Actually, air checking appears similar to the injury caused by pressing a thumb nail directly into the tuber. The surface is covered with many crescent-shaped slits which are sometimes confused with symptoms of ring rot. The tubers dry out rapidly and shrivel unless stored in moist conditions.

CONTROL: 1. Handle tubers carefully.

2. Better methods of handling in display and market storage, including proper humidity.

I. SKIN DEFECTS

B. Non-parasitic

6. GROWTH CRACKS

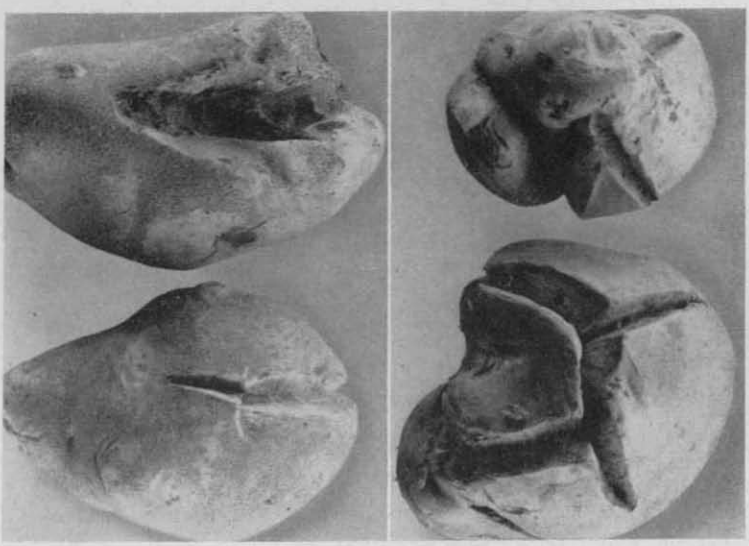

Fig. I.—B-6. Growth cracks on Russet Burbank (left) and Bliss Triumph (right).

CAUSE: Uneven or sudden changes in growing conditions. Due, in part, to individual tuber environment or varietal characteristics and possibly in some cases to virus.

DISTRIBUTION: General.

IMPORTANCE: Usually minor. More important in Bliss Triumph and Pontiac than in Russet Burbank. Most round white varieties are not seriously affected.

SYMPTOMS: Growth cracks occur most often toward the bud end of the tuber and usually extend lengthwise in the Russet Burbank. The cracks vary in size but usually heal over and no rot follows the injury.

CONTROL: Good stands of multiple-stemmed hills, suitably spaced, accompanied by irrigation and cultural practices to maintain uniform growing conditions throughout the season, will help control this trouble.

I. SKIN DEFECTS

B. Non-parasitic

7. ENLARGED LENTICELS

Fig. I.—B-7. Enlarged lenticels on Russet Burbank tubers. These specks are raised masses of corky tissue surrounding the lenticels. It is sometimes confused with common scab.

CAUSE: Excessive moisture before harvest.

DISTRIBUTION: General; locally at lower ends of the rows or in low, wet places.

IMPORTANCE: Usually minor.

SYMPTOMS: The lenticels or breathing pores on the tuber enlarge and form prominent, corky areas rather evenly distributed over the surface of the tubers. These appear somewhat like common scab but are smaller and lighter in color, sometimes resembling small kernels of popped corn.

CONTROL: Prevent overwatering and provide good field drainage.

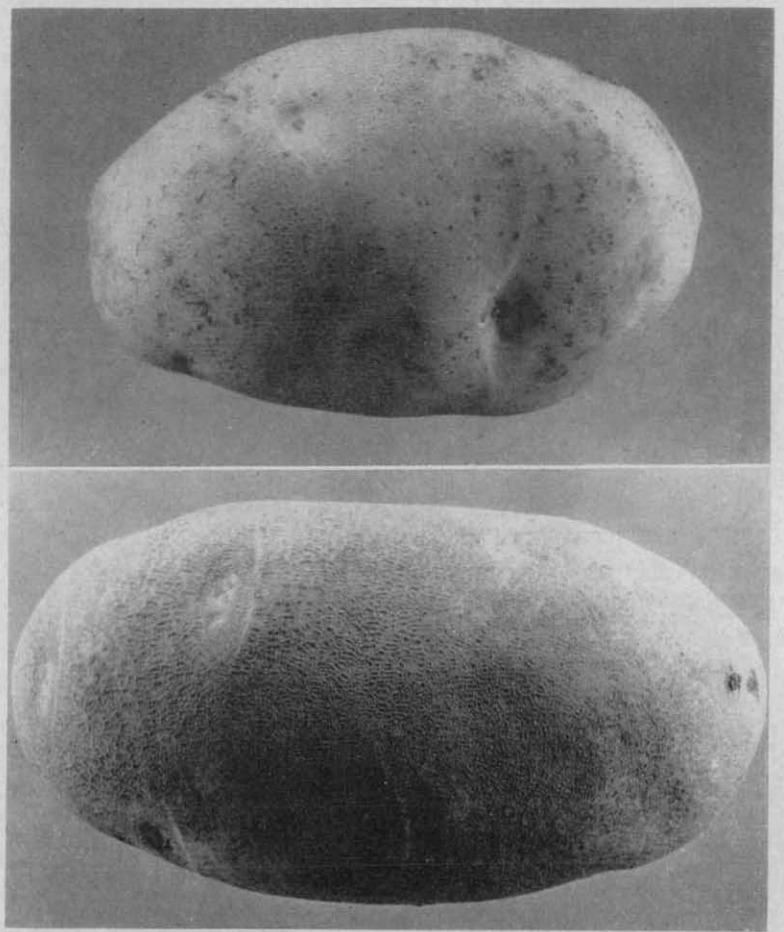

Fig. I.—B-8. Smooth skin on Russet Burbank (above) as compared with normal russeting on tuber (below). Under some conditions, tubers may be more nearly round and smoother than the one shown.

I. SKIN DEFECTS
B. Non-parasitic

8. SMOOTH SKIN (in Russet Burbank)

CAUSES: 1. Various types of abnormal nutrient or pH relationships. Among the most-common of these are:
   a. Excess of nitrogen or potash.
   b. Deficiency of phosphorus.
   c. Effects of soils high in alkali salts.
   d. Effects of strongly acid soils.
2. Sports or mutants.

DISTRIBUTION: General, but particularly in areas of alkali soils.

IMPORTANCE: Considerable; more serious than generally realized.

SYMPTOMS: Those cases of smooth skin in Russet Burbank which are due to abnormal nutrient or pH relationships vary widely in degree of smoothness and may occur on fairly well shaped tubers of any size. When due to alkali soil, tubers may be nearly normal in shape and size but with smooth skins, or they may be small, shaped like Rurals, and perfectly smooth skinned. The change in type, size, shape of tuber, and texture of skin caused by alkali soil conditions is almost unbelievable. Spots in the field may show all stages of this condition. When smoothness is due to sports or mutants, tuber size and shape are normal except that the skin is perfectly smooth and the progeny are similarly smooth skinned. Actual observations and follow-up tests have explained some of the causes regarding the occurrence of smooth skin in Russet Burbank which had previously been puzzling.

CONTROL: 1. Provide adequate and balanced nutrition.
2. Select good seed stocks and eliminate smooth-skinned potatoes from them.
3. Avoid planting on very acid soils or on those high in alkali salts.

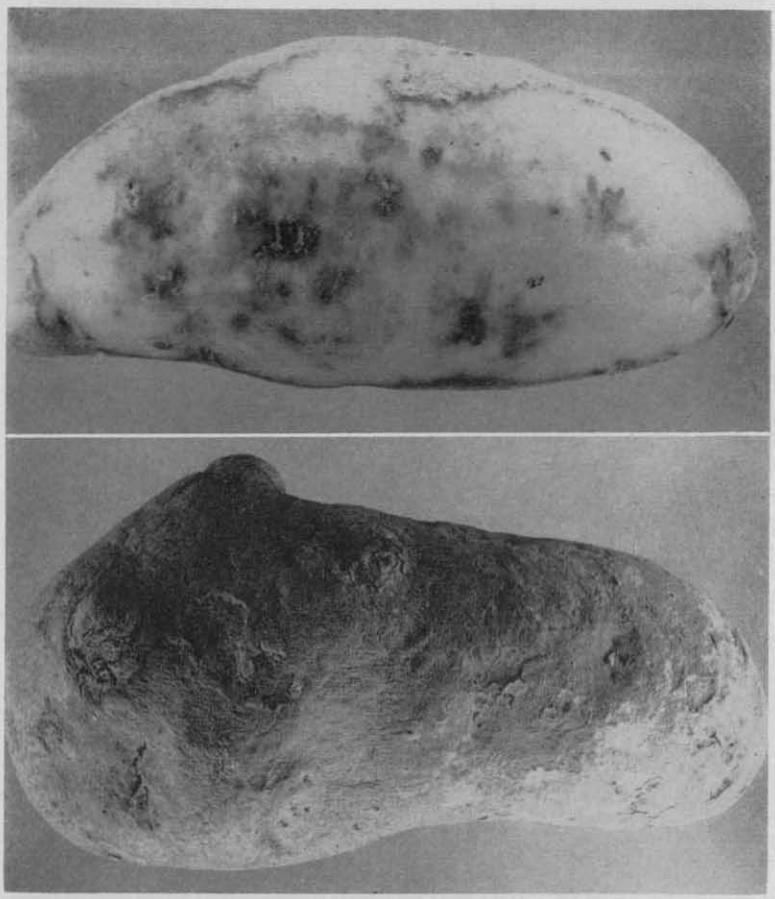

Fig. I.—C-1. Measles on Russet Burbank. The upper tuber is partially peeled to show the reddish-brown discoloration of the affected tissue. In many respects the tissue is similar to that affected with rootknot nematodes (compare with I—A-3).

I. SKIN DEFECTS

C. Miscellaneous

1. MEASLES

CAUSE: Not known. It has been suggested that measles may be due to slight field frost, that it is a phase of heat necrosis, or that it is a phase of water rot. None of these theories seems to apply to all cases, although each theory may be partially correct. No parasitic organism seems to be consistently associated with the symptoms.

DISTRIBUTION: Several locations in southern Idaho and also observed in the Yakima Valley of Washington.

IMPORTANCE: Serious when it occurs. In some cases it is a definite grade defect.

SYMPTOMS: The first symptoms noted are a rough, scaly skin and a dull, lifeless appearance of affected tubers. There may be a tan-colored area, usually around the lenticels, which enlarges and extends into the tuber, forming pockets of pink or brown tissue. In many respects the affected inner tissue appears like rootknot nematode injury. Later in storage the affected tissue may become darker, almost black, and appear as raised or puffy areas which finally resemble black rot and end in complete breakdown of tubers.

CONTROL: No control measures are known.

Fig. I.—C-2. False "nematode rot" on Russet Burbank, showing the skin checking (above) and the unaffected tissue of cut tubers (below). (Contrast with III—A-10.)

I. SKIN DEFECTS

C. Miscellaneous

2. FALSE "NEMATODE ROT"

CAUSE: Unknown. It is associated with heavy, cloddy soil where excessive moisture has occurred.

DISTRIBUTION: Scattered. It occurs in spots or areas of a field and occasionally may be fairly extensive.

IMPORTANCE: Minor, except from the standpoint of confusion with potato rot nematode injury and possibly with ring rot.

SYMPTOMS: This defect resembles potato rot nematode injury, since the external symptoms are almost identical. The skin is checked, and small cracks, holes, and scaly areas are found on the tubers. It differs from nematode injury in that no chalky or starchy areas are found in the tissue under the scaly surface, but the tuber is quite solid and no nematodes are present.

CONTROL: No control measures are known.

I. SKIN DEFECTS
C. Miscellaneous

3. SKIN CRACKING

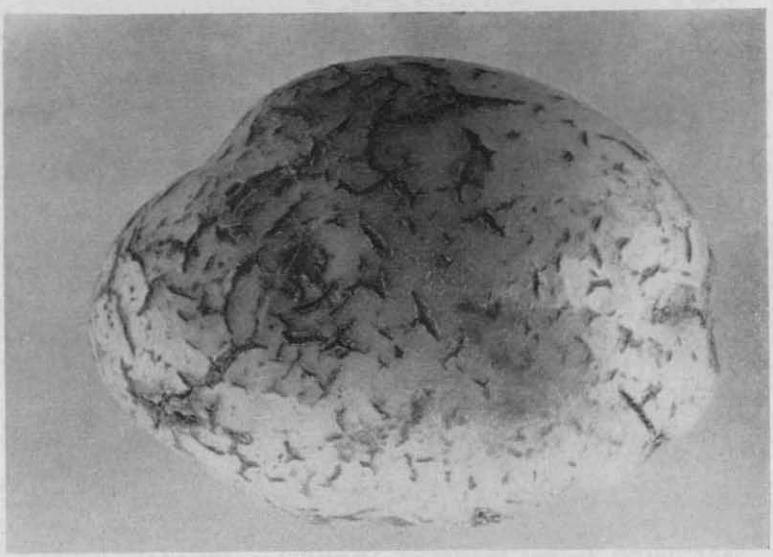

Fig. I.—C-3. Skin cracking on Chippewa. (Also common on White Rose.)

CAUSE: Unknown.

DISTRIBUTION: Scattered.

IMPORTANCE: Probably minor. However, some lots show appreciable damage to their appearance.

SYMPTOMS: The skin of the tubers shows a few to many rather short narrow cracks over a small portion or perhaps the entire tuber. No rot appears to be involved and no tissue changes are apparent. It is different, however, from any other type of skin cracking observed.

CONTROL: No control measures are known.

I. SKIN DEFECTS

C. Miscellaneous

4. RING SPOT

Fig. I.—C-4. Ring spot on Chippewa. Note the concentric zones of the spots.

CAUSE: Unknown.

DISTRIBUTION: Noted at Moscow, Idaho, on Chippewa in 1944, and reported to occur also at Pullman, Washington.

IMPORTANCE: Minor.

SYMPTOMS: Small to large generally round spots develop concentric rings on the surface of the tubers. The margins are clear-cut and the spots are slightly depressed. The tissue is tan to brown in color and does not extend deeply into the tuber. Although the final course of the disease is not known, the spots often enlarge and the tubers shrivel severely.

CONTROL: No control measures are known.

I. SKIN DEFECTS

C. Miscellaneous

5. ELEPHANT HIDE

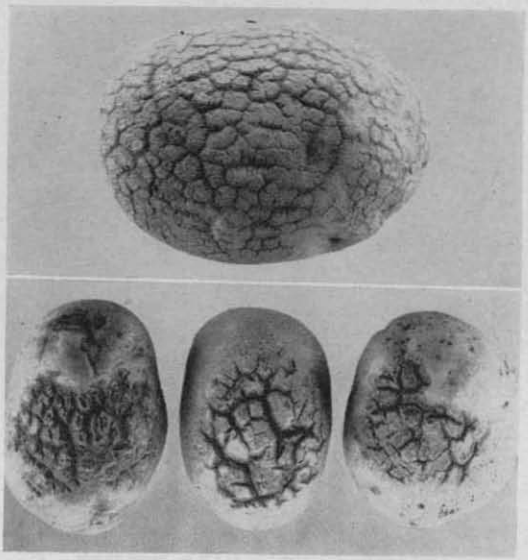

Fig. I.—C-5. Elephant hide on Russet Burbank. The upper tuber is affected over the entire surface.

CAUSE: Unknown. This particular type of condition, according to tests conducted in 1945, is not perpetuated through the stock. It is probably due to environmental factors such as contact with decaying organic matter or possibly with fertilizer or soil salts.

DISTRIBUTION: Occasional specimens throughout areas where Russet Burbank is grown.

IMPORTANCE: Minor, although affected tubers are discarded as culls.

SYMPTOMS: Portions or the entire surface of some tubers show very coarse netting or furrowing of the outer skin. The extreme cases make it difficult to understand how such a wide deviation from normal netting could be produced so locally by external factors.

CONTROL: Unknown.

I. SKIN DEFECTS

C. Miscellaneous

6. DIMPLE SKIN (pitting or pox)

Fig. I.—C-6. Dimple skin on Russet Burbank, showing the smooth-surfaced pits or pox.

CAUSE: Unknown.

DISTRIBUTION: Scattered.

IMPORTANCE: Minor.

SYMPTOMS: The surface of infected tubers looks as if portions of tissue had been neatly gouged out, leaving many small depressions resembling the surface markings of a golf ball. Only part of the tuber is affected.

CONTROL: No control measures are known.

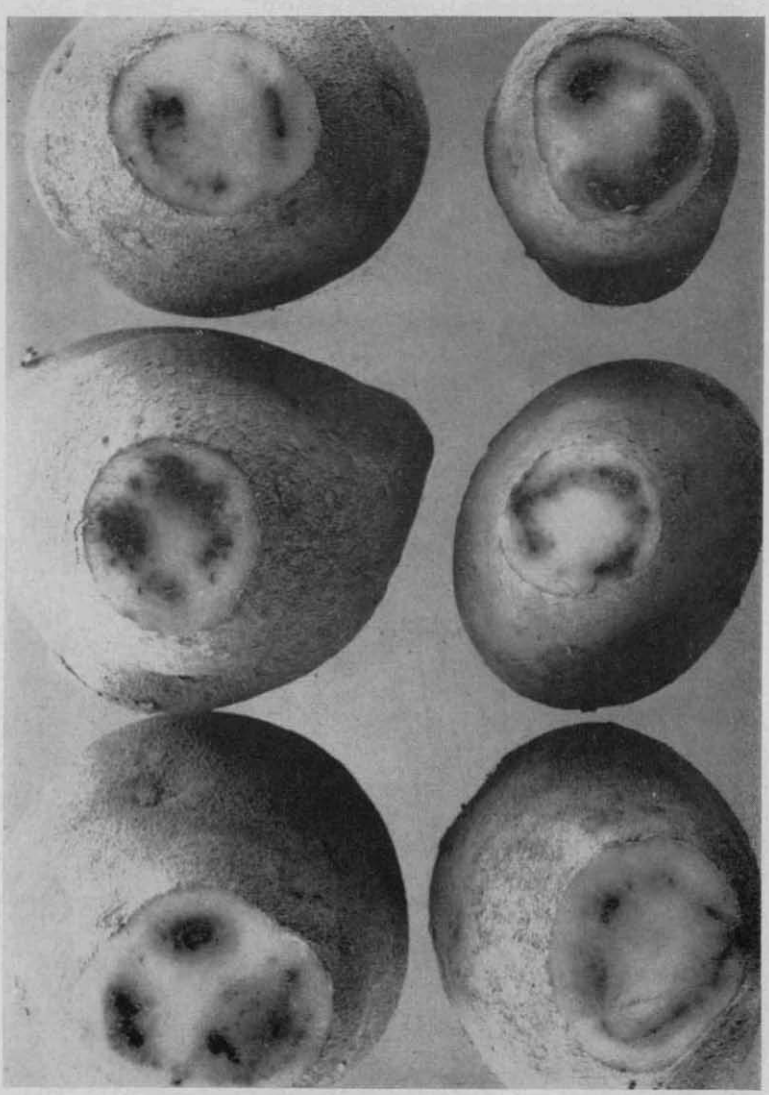

Fig. II.—1. Vascular discoloration in Russet Burbank tubers, showing various degrees of injury. It is believed that this type is more or less characteristic of injury by fungi. (Compare with II—2.)

II. TISSUE DEFECTS

1. VASCULAR DISCOLORATION (primarily fungous)

CAUSAL ORGANISMS: 1. *Fusarium oxysporum* Schlecht. and probably other organisms.

2. *Verticillium albo-atrum* Reinke and Berth.

In addition, it has been claimed that certain non-parasitic factors and a virus which produces stem-end browning are sometimes involved. Chemical vine killers may produce similar symptoms.

DISTRIBUTION: General, though spotted in regard to severity.

IMPORTANCE: Considerable.

SYMPTOMS: In vascular discoloration caused by *F. oxysporum* or *V. albo-atrum* there is a slight discoloration of tissue below the stem end of affected tubers. Discoloration of the vascular ring appears as a slight netting or in some cases a severe, brown-colored streaking in part or all of the vascular ring, sometimes extending nearly to the bud end of the tuber. Apparently no rot develops unless other organisms enter. This injury is often spoken of as *Fusarium* wilt.

Of special interest is the fact that during the survey, a rather small amount of typical *F. oxysporum* type of discoloration in tubers could be found. Several lots grown on the Egan bench (Upper Snake River Valley), where *Fusarium* wilt (early dying) has been regarded as common and serious, were examined and only rarely did vascular discoloration of any type occur. The observation raises the pertinent question as to whether *Fusarium* spp. is really the cause of so much premature dying of vines as has been thought. Recent evidence points to *V. albo-atrum* as a causal agent of early dying. On the other hand, it is agreed that some tubers carrying the wilt organisms may not show vascular discoloration and some showing vascular discoloration may be sterile.

CONTROL: 1. Plant clean seed.
2. Use long rotations.
3. Provide an adequate state of soil fertility.
4. Practice good cultural methods.
5. Rogue wilted plants in seed plots.

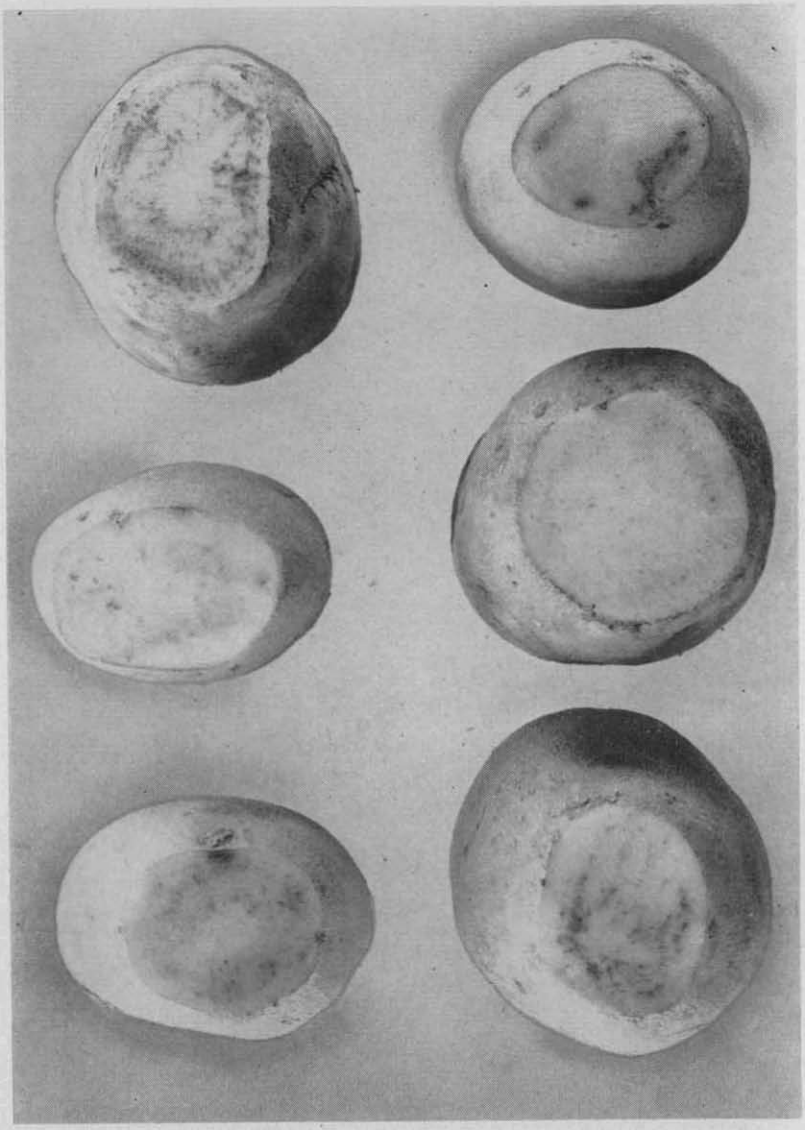

Fig. II.—2. Net necrosis in Russet Burbank tubers, showing different amounts of injury. This type of netting affecting the phloem is believed characteristic of that caused by virus, leaf roll in particular.

II. TISSUE DEFECTS

2. NET NECROSIS (primarily virus)

CAUSE: This discoloration is usually a result of current-season infection with leafroll virus (*Corium solani* Holmes).

DISTRIBUTION: Probably general; occurs in most sections where leafroll spread takes place and susceptible varieties are grown.

IMPORTANCE: Apparently this disease is very much on the increase in the Northwest and has become a serious factor in production and grading.

SYMPTOMS: Tuber shape and external appearance may be perfectly normal and net necrosis is seen only when the tuber is cut. The phloem tissue is more or less filled with a network of fine lines, usually brown in color. This netting may extend only a short distance or throughout the entire potato. Discoloration increases in amount and severity in storage. The finer netting and presence of phloem discoloration differentiates it from the vascular type.

CONTROL:

1. Plant only disease-free seed.
2. Control aphids.
3. Rogue out leafroll plants in seed stocks as soon as can be detected. In commercial stocks, this practice may also prove profitable. Volunteer plants should be destroyed.
4. Plant varieties resistant to net necrosis (White Rose, Katahdin, Sebago).
5. Market infected lots promptly.

II. TISSUE DEFECTS

3. FROST NECROSIS (non-parasitic)

Fig. II.—3. Frost necrosis in Russet Burbank tubers. This type of netting is similar to net necrosis caused by virus, but the strands are more generally distributed throughout the tuber and are often gray in color.

CAUSE: Low temperatures.

DISTRIBUTION: General. Frost necrosis often occurs when potatoes have insufficient protection in cold weather.

IMPORTANCE: Usually minor, but in some lots it is serious.

SYMPTOMS: Injury from frost often appears as a net necrosis of tuber tissue. Fine, dark brown to gray streaks or strands occur in the vascular ring or generally in the tuber in all directions, giving the impression of a network. If the netting is due to frost, there usually will be various stages of breakdown. The discoloration does not disappear and the culinary value is impaired further because these tubers develop an undesirable sweetish taste while stored at low temperatures.

CONTROL: Protect potatoes from temperatures below 32° F.

II. TISSUE DEFECTS

4. HEAT NECROSIS (non-parasitic)

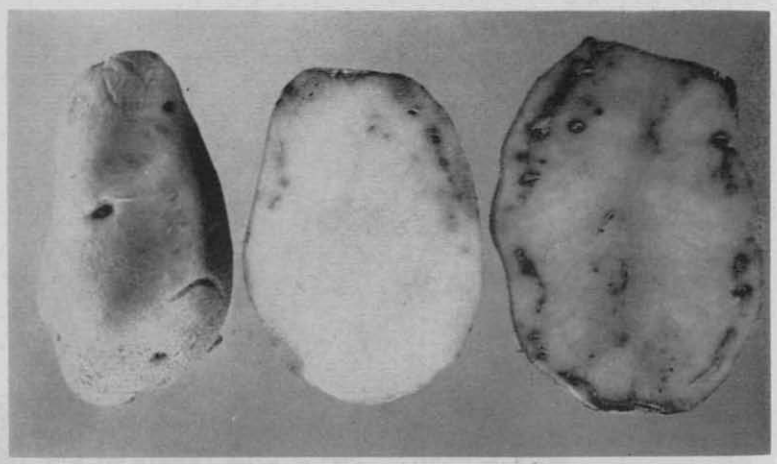

Fig. II.—4. Heat necrosis in White Rose tubers. This injury, although not confined entirely to the vascular ring, is usually closely associated with it and is more blotchy than net necrosis.

CAUSE: High temperatures, especially when vines die early on light, sandy soil.

DISTRIBUTION: Probably confined largely to lower elevations and early-potato sections.

IMPORTANCE: Generally it is minor but in some cases it has accounted for nearly complete loss of crops.

SYMPTOMS: Affected tubers show slate-gray to brown patches in the tissue near and perhaps associated with the vascular system. No true rot develops but the value of the tubers is seriously impaired. There are no external symptoms and diagnosis depends on cutting the tubers.

CONTROL: 1. When possible, harvest the crops shortly after the vines die if grown on a light, sandy soil or where very high temperatures occur.

2. Provide adequate moisture up to digging time.
3. Resistant varieties (Russet Burbank).

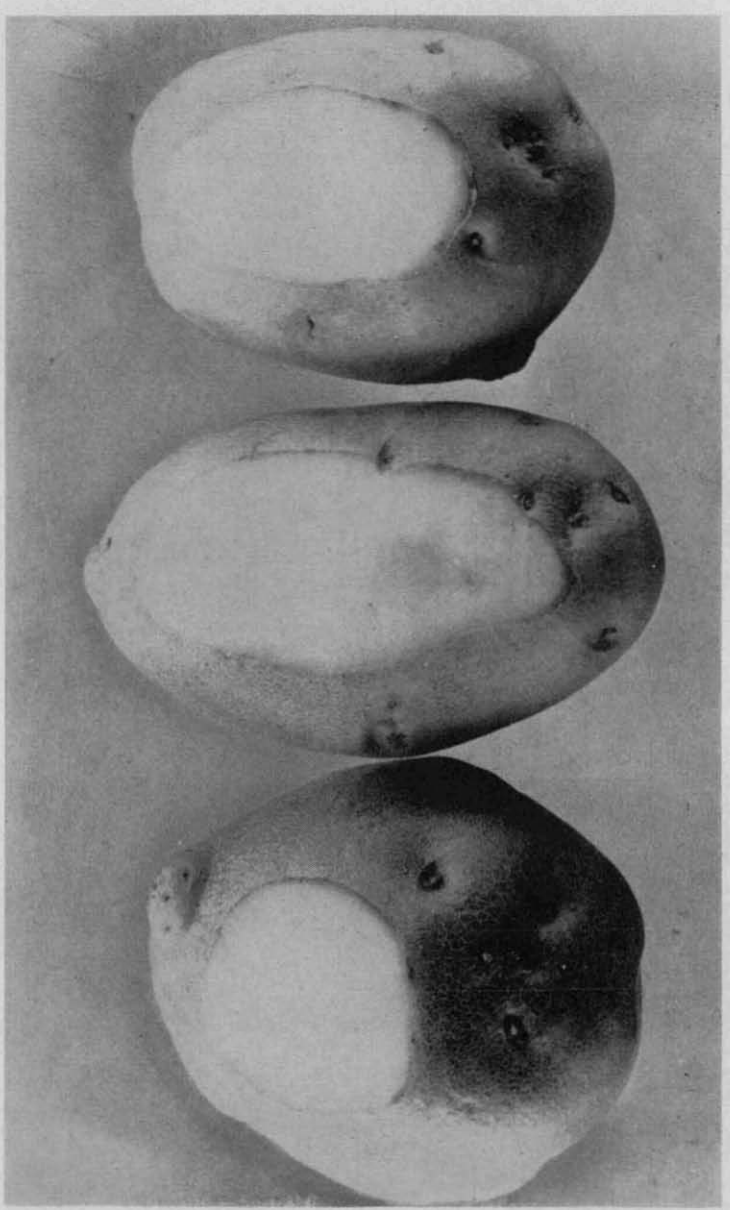

Fig. II.—5. Greening of Russet Burbank tubers. The affected portion, usually an exposed end, becomes a deep green color and the tissue underneath turns green or yellow. The affected tuber has a bitter taste and is classed as a cull even if there is only a trace of green present.

II. TISSUE DEFECTS

5. GREENING (non-parasitic)

CAUSE: 1. Exposure to sunlight in the field before harvest. Too-shallow planting and improper hilling are important contributing factors. *Rhizoctonia* also forces tubers to set near the surface by cutting off stolons and stems; thus exposure is common. Some varieties naturally set tubers near the surface, making them more liable to injury.

2. Exposure of tubers to natural or artificial light either in the cellars or on display.

DISTRIBUTION: General, although some lots are more severely affected than others.

IMPORTANCE: Very serious, as affected tubers are discarded as culls because they are bitter in taste. Only a trace is sufficient cause for rejection, since the whole tuber carries the bitter flavor.

SYMPTOMS: Light to intense green-colored tubers are spoken of as "green heads." Usually the bud end is affected and may involve only a small area or more than half of the tuber. Usually the inner flesh becomes yellow or cream-colored.

CONTROL: 1. Keep tubers covered before harvest by deep planting and proper hilling. In some cases, the fields are rolled to fill in the cracks of the soil. Control of *Rhizoctonia* is important also.

2. Proper size of sets and spacing to produce good stands, and thus prevent extremely large tubers, will lessen the danger of greening.

3. Keep tubers in dark storage and do not leave long on display.

4. Avoid long exposure to electric lights in the cellar or warehouse.

II. TISSUE DEFECTS

7. INTERNAL BROWN SPOT (non-parasitic)

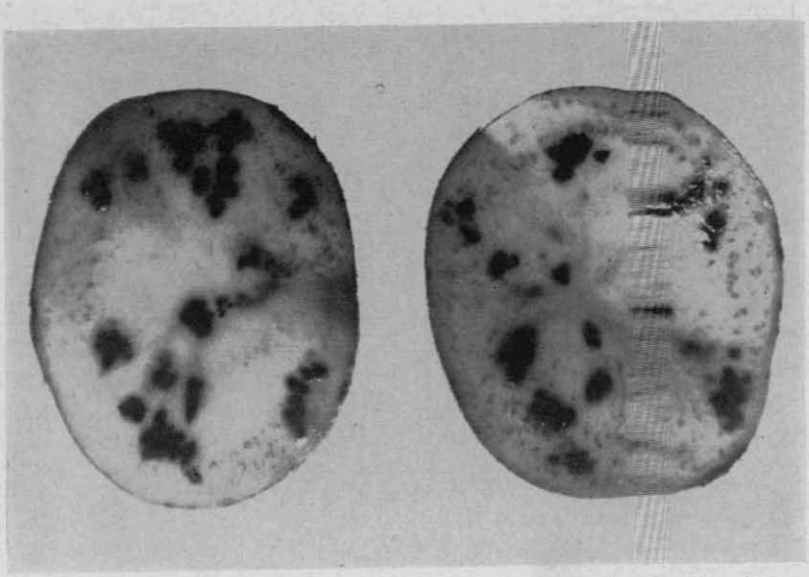

Fig. II.—7. Internal brown spot, showing dead areas within tubers. (Photo by F. D. Heald.)

CAUSE: Probably due to a lack of adequate soil moisture during the latter part of the growing season.

DISTRIBUTION: Scattered, but occurs most frequently in light, sandy soils which are not irrigated regularly.

IMPORTANCE: Usually minor, although a few lots have been seriously affected. Katahdin appears to be especially susceptible to this defect.

SYMPTOMS: No external symptoms are evident. Groups of dead cells which are free from fungi and bacteria appear as irregular, dry, brown, or rust-colored spots scattered through the central portion of the tuber.

CONTROL: Adequate soil moisture is undoubtedly the solution to this problem. Although the trouble is not transmissible, severely affected tubers should not be planted, as they may produce weak plants.

II. TISSUE DEFECTS

8. HOLLOW HEART (non-parasitic)

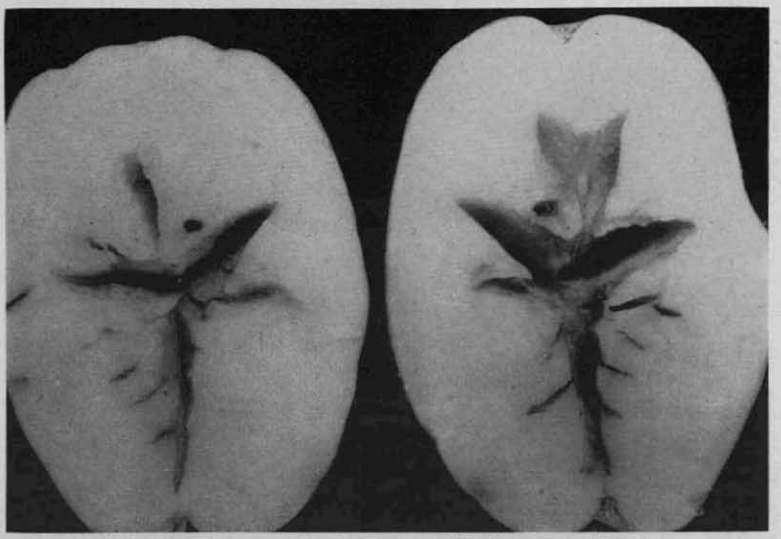

Fig. II.—8. Hollow heart of Russet Burbank. The hollow area may vary widely in size and shape.

CAUSE: Uneven growing conditions in the field.

DISTRIBUTION: General.

IMPORTANCE: Usually minor; however, when present in an appreciable amount it is especially serious, since it is difficult to determine without cutting the tubers. Some varieties (Katahdin, Chippewa, Mohawk) are especially susceptible.

SYMPTOMS: This disease is characterized by tubers showing cavities usually near the center. It is most prevalent in oversize tubers but its presence cannot be determined accurately without cutting.

Frequently the hollow areas are compound and bordered by discolored tissue. If the affected areas extend to the surface, the tubers usually rot during storage.

CONTROL: 1. Close spacing and good stands of multiple-stemmed hills should reduce the amount of hollow heart.

2. Provide uniformly good growing conditions throughout the season.

3. Vines may be killed to reduce oversize tubers.

II. TISSUE DEFECTS

9. BLACK HEART (non-parasitic)

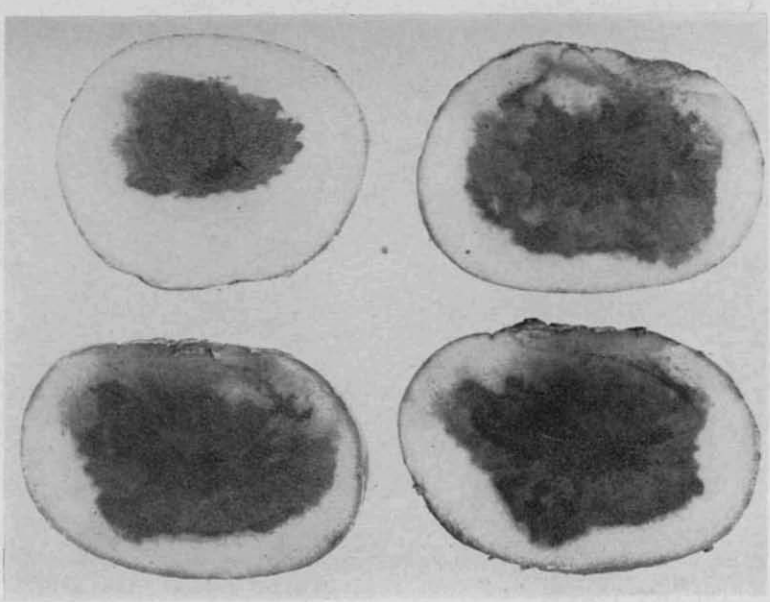

Fig. II.—9. Black heart of potato tuber. (Photo by B. F. Dana.)

CAUSE: High temperatures accompanied by poor aeration. It probably does not occur in the field or in ordinary storage unless artificial heat is supplied.

DISTRIBUTION: Known in refrigerator cars which may be overheated and poorly ventilated.

IMPORTANCE: Minor, except in rare cases where it may result in complete loss.

SYMPTOMS: The center portions of tubers are usually affected most severely. The tissue turns slate gray, then dark, and finally black. In extreme cases, the potatoes break down completely and even when injury is mild the tubers are worthless.

CONTROL: Avoid high temperatures and poor ventilation in storage or transit.

II. TISSUE DEFECTS

10. FLABBINESS

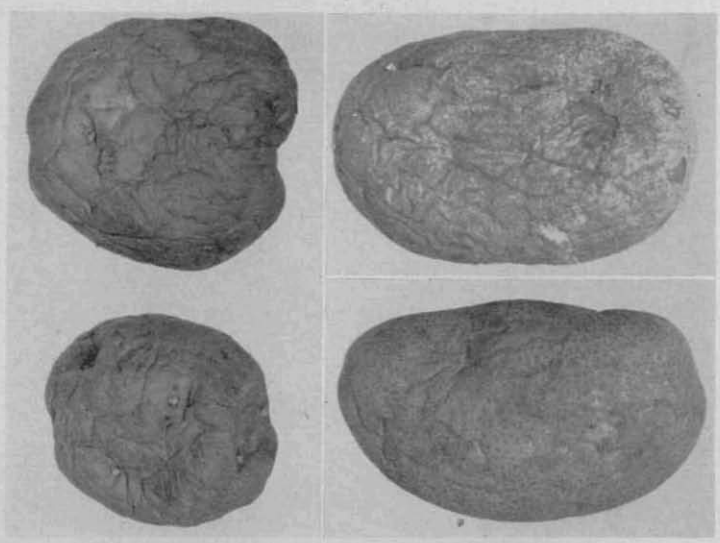

Fig. II.—10. Flabbiness of Bliss Triumph (left) and Russet Burbank (right).

CAUSE: Excessive loss of water from the tuber. Long storage in dry soil or atmosphere, excessive sprout growth, or certain diseases such as purple-top wilt may produce flabby tubers.

DISTRIBUTION: Scattered.

IMPORTANCE: Usually minor, but tubers exhibiting this abnormality are practically worthless.

SYMPTOMS: Potatoes are very wrinkled and shriveled in appearance and rubbery in texture. The skin may or may not be broken.

CONTROL: 1. Provide proper moisture in field and storage.
2. Control leafhoppers which transmit purple-top wilt.

Fig. III.—A-1. Black rot on Russet Burbank. The upper photo shows the infection having entered an injury caused by a broken-off knob. The lower photo shows the extent of tissue invasion in the same tuber.

III. ROTS

A. Parasitic

1. BLACK ROT (fungous)

CAUSAL ORGANISM: *Fusarium sambucinum f. 6.* Wollenw.
F. coeruleum (Lib.) Sacc.
F. flocciferum (Cda.) and possibly others.

The exact nomenclature of the *Fusarium* spp. involved is not known.

DISTRIBUTION: General.

IMPORTANCE: Slight to very serious. *This is regarded as the most common and severe type of storage rot and is a very important factor in seed-piece decay.*

SYMPTOMS: Wide variations in color and consistency of decayed tissue occur, probably due to various factors, particularly temperature. Typically, black rot is characterized by moist, firm, discolored tissue beneath an injury, such as a cut, a bruise, or where a knob has been broken off. It may also gain entrance through lenticels anywhere on the tuber. Superficially it is slightly sunken but the extent of the decay cannot be judged from the surface. Black rot frequently follows the vascular tissue but may extend in long blotches or pockets or break out to the surface. The color of the rot may be affected by the temperature at which it develops. At temperatures around 70° F., the rot is light brown, whereas at colder storage, the color is darker, usually black. In late storage, masses of fungus growth with a black, blue, or violet color appear on the surface, somewhat resembling small *Rhizoctonia* sclerotia. There is good evidence that black rot may result in a condition commonly spoken of as shell rot, depending on how the rot progresses inside the tuber. In scalded tubers, black rot is very common and often produces a wet rot, especially at the bud end of immature tubers. The tissue color is brownish yellow, rather than black.

CONTROL: 1. *Avoid bruises or injuries in harvesting or handling.*
2. Store at low temperature and moderate relative humidity.
3. Provide good ventilation in storage.
4. Plant single drops (whole tubers) to minimize seed-piece decay.

Fig. III.—A-2. Powdery dry rot on Russet Burbank, showing various stages of infection. The lower tubers are covered with pinkish-white spore masses on dry, rotted tissue.

III. ROTS

A. Parasitic

2. POWDERY DRY ROT (fungous)

CAUSAL ORGANISM: *Fusarium tricotheceoides* Wollenw. and possibly other *Fusarium* spp.

DISTRIBUTION: General, although principally in areas with warm, dry summers. More serious in western than in eastern states.

IMPORTANCE: Slight to very serious.

SYMPTOMS: Sunken, shriveled areas filled with powdery, dry, decayed tissue are characteristic. Frequently the surface and cavities in the tuber are covered and filled with masses of pink fungus mycelium and spores. The rot, mostly gray in color, may progress rapidly, finally leaving the whole tuber a light, punky mummy. The decay generally starts at a cut, bruise, or other injury, but sometimes apparently from the point of stem attachment.

CONTROL: 1. Prevent injury, such as bruises and cuts, to the tubers.
2. Store under conditions of low temperature, good ventilation, and moderate relative humidity.

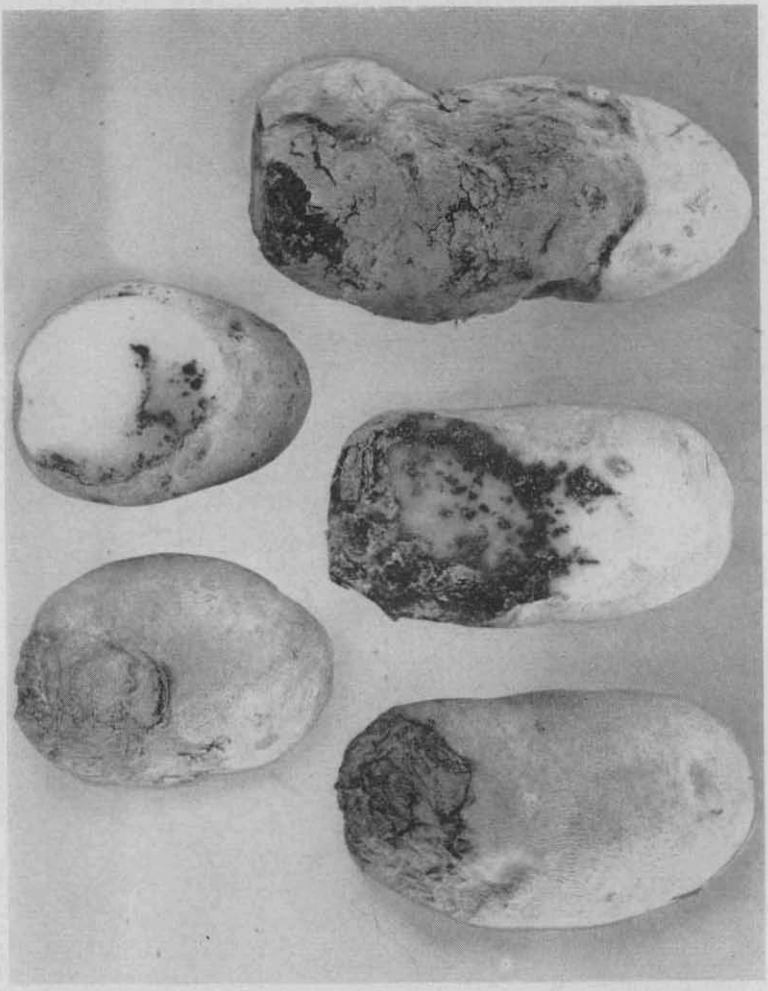

Fig. III.—A-3. Side rot on Russet Burbank. The decayed tissue is quite firm and dry and often follows the vascular ring.

III. ROTS

A. Parasitic

3. SIDE ROT (fungous)

CAUSAL ORGANISM: *Fusarium eumartii* Carp.

DISTRIBUTION: Probably quite general.

IMPORTANCE: Considerable.

SYMPTOMS: The rot is firm, rather dry and granular in consistency, and follows the vascular tissue primarily, although frequently the rot extends to the surface and causes darkening and death of the eyes. Infection seems to occur principally through the stolon scar and may in the early stages be confused with jelly-end rot because the tissue shrivels similarly. It may enter through the side or extend down over the shoulder of the tubers, giving rise to the term "side rot." Frequently only one side of the vascular ring shows infection. This rot is very active, being severe and extensive in its development. In time the whole tuber is destroyed and becomes a mummy.

CONTROL:
1. Plant clean seed.
2. Use long rotations.
3. Store at cool temperatures with moderate relative humidity.

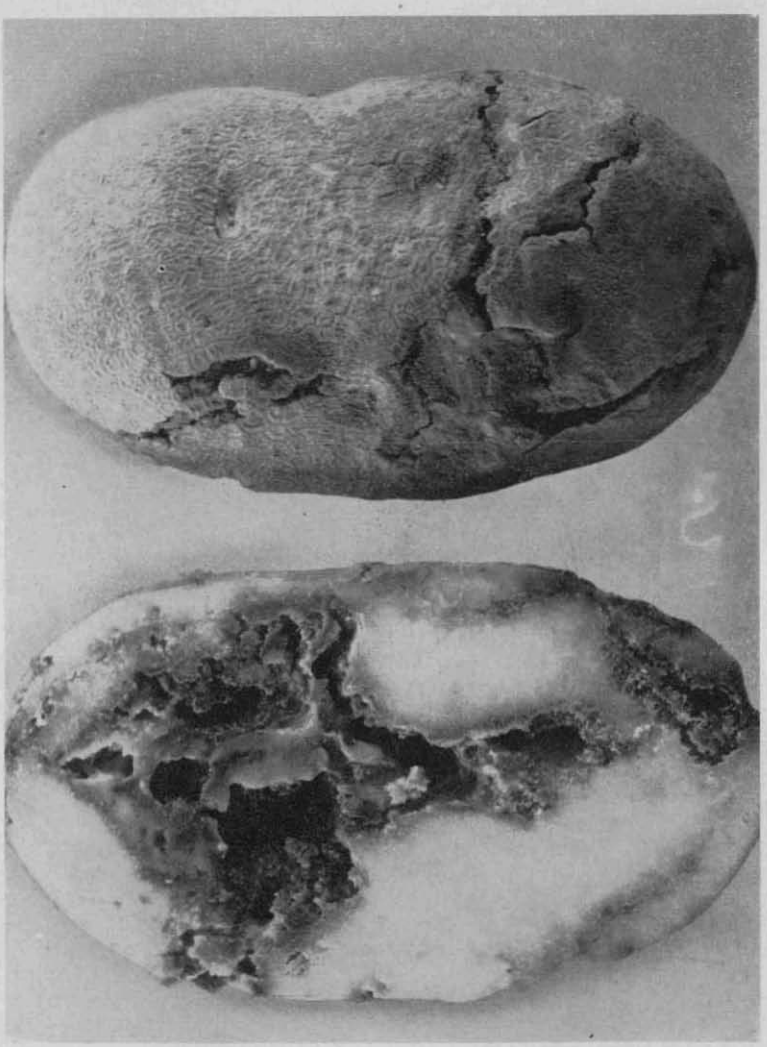

Fig. III.—A-4. Ring rot on Russet Burbank, showing the external and internal symptoms. Note skin-cracking (above) and the tendency of the rot to follow the vascular ring (below).

III. ROTS

A. Parasitic

4. RING ROT (bacterial)

CAUSAL ORGANISM: *Corynebacterium sepedonicum* (Spieck. and Kotth.) Skapt. and Burk.

DISTRIBUTION: General. Present in varying amounts in nearly all potato-growing areas.

IMPORTANCE: Extremely serious in certified seed production, since only a trace disqualifies a whole field from certification. Serious in commercial stock not only from possible extensive loss but from danger of contamination of seed stock, since the disease is highly infectious.

SYMPTOMS: Infected tubers very frequently show skin checking and have a dull, lifeless appearance much as if they had been baked. In early stages it is impossible to note infection and only by cutting the stem end, where slight vascular discoloration occurs, and by laboratory technic can identification be certain. In later stages the infected tubers may become light shells which crush easily showing a soft, watery rot in the center due principally to the action of other organisms. If the stem end is cut from a tuber which is still fairly solid, pressure on the sides may force pieces of soft decayed tissue and masses of organisms out of the vascular ring much as pus out of a sore. In advanced cases tubers finally disintegrate completely. Most of the severely affected tubers do not reach storage but are occasionally found there. If storage conditions and temperatures are proper, probably little change takes place in amount of decay. Otherwise the rot advances and is classed as wet rot. In early-dug potatoes that carry ring rot, proper sorting and grading is impossible as mild cases will escape detection and will usually break down later.

CONTROL: 1. *Use only disease-free seed.*

2. Use only new or disinfected containers for handling seed.
3. Plant single drops or disinfect cutting knives with boiling water or other effective disinfectant.
4. Spray storage quarters and equipment with copper sulfate or other effective chemical, and practice strict sanitation.

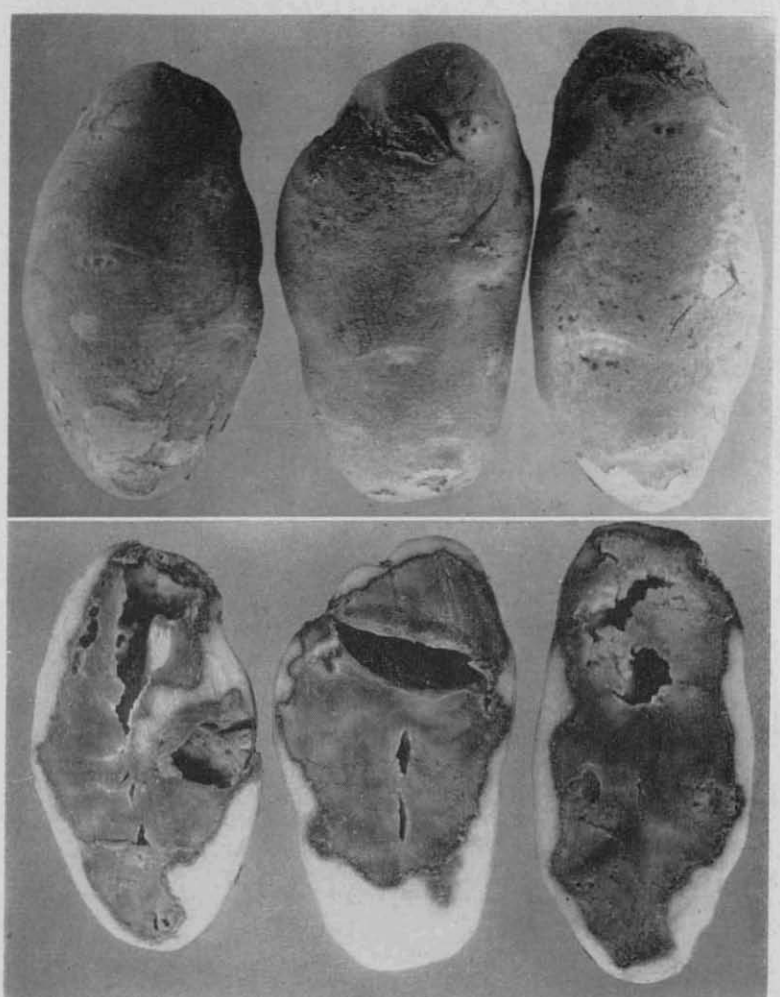

Fig. III.—A-5. Leak on Russet Burbank. The lower tubers are the same as shown above and indicate the internal condition. The rot is brown, jelly-like, and very watery.

III. ROTS

A. Parasitic

5. LEAK (fungous)

CAUSAL ORGANISM: *Pythium debaryanum* Hesse and probably other *Pythium* spp. Some writers claim *Rhizopus* spp. also are involved.

DISTRIBUTION: General, although most damage has been found in the early-potato sections.

IMPORTANCE: This disease is regarded as one of the principal storage rots. It is also often serious in early-shipped potatoes and on immature tubers dug on warm fall days.

SYMPTOMS: Infection apparently starts through cuts or wounds for the most part and there may be little evidence of rot until the whole center is decayed, leaving a shell of cortical tissue. This condition gave rise to the common term of "shell rot." The decayed tissue is typically brown in color and of a uniform texture resembling a soft, watery paste. At high temperatures in early storage or shipment, water may drip from infected tubers in great quantities, creating a condition which is favorable for the development of other rots. The margins of rotted tissues are typically sharply defined and darker brown in color than the rest. It is believed that spread of this fungus from tuber to tuber in storage is not important, but it creates conditions which are favorable for the development of other organisms. There is evidence that potatoes from some fields are more seriously affected than others.

CONTROL:
1. Prevent injury to tubers during harvest.
2. Keep tubers as cool and dry as possible during harvest and loading operations.
3. Store promptly at low temperature and moderate relative humidity.
4. Since the organisms are soil borne, long rotations should be followed.

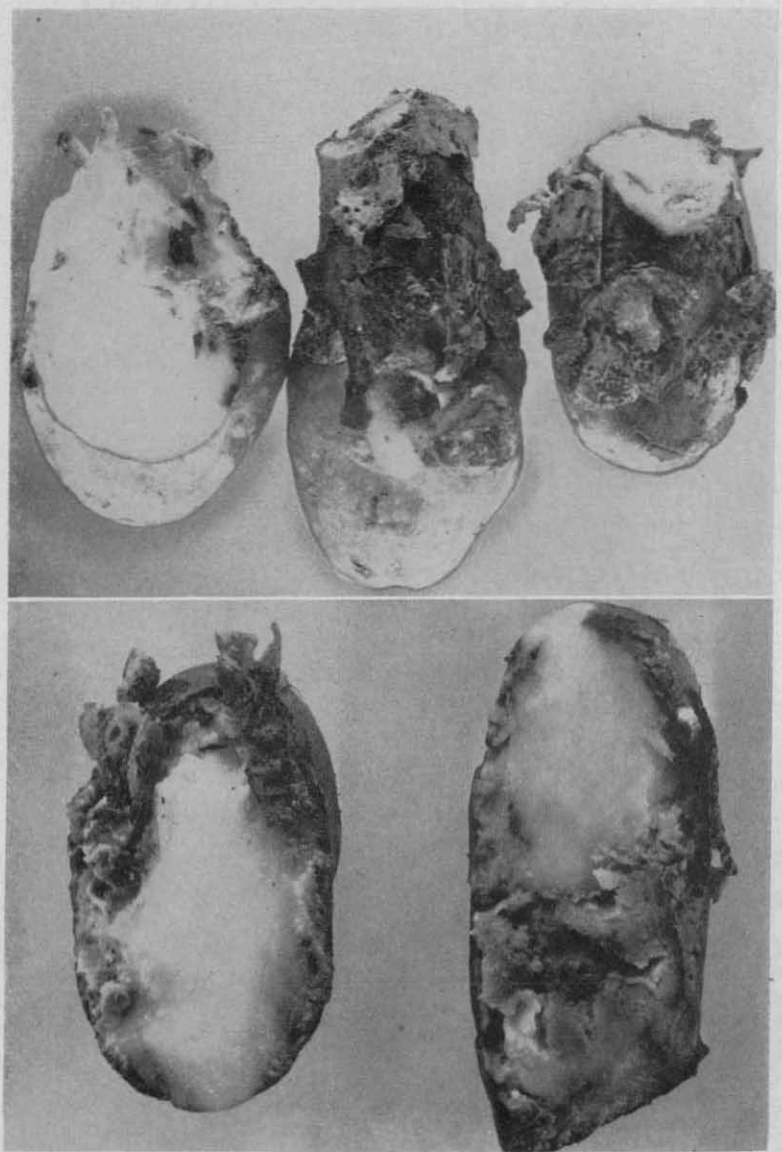

Fig. III.—A-6. Water rot or pink rot on Russet Burbank. The rot is soft and watery, sloughing away easily, and the skin separates readily, exposing a tissue that turns pink.

III. ROTS

A. Parasitic

6. WATER ROT (also known as pink rot) (fungous)

CAUSAL ORGANISM: *Phytophthora erythroseptica* Pethybridge. The fungus becomes an active parasite principally if not entirely under conditions of high soil moisture before harvest.

DISTRIBUTION: Probably general, especially in irrigated sections.

IMPORTANCE: Very serious in portions of certain fields. It appears likely that this disease is very important over a large commercial area, although it varies widely from year to year. In some cases, potatoes in large portions of certain fields were not picked up because of the rot. A concentration of affected tubers in storage bins may cause a rapid breakdown and wet rot, resulting in complete loss.

SYMPTOMS: Typically the external appearance of water rot resembles certain forms of frost injury. The outer tissue near the stem end (in nearly every case examined) shows a black or dark brown, water-soaked appearance, and in early stages the rot extends only a short distance into the tuber. The internal-rotted tissue is a dirty, creamy white at first and seems to be leathery. On exposure to air it turns a pink color, later becoming darker brown with a mushy consistency. The skin on affected tubers slips off easily, exposing dark bodies which are probably the enlarged lenticels. In many cases the outer shell may be sloughed off, exposing a core of apparently unaffected tissue. The rot is very wet and is accompanied by a foul odor of fermentation. The complete breakdown of certain bins leads one to think that the rot spreads in storage. As in the case of leak, this "spread" is much more likely due to the action of secondary organisms which thrive in the wet conditions caused by the original water rot tubers than to *P. erythroseptica* directly.

CONTROL: 1. Prevent excessive moisture in fields, especially late in the season, by limiting length of run and providing good drainage.

2. Do not bring infected tubers into storage.

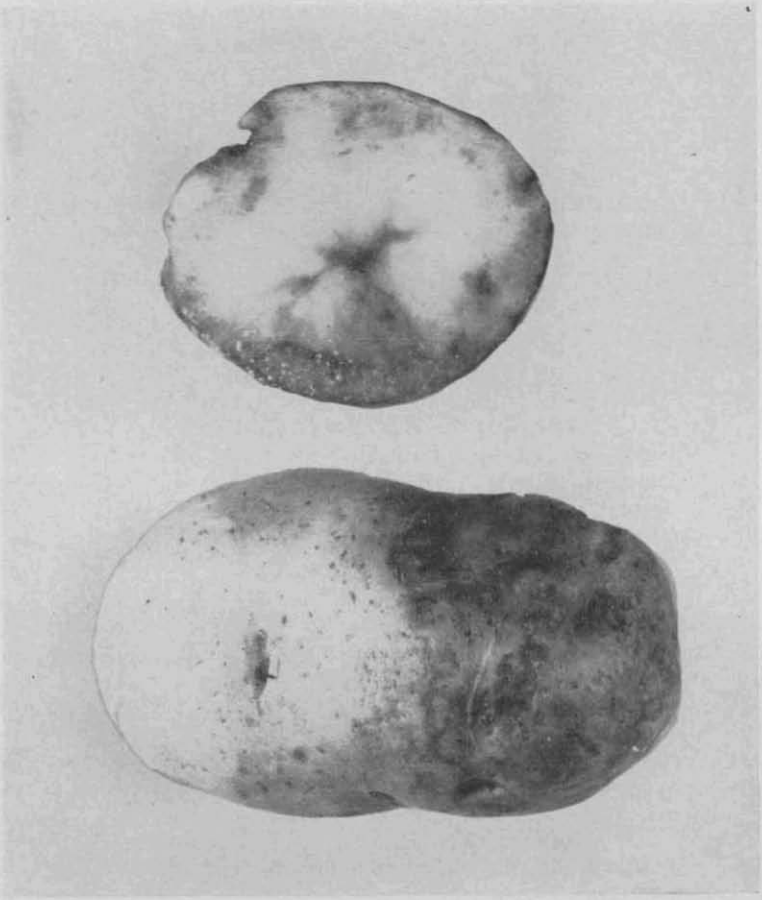

Fig. III.—A-7. Late blight on White Rose. Note the metallic luster of affected skin and the dry rot beneath. (Photo by G. H. Nolen.)

III. ROTS

A. Parasitic

7. LATE BLIGHT (fungous)

CAUSAL ORGANISM: *Phytophthora infestans* (Mont.) DBy.

DISTRIBUTION: Widespread. In America, it is most serious along the Atlantic and Pacific Coasts. Not observed in Idaho. It is occasionally serious in the Yakima Valley and northeastern Washington.

IMPORTANCE: One of the most destructive potato diseases when prevalent.

SYMPTOMS: A dry or wet rot may develop either before or after harvest, depending on environmental conditions and the presence or absence of secondary organisms. At first a brown or purplish-black metallic discoloration of the skin and a reddish-brown discoloration of the tissue just below the skin develops, usually not penetrating more than one-fourth inch. However, secondary organisms may result in a partial or complete breakdown of the affected tuber.

CONTROL:
1. Plant only disease-free seed.
2. Spray or dust with an effective fungicide.
3. Destroy infected tops before harvest.
4. Market promptly or store at low temperatures.
5. Plant resistant varieties, such as Sebago, Sequoia, Glenmeer, Placid, Virgil, Empire, Ashworth, Potomac, Essex, Menominee, Calrose, and Kennebec.

III. ROTS

A. Parasitic

8. EARLY BLIGHT (fungous)

Fig. III.—A-8. Early blight on Russet Burbank. Note small, sunken, dark lesions. (Photo by A. E. Rich.)

CAUSAL ORGANISM: *Macrosporium* [*Alternaria*] *solani* (Ell. and Martin) Sor.

DISTRIBUTION: Scattered. Occurs in irrigated sections as well as in the more humid regions.

IMPORTANCE: Often severe on foliage, but usually minor on tubers.

SYMPTOMS: Small, shallow, decayed spots on surface of tuber, the margins of which are raised and slightly puckered. Secondary rot organisms may gain entrance through lesions.

CONTROL: 1. Thorough spraying with bordeaux mixture or some other good fungicide may be desirable if the disease is severe.

2. Store at low temperatures.

III. ROTS

A. Parasitic

9. SOFT ROT (bacterial)

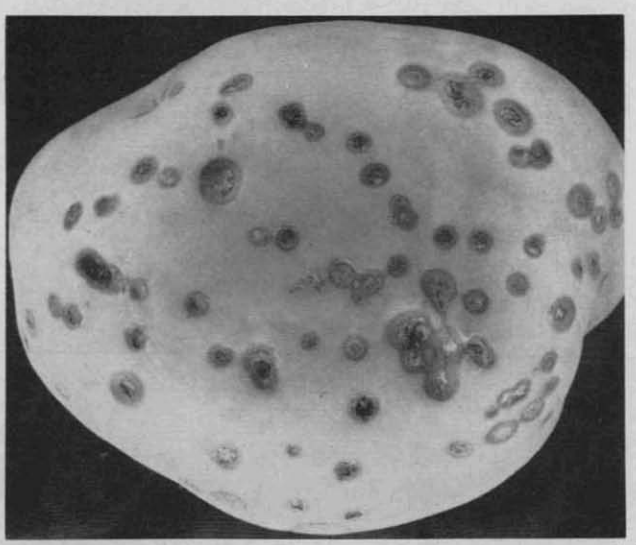

Fig. III.—A-9. Soft rot on Chippewa, illustrating the entrance of the bacterial infection through the lenticels. (Photo by J. M. Raeder.)

CAUSAL ORGANISM: *Erwinia carotovora* (Jones) Holland.

DISTRIBUTION: Widespread.

IMPORTANCE: This disease is probably of more importance than is realized. Since it is involved in both primary and secondary invasions, the exact damage is not only hard to determine but accurate diagnosis is difficult.

SYMPTOMS: Description of the rot involved is very difficult since it is so closely associated with other rots, both primary and secondary. Tuber infection takes place through wounds or natural openings, such as lenticels. Generally a slimy, foul-smelling, wet rot develops, resulting in the final disintegration of the tuber. This is especially common after frost injury.

CONTROL: 1. Prevent tuber injuries.
2. Provide low temperatures and avoid wet storage conditions.

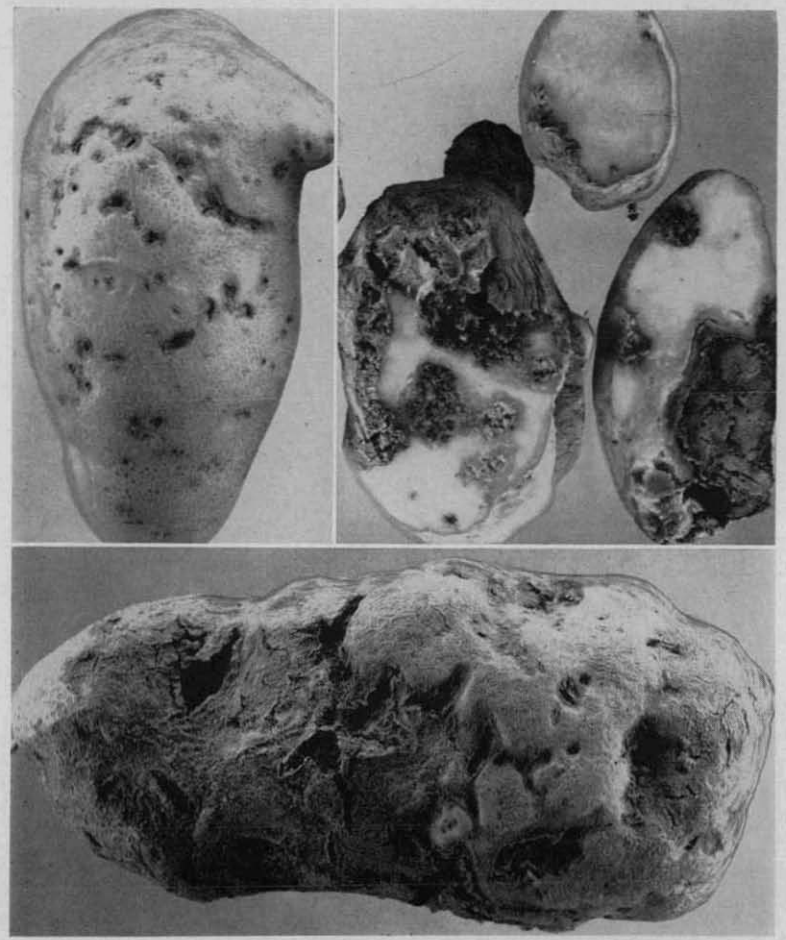

Fig. III.—A-10. Potato rot nematode injury on Russet Burbank. Note the lesions (upper left) varying from pin-point holes to large blotches. In the upper right may be seen the chalky areas in the cut tissue. These contain the nematodes.

III. ROTS

A. Parasitic

10. POTATO ROT NEMATODE (nematode)

CAUSAL ORGANISM: *Ditylenchus destructor* Thorne.

DISTRIBUTION: Known in North America only in a localized area in southern Idaho and in Prince Edward Island, Canada.

IMPORTANCE: With the exception of a few fields, the infestations are little more than traces. The actual loss except in a few cases is decidedly minor. Its real importance is due to the possible danger of spread to other localities.

SYMPTOMS: The first evidence on the tubers resembles pin-point holes with depressed margins. These gradually enlarge as adjacent areas are invaded by the rapidly multiplying nematodes, while the tissues become spongy and the skin checks in ragged cracks. Dry, gray, starchy pockets are found when the tuber is cut or peeled and in these infected areas all stages of the worms from eggs to adults are found. Under particularly high temperatures or near the end of the normal storage season, the lesions may include the entire tuber, ending in a dry rot.

The dry, starchy pockets when properly evaluated are almost infallible in diagnosis. The disease is easily confused with ring rot, late blight rot, certain types of scab, wireworm injury, and, most of all, false "nematode rot."

CONTROL: 1. Cooperate by reporting suspected infestations.
2. Follow closely the instructions of the official control agencies.

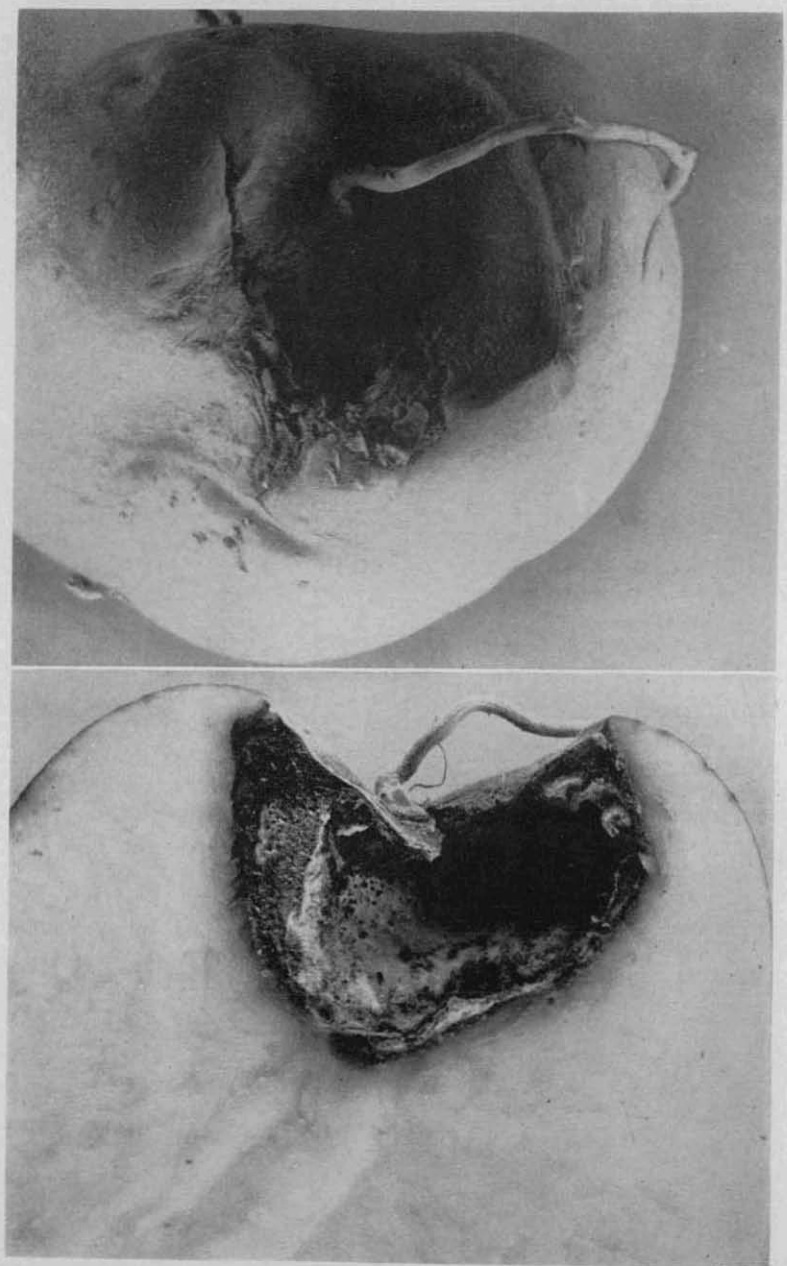

Fig. III.—A-11. Black-leg injury on Bliss Triumph. The rot develops first at the stem end.

III. ROTS

A. Parasitic

11. BLACK LEG (bacterial)

CAUSAL ORGANISM: *Erwinia atroseptica* (van Hall) Jennison.

DISTRIBUTION: General. Most prevalent where cool, moist conditions prevail during growing season.

IMPORTANCE: Slight to serious. Cases have been seen in early potatoes where over 30 per cent of the plants were affected. It is an important disease in certified lots since only a very small percentage is allowed. It is favored by cool, wet weather.

SYMPTOMS: Typically the rot caused by black leg starts at the stem end and appears as slightly sunken, black tissue which eventually extends through the center of the tuber. The rot may be soft and watery or rather dry, leaving a shell rot in certain stages. Black-leg rot may be common in the field and continue to develop in storage, where it may easily be confused with other rots.

CONTROL: 1. Provide low temperatures (40° F.) and avoid wet storage conditions.
2. Plant disease-free seed and handle carefully to prevent drying or heating.
3. Plant single drops (whole tubers).
4. Crop rotation may be helpful.

III. ROTS

A. Parasitic

12. PENICILLIUM ROT (fungous)

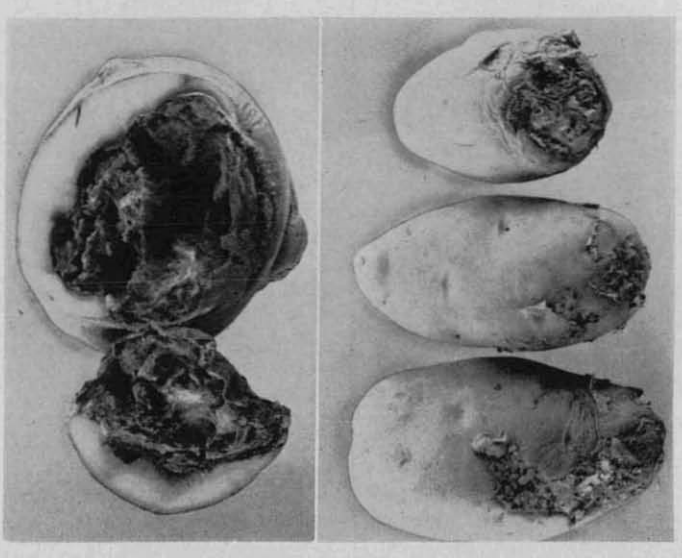

Fig. III.—A-12. *Penicillium* rot on Russet Burbank. The tubers on the right show infection on the feathered and scalded areas while the one on the left shows complete breakdown with bluish-green masses of spores on the rotted tissue.

CAUSAL ORGANISM: *Penicillium* spp.

DISTRIBUTION: Scattered.

IMPORTANCE: Minor.

SYMPTOMS: The rot is characterized by blue-green spore masses on scalded or injured tubers. Apparently these defects provide an entry for the fungus, which is a rather weak parasite. The rotted tissue is moist, rather firm, and has a moldy odor.

CONTROL: 1. Prevent tuber injuries.
2. Dig only mature tubers and provide good ventilation in storage.

III. ROTS

A. Parasitic

13. BOTRYTIS ROT (fungous)

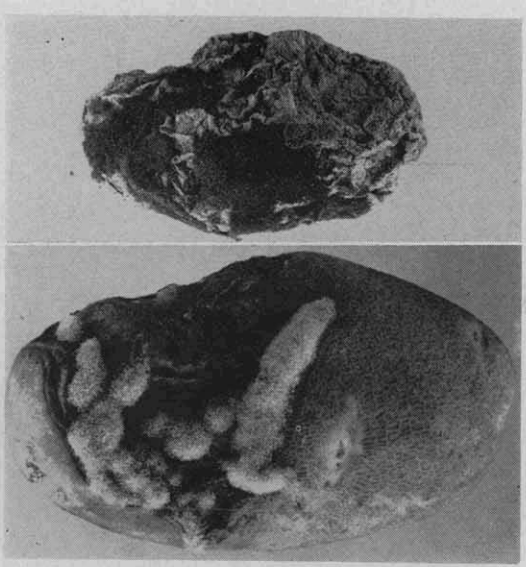

Fig. III.—A-13. *Botrytis* rot on Russet Burbank. The spore masses on the upper tuber are very dark while those on the lower one are gray.

CAUSAL ORGANISM: *Botrytis cinerea* Pers. ex Fr. and B. *vulgaris* Fr.

DISTRIBUTION: Scattered.

IMPORTANCE: Minor.

SYMPTOMS: Tubers affected by *B. cinerea* show a soft, moist rot and shriveling with abundant evidence of the gray, fluffy mass of fungus on rotted areas. Infection seems to take place through injuries. The rot caused by *B. vulgaris* is dry and the spore masses are black instead of gray. It would appear that *Botrytis* rot is not common.

CONTROL: Probably no measures are necessary except to prevent injury to tubers.

III. ROTS

A. Parasitic

14. ARMILLARIA ROT (fungous)

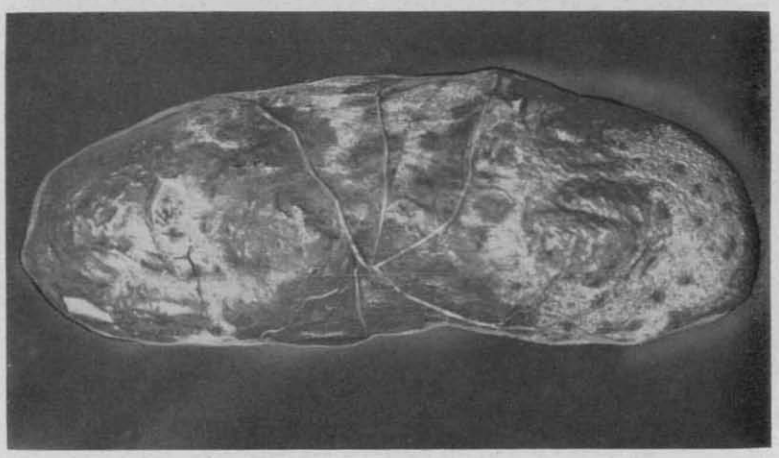

Fig. III.—A-14. *Armillaria* rot on Russet Burbank. Note rope-like strands of mycelium. (Photo by A. E. Rich.)

CAUSAL ORGANISM: *Armillaria mellea* Vahl.

DISTRIBUTION: Coastal areas of Oregon and Washington.

IMPORTANCE: Minor.

SYMPTOMS: Light brown, slightly sunken rotted areas usually connected by a few long black strands of thread-like fungous tissue. The internal rotted portion consists of alternating layers of yellowish and white tissue.

CONTROL: Avoid planting potatoes on newly cleared orchard-land or wood-land.

III. ROTS

A. Parasitic

15. STEM-END HARD ROT (fungous)

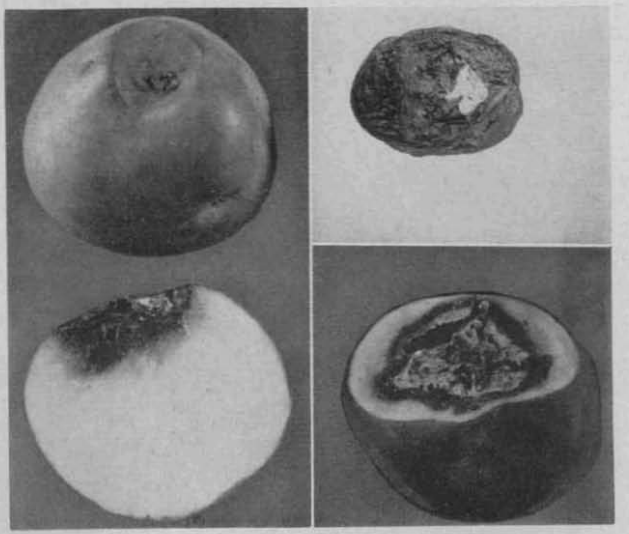

Fig. III.—A-15. Stem-end hard rot. The upper left tuber shows the external appearance at an early stage and the upper right shows an advanced stage. The type and extent of decay are shown in the tubers below. (Photo by W. R. Foster.)

CAUSAL ORGANISM: *Phomopsis tuberivora* Gussow and Foster.

DISTRIBUTION: Reported only from coastal area of British Columbia and Whatcom County, Washington.

IMPORTANCE: Minor, except isolated cases.

SYMPTOMS: A hard, dry, corky rot develops at the stem end. Slightly sunken, circular, brown lesions with gray margins appear on the surface of mature tubers, the lesions varying in size from minute to those involving practically the entire tuber. Small, immature tubers may be completely mummified. When an affected tuber is cut longitudinally, a dark, conical, corky zone, extending toward the center, is observed.

CONTROL: 1. Plant disease-free seed. Seed treatment with mercuric chloride has been reported ineffective.
2. Store potatoes between 35° and 40° F.

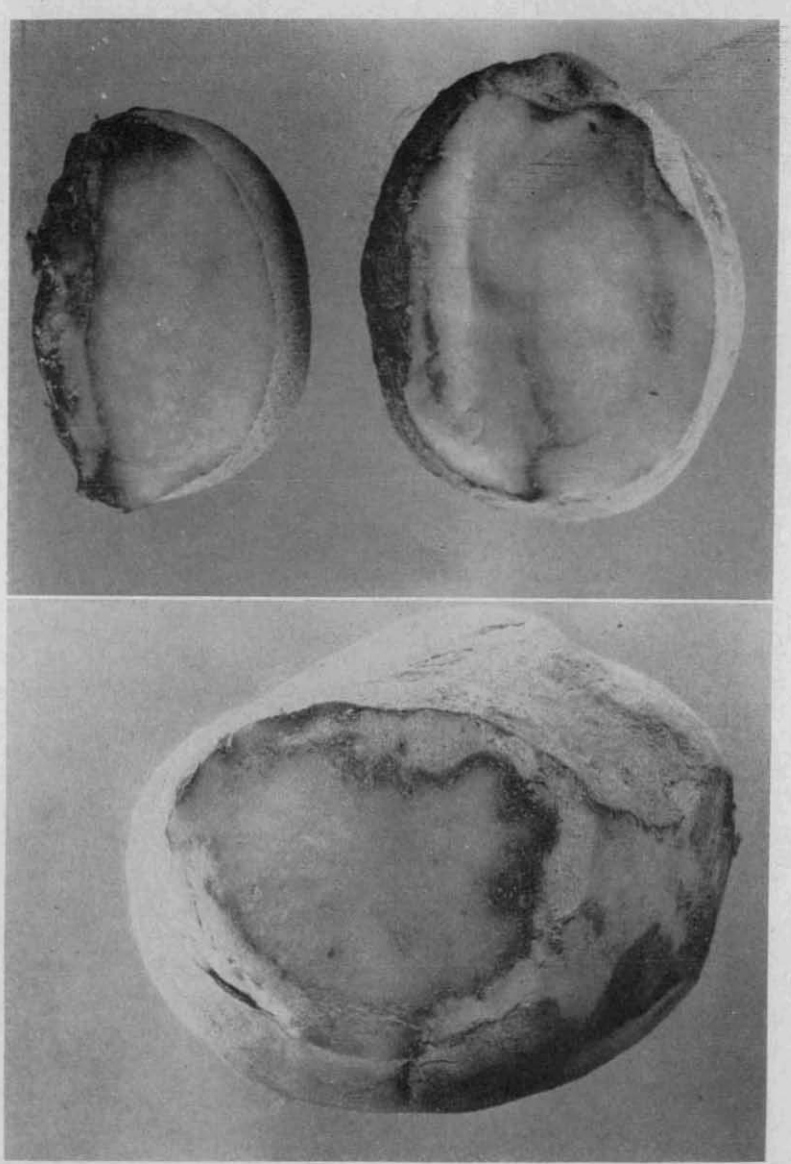

Fig. III.—B-2. Freezing injury on Russet Burbank. The affected tissue shrinks and often becomes hard and chalky, but wide variations occur.

III. ROTS

B. Non-parasitic

2. FREEZING

CAUSE: Low temperatures.

DISTRIBUTION: General, both in field and storage.

IMPORTANCE: Slight to total loss of crops either before or after harvest.

SYMPTOMS: Severe frost damage shows a complete breakdown and watery rot of affected tubers. In some cases, such as field frost, where only portions of tubers are frozen, the damaged tissue later dries up. In this event, the affected portion of the tuber shrivels, becomes dry, gray in color, and extremely hard. In some frosted tubers, dark gray blotches or areas much like those in black heart develop in the internal tissue. Frozen tubers usually break down completely, resulting in a wide variation of symptoms, principally wet rots accompanied by a foul odor.

CONTROL: Measures are more or less self evident and should be followed where possible.

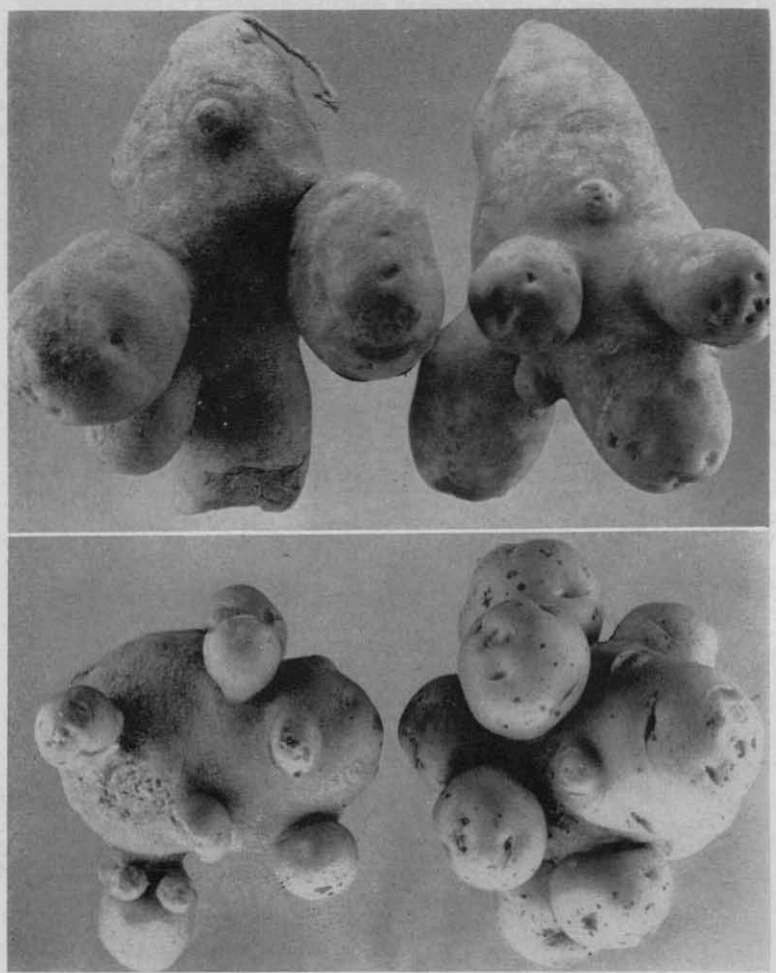

Fig. IV.—1. Knobbiness on Russet Burbank. The tuber at lower left shows knobs which have developed on another.

IV. SHAPE DEFECTS

1. KNOBBINESS (second growth) (primarily non-parasitic)

CAUSES: Various, the most common ones being environmental factors affecting growth, such as fertility, moisture, and other growing conditions. It is not necessarily related to poor seed stock. Poor stands, rank vine growth, and light tuber set tend to produce a crop of knobby tubers. *Rhizoctonia* is often a contributing factor.

DISTRIBUTION: General. Russet Burbank is highly susceptible to this defect.

IMPORTANCE: Very serious. Some indication of loss is seen when some lots will grade about 90 per cent No. 1 tubers and others will not run over 50 per cent.

SYMPTOMS: Knobby potatoes are those showing protuberances of various sizes and shapes attached to a "primary" tuber. Extreme variations are seen, ranging from merely a swollen eye to large, irregular growths consisting of small knobs on larger ones.

CONTROL: 1. Obtain uniform stands of suitably spaced, multiple-stemmed hills.
2. Provide fertility and other cultural practices to maintain uniform growing conditions throughout the season.
3. Control *Rhizoctonia.*
4. Resistant varieties (round types).

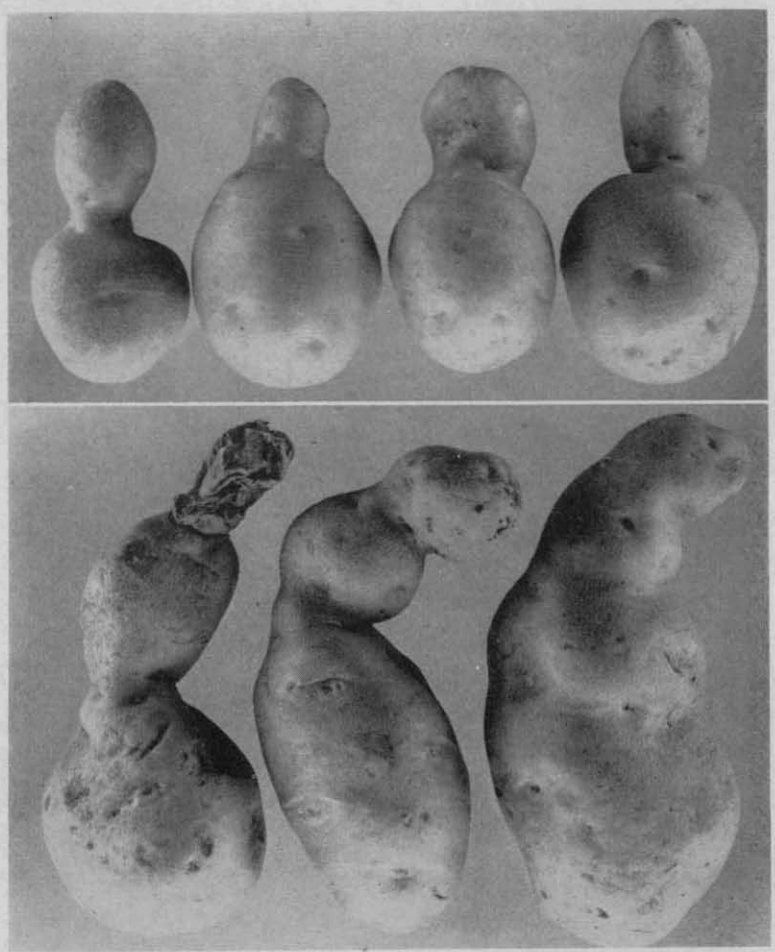

Fig. IV.—2. Bottle neck of Russet Burbank. The upper row shows characteristic bottle-neck tubers while the lower row is typical of dumbbell shapes.

IV. SHAPE DEFECTS

2. BOTTLE NECK (including variations and dumbbell tubers) (non-parasitic)

CAUSES: Environmental factors, principally soil moisture and weather conditions. Balance of nutrients in regard to soil fertility may also be important. The peculiar shapes undoubtedly result from wide variations in rate of tuber development. It is believed that a delay of the first irrigation may cause bottle-neck tubers.

DISTRIBUTION: General, especially in the Russet Burbank variety.

IMPORTANCE: Because of the relation to grade factors, this condition is very important and often accounts for a high percentage of clipped ends. Jelly end usually develops considerably on bottle-necked tubers. In some lots, over 50 per cent of the tubers are bottle necks or possess some similar variation.

SYMPTOMS: As the name suggests, affected tubers have a small stem end and a larger bud end. In some cases, the "necks" are long and narrow and sometimes they are almost like buttons. When there is a constriction near the middle of the tuber, a dumbbell shape is developed.

CONTROL: 1. Provide adequate, uniform soil moisture throughout the growing season.
2. Provide a suitable level and balance of soil fertility.
3. Round varieties are not commonly affected.

Fig. IV.—3. Pointed tubers of Russet Burbank. The upper specimens illustrate small bud ends while the lower ones show small stem ends. Two of the lower potatoes are affected with jelly end, a common occurrence on tubers of this type. (See III—B-1.)

IV. SHAPE DEFECTS

3. POINTED TUBERS (non-parasitic)

CAUSES: Probably uneven growing conditions influenced by soil moisture, fertility, and weather. If good growing conditions follow very poor ones, it is assumed that the tubers may develop pointed stem ends. On the other hand, tubers with pointed bud ends may form if poor growing conditions follow favorable ones. It is believed that withholding the first irrigagation too long has a tendency to form many pointed (stem end) and bottle-neck tubers. The spindle tuber virus may also be a factor.

DISTRIBUTION: General, where long varieties are grown.

IMPORTANCE: The importance is probably directly correlated with jelly end, since pointed tubers (small stem end) are especially susceptible to it. As a grade factor, the defect is a serious one. Tubers with pointed bud ends are more liable to scald, as noted previously.

SYMPTOMS: As indicated by the name, affected tubers have pointed ends, either (a) stem end or (b) bud end. Tubers pointed on the stem end are by far the most common. As a general rule, pointed tubers seldom are knobby.

CONTROL: Undoubtedly the most important control measure is to provide adequate, uniform soil moisture and fertility throughout the growing season. Wide fluctuations are almost certain to produce tuber-shape defects of one kind or another.

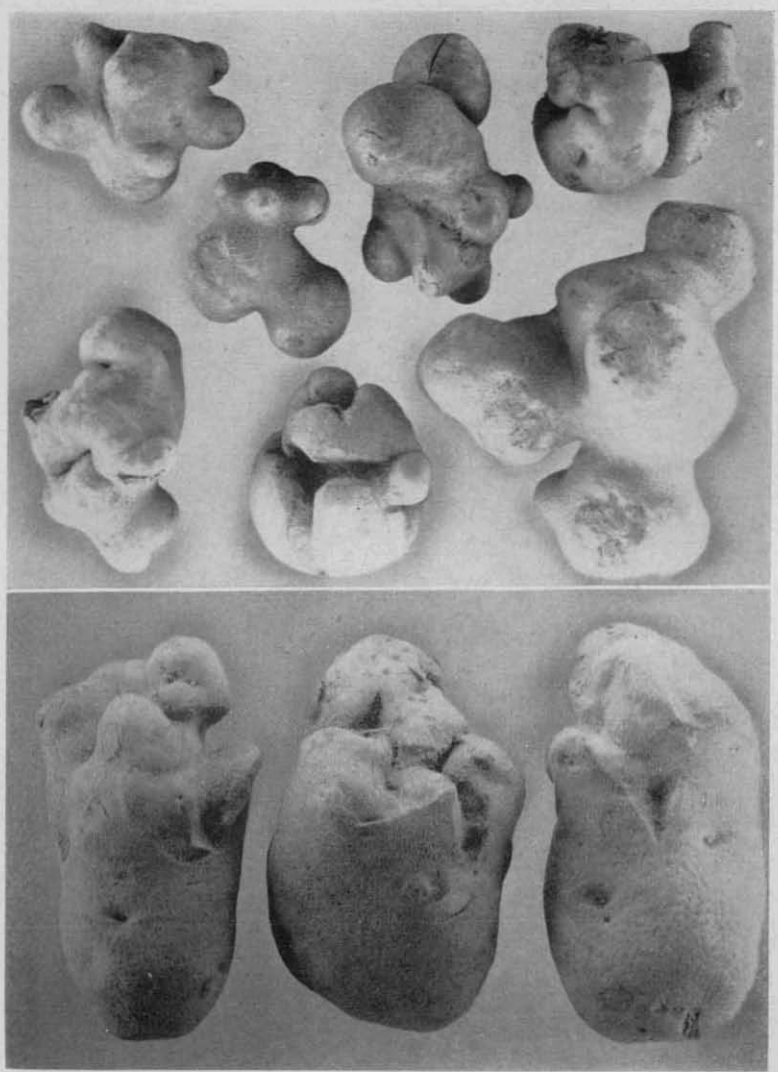

Fig. IV.—4. Rough tubers of Russet Burbank. The upper photo shows grotesquely shaped tubers and the lower photo illustrates malformations which are often appropriately called "monkey faces."

IV. SHAPE DEFECTS

4. ROUGH TUBERS

CAUSE: Not fully known. The type illustrated may be due to *Rhizoctonia,* to mechanical factors, such as hard, cloddy soil, or to a variety of other causes or combinations.

DISTRIBUTION: Probably general.

IMPORTANCE: Some lots show a fairly high percentage of rough tubers, while others are quite free from the defect. The loss generally would be significant.

SYMPTOMS: This type of tuber defect is characterized by grotesque malformations, by "growth cracks," scar tissue, and, in some cases but not typically, a tendency toward knobbiness. Tubers may be angular, nearly flat, nearly round, or even L-shaped. Certain ones suggest the name "monkey face."

CONTROL: No definite control measures can be recommended because so little is known of the actual causal factors. However, proper cultural practices and control of *Rhizoctonia* should reduce the incidence of malformed tubers.

Fig. IV.—5. Spindle tuber in Russet Burbank, showing actual spindle-shaped tubers (above) and elongated tubers with prominent eyes (below).

IV. SHAPE DEFECTS

5. SPINDLE TUBER (virus)

CAUSE: Virus (*Acrogenus solani* Holmes). The virus also causes a disease of the growing plant, reducing yield and changing the shape of the tubers. Giant hill may also be involved in some cases.

DISTRIBUTION: General, although it varies widely in different lots in the same locality.

IMPORTANCE: Except for rather unusual cases, the loss is probably minor.

SYMPTOMS: Affected tubers are usually long and narrow, often spindle shaped, with prominent "eye-brows" and with extra eyes at the bud end. Giant hill plants may often form rough, spindle-shaped tubers. Tuber diagnosis in the bin is not always possible.

CONTROL: 1. Plant disease-free seed.
2. Discard suspected tubers.
3. Rogue diseased plants in seed fields.

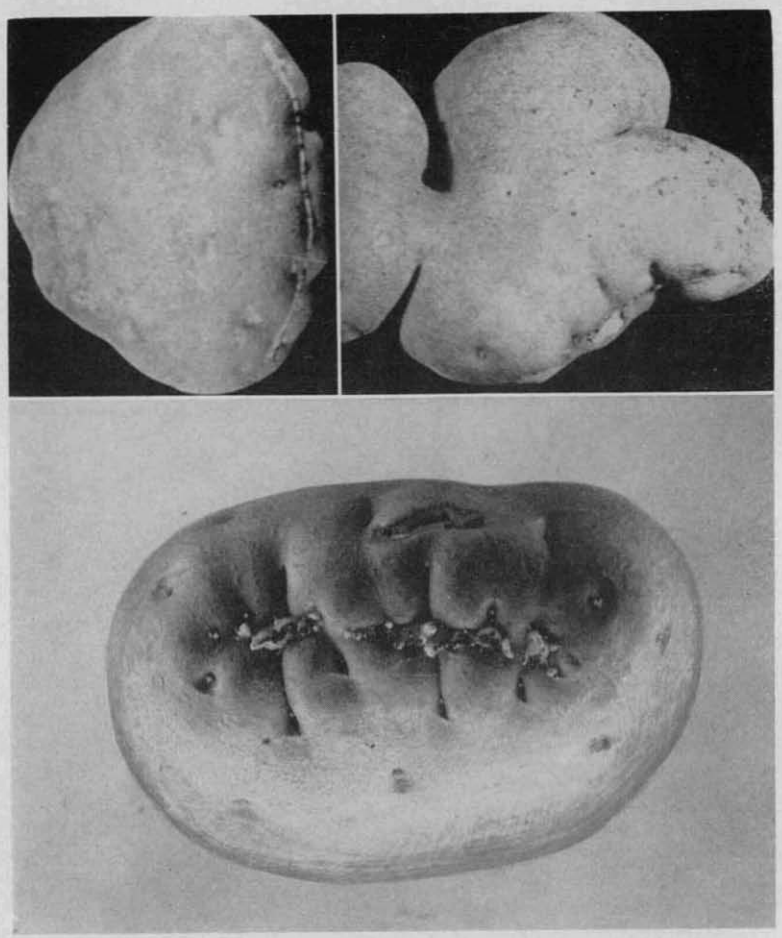

Fig. IV.—6. Stitched end in Russet Burbank. Note the "sewed" appearance and abundance of eyes on the bud ends.

IV. SHAPE DEFECTS

6. STITCHED END (fasciation)

CAUSE: Not definitely known. Probably either a virus or genetic disorder since it is tuber-perpetuated.

DISTRIBUTION: Specimens have been collected in the Upper Snake River and Yakima valleys.

IMPORTANCE: Probably minor, although it may be more important than realized.

SYMPTOMS: This is one of the most interesting diseases encountered. Affected tubers are usually flat, with a broad, angular bud end with constrictions such as might be formed when a wound is stitched. There are many buds, in fact almost a continuous line of them across the bud end. They have a tendency to sprout early. In extreme cases, tubers appear much like a baseball mitt or glove.

The multiple eyes or buds give rise to a broad, flat-stemmed (fasciated or ribbon-like) plant.

CONTROL: 1. Plant only healthy seed.
2. Discard affected tubers.
3. Rogue out affected (fasciated) plants.

IV. SHAPE DEFECTS

7. DIMPLE END

Fig. IV.—7. Dimple end on Russet Burbank. The bud end, which is devoid of eyes, is the part affected.

CAUSE: Unknown.

DISTRIBUTION: A few cases have been seen in lots in the Upper Snake River Valley, and in other scattered locations in Oregon and Washington.

IMPORTANCE: Very minor. Its inclusion here is primarily for interest and to determine its distribution if and when noticed.

SYMPTOMS: Affected tubers show a rather large definite depression on the bud end. Generally eyes are absent in the dimple.

CONTROL: None suggested.

IV. SHAPE DEFECTS

8. ROOT CONSTRICTION

Fig. IV.—8. Root constriction on Russet Burbank. The furrows are due to pressure from roots entwining the tuber as it enlarges.

CAUSE: Interference with normal tuber development by roots. Soil condition is probably an important contributing factor.

DISTRIBUTION: It has been noted generally but for some reason it is more prevalent in certain fields.

IMPORTANCE: Minor. Severely affected tubers are graded out.

SYMPTOMS: In mild cases, shallow lines of depression extend across the tuber surface. Sometimes they crisscross and form patterns. In severe cases, the whole tuber is malformed and becomes a cull.

CONTROL: It is probably impossible to control this defect but attention should be given to preparing a good seed bed and keeping the soil loose and friable.

Fig. V.—1. Wireworm injury on Russet Burbank. Note the tunnels and holes in the lower tubers and the extreme injury shown in the upper photo.

V. INSECT AND RELATED INJURIES*

1. WIREWORMS

CAUSE: Larvae of click beetles or snapping beetles, principally those of the sugar-beet wireworm (*Limonius californicus* Mann.) and the Pacific Coast wireworm (*L. canus* Lec.).

DISTRIBUTION: Widespread; particularly abundant in irrigated lands in Washington, Oregon, and Idaho.

IMPORTANCE: The unsightly burrows cause the potatoes to be of inferior quality. One to five wireworms per square foot of soil may cause such severe damage that the crop is unmarketable.

SYMPTOMS: Early injury, when the tubers are small, causes deep, funnel-shaped cavities to be formed as the potatoes mature. Mid-season injury results in the formation of pits one-fourth to one-half inch deep and one-sixteenth to one-eighth inch in diameter, sometimes lined with discolored scar tissue caused by *Rhizoctonia* infection. Late injury consists of clean-cut round holes, and scar tissue is not prominent. Rot infection sometimes enters the tuber through wireworm injuries.

CONTROL: 1. Include three or four consecutive years of alfalfa in the rotation previous to potatoes.
2. Plowing, flooding, or drying infested soil in summer will reduce wireworm numbers.
3. Apply ten gallons of ethylene dibromide solution (40% by weight) per acre eight inches deep by machine or ahead of plow.

* The section on *Insect and Related Injuries* was prepared by B. J. Landis, Senior Entomologist, U.S.D.A., Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, and H. S. Telford, Associate Entomologist, Washington Agricultural Experiment Station, under a cooperative potato project and approved by the Director of the Washington Agricultural Experiment Station. Acknowledgment is given to W. C. Lane, of the Bureau of Entomology and Plant Quarantine at Walla Walla, for his contribution to the discussion on wireworms.

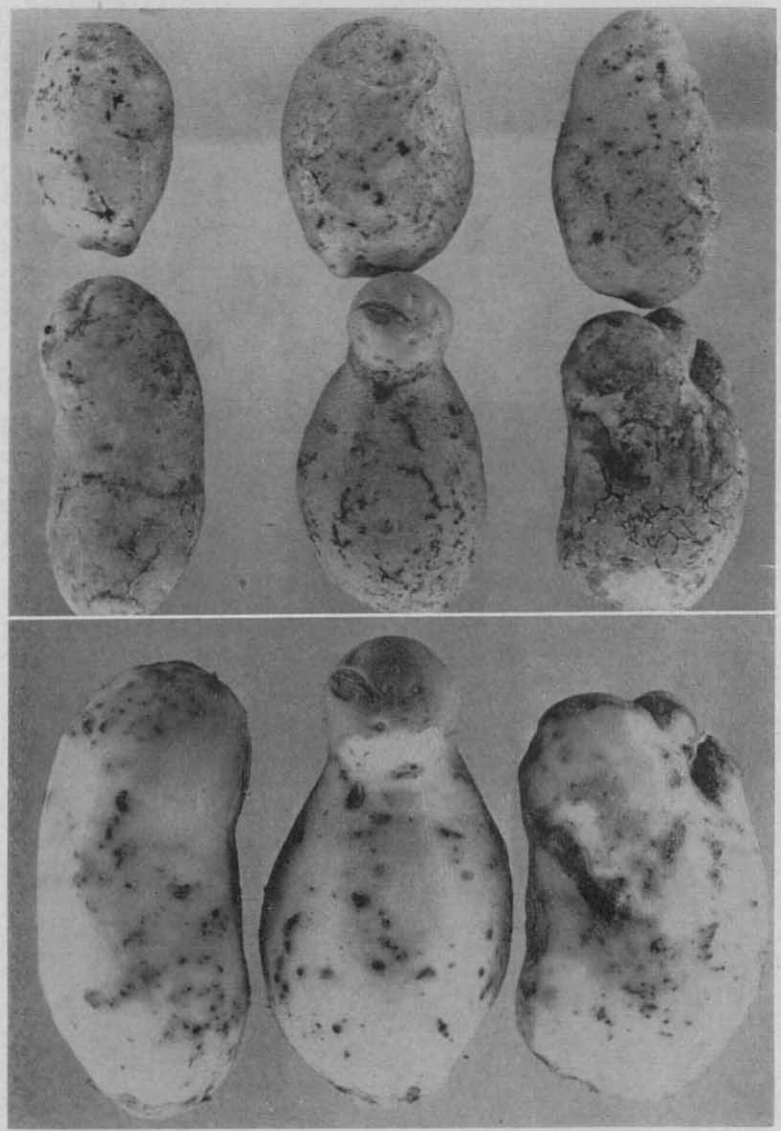

Fig. V.—2. Flea-beetle injury to Russet Burbank. The lower tubers are peeled to show the "splinters" which remain in the outer tissues.

V. INSECT AND RELATED INJURIES

2. FLEA BEETLES

CAUSE: Larvae of small black or brown beetles, principally the tuber flea beetle (*Epitrix tuberis* Gent.), but in some localities the western potato flea beetle (*E. subcrinita* (Lec.)) and the tobacco beetle (*E. hirtipennis* Melsh.).

DISTRIBUTION: Widespread. The tuber flea beetle occurs in the potato-growing areas of Washington west of the Columbia River and in parts of Oregon west of The Dalles, Prineville, and Crescent. The western potato flea beetle occurs throughout the Northwest. The tobacco flea beetle occurs in small numbers in central and eastern Washington, and in moderate numbers in western and southern Idaho.

IMPORTANCE: In areas infested with the tuber flea beetle, moderate to complete losses of crops may occur unless insecticides are applied. Injury from the western potato flea beetle and the tobacco flea beetle is less severe but is of special concern in southern Idaho in potatoes used for dehydration.

SYMPTOMS: Surface injury, internal injury, or both, may occur. Surface injury consists of pimple-like eruptions or rough, winding trails about one-sixteenth inch wide and of varying length, produced by larvae feeding just beneath the epidermis. Internal injury consists of single or groups of narrow, brown slivers, or feeding tunnels that extend into the tuber for one-fourth to three-fourths inch.

CONTROL: Several applications of 5% DDT dust at 10- to 12-day intervals. Early applications will require 20 pounds per acre. This dosage should be increased to 35 pounds as the foliage matures.

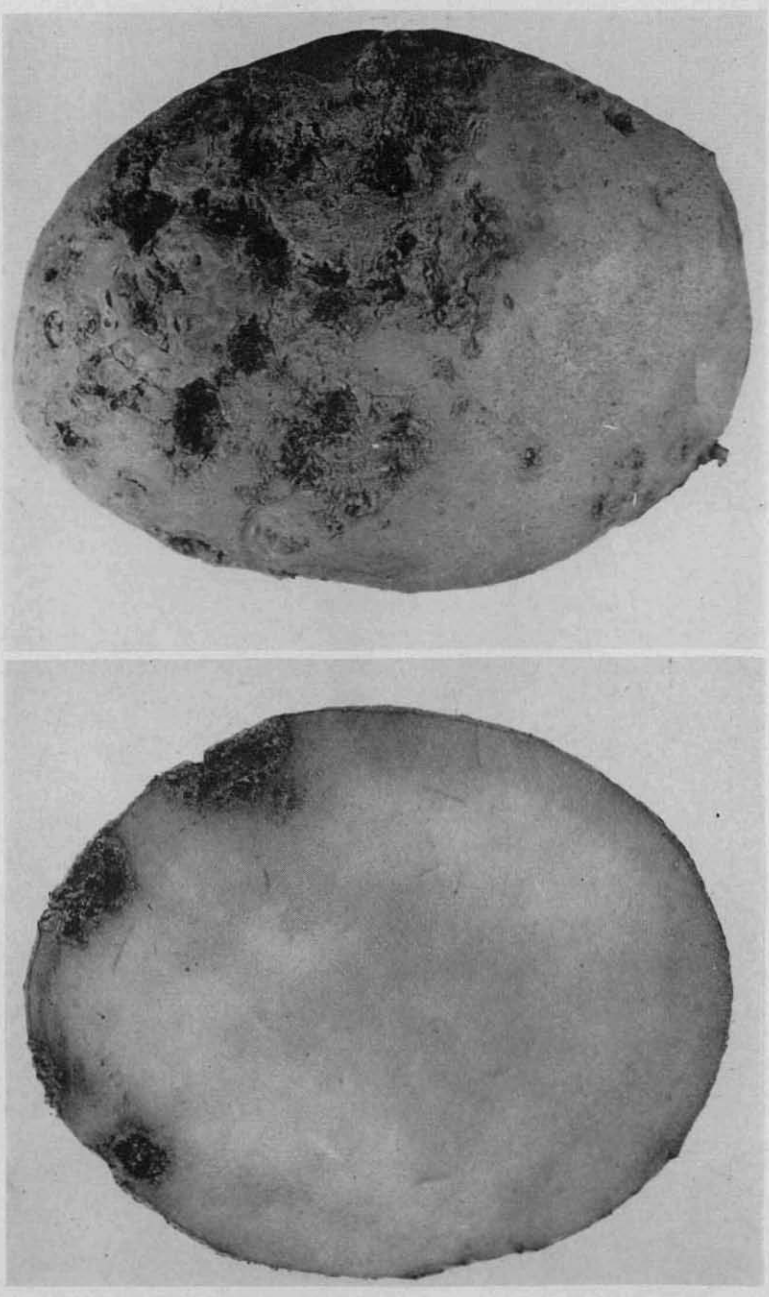

Fig. V.—4. Potato scab gnat injury to potato tubers. The tuber on the top shows the external appearance and the one on the bottom shows the type and extent of internal injury. (Photo by W. A. Rawlins.)

V. INSECT AND RELATED INJURIES

4. POTATO SCAB GNATS

CAUSE: Maggots of a small, fragile fly, the potato scab gnat (*Pnyxia scabiei* (Hopk.)).

DISTRIBUTION: A pest of potatoes in the Northeastern and Central States and first reported in Washington at Yakima in 1946.

IMPORTANCE: Capable of causing severe losses, particularly when associated with common scab (*Streptomyces scabies*).

SYMPTOMS: Injury consists of unsightly, irregular pits one-eighth to one-quarter inch deep filled with black, granular refuse. Very small, slender maggots occur at the bottom of the pits. These larvae usually enter breaks in the skin produced by common scab or various insects and other pests. Scab gnats may cause secondary rot to develop in stored tubers.

CONTROL: Prevention of scab infection and the control of soil insects and related pests of potatoes greatly reduce infestation. Measures that prevent the heating and sweating of potatoes in storage retard the secondary spread of the scab gnat.

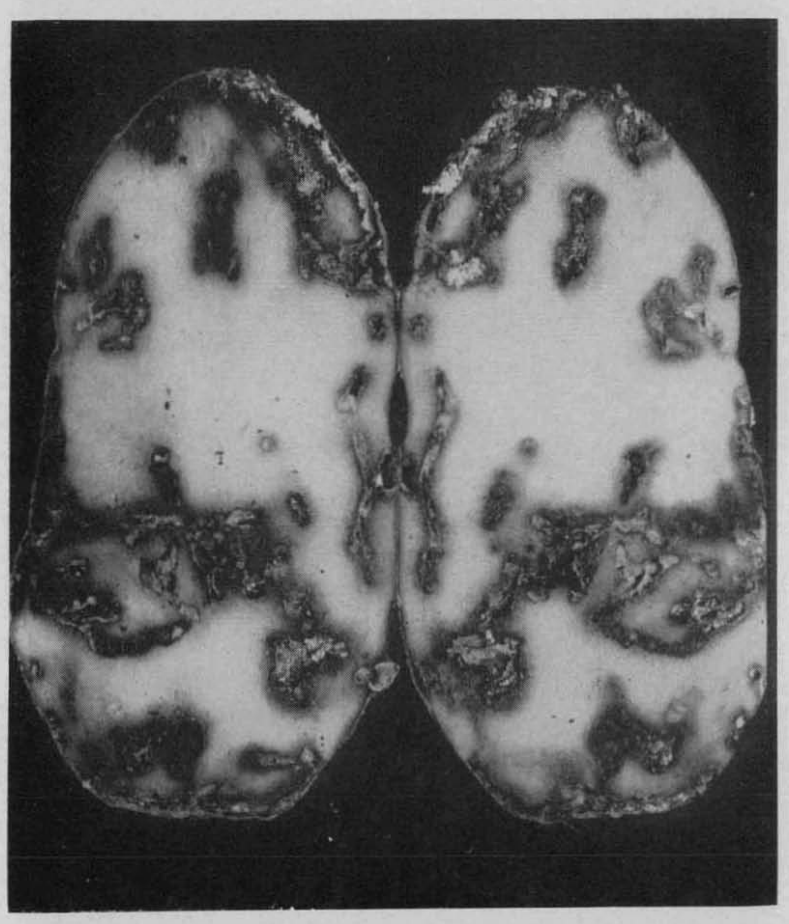

Fig. V.—5. Potato tuberworm damage. Note the tunnels in the tissue. (Photo courtesy of U.S.D.A.)

V. INSECT AND RELATED INJURIES

5. POTATO TUBERWORM

CAUSE: Larvae of a small moth, the potato tuberworm (*Gnorimoschema operculella* (Zell.).

DISTRIBUTION: Rare. Specimens have been found in potatoes at Seattle, Auburn, and Yakima, Washington, but apparently the insect has not become established. In 1946 an infestation was found in stored potatoes near Burley, Idaho.

IMPORTANCE: This insect is usually of little importance to the growing crop but is particularly destructive to potatoes in storage. The failure of local infestations of the tuberworm to persist for more than a year or two after being introduced accidentally in infested potatoes indicates that our climate is not particularly favorable for this insect.

SYMPTOMS: Newly hatched larvae mine in the leaves, small stems, and tubers. Those infesting leaves produce blotch mines between the upper and lower epidermis and occasionally enter the stem. Larvae penetrating the tubers feed near the surface at first and later produce winding burrows throughout the tuber. The burrows may be one to three inches in length and as much as three-sixteenths of an inch in width. The portion of the burrow occupied by the larva is fresh and white, but the older parts contain a gray or brown refuse.

CONTROL: Fumigation of infested potatoes with methyl bromide prior to storage or shipment, under the direction of the county agent or any other qualified persons.

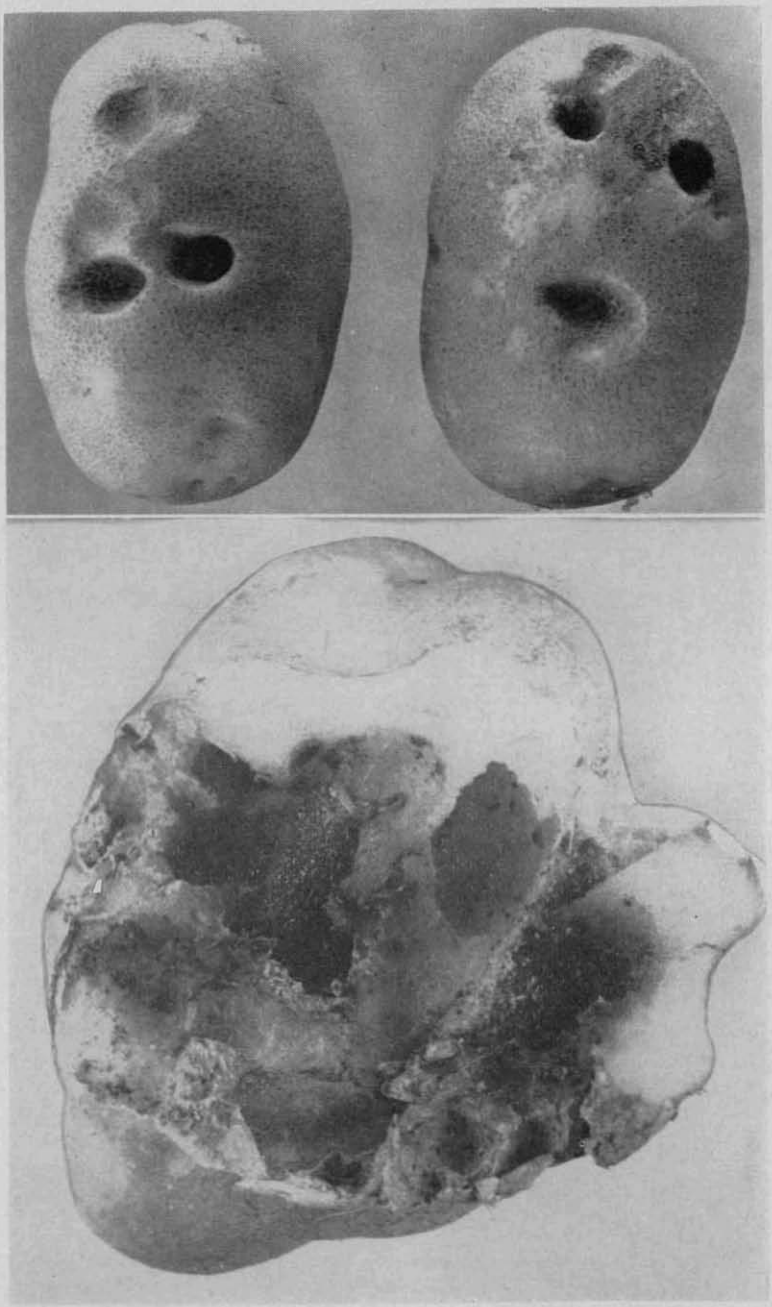

Fig. V.—6. Snail injury to Russet Burbank (above) and slug injury (below). Note presence of slug. (Lower photo courtesy of U.S.D.A.)

V. INSECT AND RELATED INJURIES

6. SNAILS AND SLUGS

CAUSE: Slimy, soft-bodied, slow-moving creatures leaving a trail of mucus. Snails are partly enclosed in a whorled, calcareous shell, but slugs have no shells. Various species occur.

DISTRIBUTION: Generally distributed but usually most abundant west of the Cascades. Appreciable damage to potato tubers has been reported only from the Upper Snake River Valley.

IMPORTANCE: Rare. Injury may be worse in low, subirrigated fields, or along irrigation ditches after the "demossing" operations. Serious losses have occurred in a few fields. Potatoes in damp storage cellars are sometimes injured.

SYMPTOMS: The feeding holes are round and one-quarter to one-half inch in diameter. The shallow holes lack the rough ridges found in white grub pits.

CONTROL: Apply metaldehyde-poisoned baits.