SOME FOREIGN POTATO MALADIES AND DOMESTIC PESTS OF POTATO IN ALASKA

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In Cooperation with
Agricultural Research, Science and Education Administration
United States Department of Agriculture

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FOREWORD

Dr. Curtis H. Dearborn, author of this and several other Alaska Agricultural Experiment Station bulletins, was one of Alaska's foremost horticulturists. For more than thirty years Dr. Dearborn conducted research on cultural practices for potatoes, garden peas, lettuce, and strawberries; the possbility of peas as an Alaska frozen-food product for local distribution; and, especially significant to Alaskans, determination of light quality available for crops.

Dr. Dearborn retired in 1981 from the experiment station. However, he continued writing the results of his many years of research and was continuing a number of projects at his home in Palmer. He was also continuing to pursue his work with Eskimo villages in the Kobuk River Valley in order to help the residents grow potatoes for local markets. Among the projects Dr. Dearborn was working on at the time of his death was this manuscript.

Dr. Dearborn will be missed by his colleagues and by the many Alaskans who knew his dedication to improving one aspect of life in this state.

James V. Drew, Director
Alaska Agricultural Experiment Station

PREFACE

Disease-free potato seed pieces, or potatoes grown from true seed derived from seedballs grown in Alaska, produce potato crops in Alaska free from most serious pests that afflict potatoes grown in other states and countries.

Precautions are offered to aid in maintaining this relatively clean, potato-growing environment. Maladies indigenous to Alaska are potato scab, *Streptomyces scabies*; black scurf, *Rhizoctonia solani*; silver scurf, *Spondylocladium atrovirens*; leak, *Pythium* spp.; skin spot, *Oöspora pustulans;* and *Fusarium* spp. Of these only scab and black scurf are significant.

Photographs to acquaint Alaskans with serious diseases, insects, and nematodes of other potato-growing regions of the world are presented. Illustrations of symptoms of maladies indigenous to Alaska are included as well as photographs of serious, introduced potato troubles that could be eradicated if a reasonable degree of persistence were exercised.

Frontispiece: Damage to some Alaska-grown potatoes by indigenous black scurf fungus, *Rhizoctonia solani*, may occur at numerous places on the crop. Stem girdle at the soil line has resulted in tuber formation above ground at the joints. Such tubers are deformed, green, and essentially worthless.

INTRODUCTION

Potatoes grown in Alaska can be damaged, yields and quality reduced, or tubers rendered unfit for food by bacterial, fungal, and virus diseases; insects; nematodes; and rodents if these are present in the seed piece or come in contact with the plant or new crop of tubers.

Material presented in this publication is intended to aid Alaskans in recognizing potato maladies presently in Alaska, to make Alaskans aware of some of the serious troubles of potatoes in other geographic regions that are not presently in Alaska, and to suggest precautions to keep these troubles out of Alaska. Diseases of potatoes in lower latitudes are well documented in Agricultural Handbook No. 474 (O'Brien, 1976). Insects most troublesome in major potato-growing areas in other regions are discussed in "Commercial Potato Production in North American," the potato Association of America handbook (Thornton and Sieczka, 1980). Still another reference is "Potato Diseases, Insects and Weeds," (northeastern United States) with excellent colored illustrations (Greider et al., 1978).

Alaskans have a very clean environment in which to grow potatoes free of most of the troubles of potatoes grown in other regions. A knowledgeable public and its appointed or elected representatives can be effective in preventing the entry and spread of potato maladies in Alaska only if the seriousness of some potato maladies not yet found in the state is clearly understood. Some may contend that the reason we are free of potato maladies is that they cannot survive in our environment. To this I say "It is better to be cautious and clean than careless and contaminated."

PRECAUTIONS AGAINST IMPORTING POTATO TROUBLES

A few words of caution are offered here to travelers and importers. No matter what size potato tuber you may be offered while visiting a foreign country and no matter how attractive and healthy the tuber may appear to be, to bring such a tuber to Alaska could be the introduction of a trouble that could jeopardize the potato enterprise and ruin our potential to export potatoes for seed purposes. As travelers we should be considerate of our clean gardening environment. The advantages in bringing home a better potato cannot outweigh that of introducing a very destructive potato pest. Potato varieties from all over the world have been evaluated in the years since 1950 at the Matanuska Research Center. These varieties first went through quarantine inspection in Maryland and, thus far, new troubles have been avoided.

Anyone wishing to import a potato from foreign sources into Alaska should first contact the USDA, APHIS, PPQ, Permit Section, Federal Building, 6505 Belcrest Road, Hyattsville, Maryland 20782. Information will be furnished from this source concerning plant pest risk and entry requirements for such importation. Federal USDA Restricted Entry Orders (Potato Regulations) restrict the movement of foreign potatoes into the United States. Potatoes will only be admitted from those foreign countries free from potato wart and other diseases or insect pests which are new to or not widely distributed in the United States.

The following table lists some foreign potato pests not occurring in the United States. It is provided in order to help identify and prevent the entry into Alaska of troublesome insects and diseases. Some of these insects and diseases are intercepted at United States ports of entry.

Flight via the polar route has made travel to European potato-growing areas as well as to other continents easy for Alaskans. Most of these areas have potato troubles that are not in Alaska and should not be brought here. Black wart fungus, *Synchytrium endobioticum* (Figure 1), is such a disease. Late blight, *Phytophthora infestans*, (Figures 2 and 3), is another fungus disease that

Table 1. Some Potato Pests Which Do Not Occur in the United States.

PEST	ORIGIN
Potato Weevil (*Eqicaerus cognatus*)	Mexico
Andean Potato Weevil (*Premnotrypes* spp. and *Rhigopsidius tucumanus*)	South America
Potato Lady Beetle (*Epilachna niponica*)	Orient
Graphognathus species	Australia, South America
Rust, *Aedidium cantense*	Honduras, Peru
Leaf Rust, *A. solanum*	British Congo
Leaf Spot Fungus, *Ascochyta solanicola*	Europe, India
Leaf Spot, *Cercospora solani-tuberosi*	India
Powdery Mildew, *Leveillula solanacearum*	Europe, USSR
Bacterial Disease, *Pseudomonas xanthochlora*	Germany
Rust, *Puccinia pitteriana*	Brazil, Columbia, Costa Rica, Ecuador, Paraguay, Peru, Venezuela
Gray Leaf Spot, *Septoria pseudo-quinae*	Bolivia, Ecuador

has not been seen in Alaska for over 25 years[1] and possibly it never has overwintered here. If late blight is discovered in Alaska, measures to eradicate it should be taken immediately. Action should be taken now to ensure that an effective fungicide is on hand that could be applied immediately to kill the fungus in all stages.

Early blight, *Alternaria solani* (Figures 4 and 5), has been reported, but the strain has not been virulent or common enough to necessitate fungicide usage, nor has tuber infection been significant. Golden nematode, *Heterodera rostochiensis* (Figures 6 and 7), is a serious root-parasite problem that we do not have; however, it is been reported on Vancouver Island, on Long Island, and in upstate New York. Colorado potato beetle, *Leptinotarsa clecimlineata* (Figures 8 and 9), is one of the most persistent and destructive of potato insects in lower latitudes and would no doubt thrive here if introduced. It is easily distinguished from other beetles because of its contrasty stripes and a photo of this insect is included here to help those who may wonder if the striped turnip beetle they find in their garden is the Colorado potato beetle. Potato tuber worm, *Gnorimoschema opercullela*

[1] Observed by C. E. Logsdon, Plant Pathologist, University of Alaska, on Gravena Island about 1955.

(Figures 10 and 11), has never been identified in Alaska, although it has been troublesome in several states and Canada. What many growers do not realize is that numerous potato pests in the 48 conterminous states and Canada could show up in the fields of newcomers to Alaska who would tolerate the infestation because they had lived with the same trouble elsewhere.

FIGURES SECTION

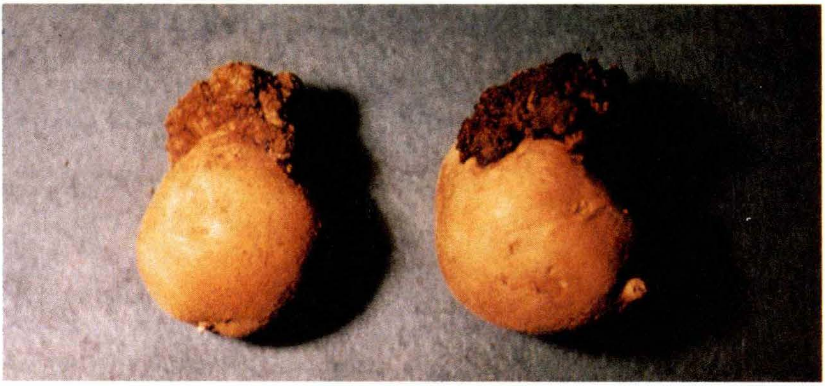

Figure 1. Black wart fungus of potato tubers showing the proliferation of tissue brought about by the fungal infection. It is a disease of the cooler potato-growing regions of the earth and could be very destructive to the Alaskan crop if it were introduced to Alaska.

Figure 2. Potato leaves showing late blight fungus infection that will soon spread throughout the leaves and destroy them. Alaskans are not equipped to cope with this fungus disease.

Figure 3. Potato tuber infected with late blight fungus. The fungus spreads in irregular patterns just under the skin, enveloping the entire tuber which finally softens to a disagreeable, mushy rot.

Figure 4. Early blight fungus has penetrated the epidermal tissue of this potato leaf and produced the alternate light and dark rings characteristic of its destructive growth.

Figure 5. Early blight infection of the tuber produces small spots of decaying tissue under the skin. Margins of the spots are raised and somewhat puckered. Discoloration and tuber decay are usually accompanied by secondary rot organisms.

Figure 6. Golden nematodes, minute threadlike worms, have invaded the root system of these potato plants. The great numbers of this parasite reduce plant vigor and significantly decrease yield.

Figure 7. Potato roots showing golden nematode cysts in several stages of maturity. The golden cysts are the more mature.

Figure 8. Colorado potato beetle, is an insatiable feeder on potato leaves. Shown here on the underside of a leaf is an orange egg mass, nymphs in various stages of growth, an immature winged beetle, and a mature beetle showing its characteristic stripes and colors.

Figure 9. Colorado potato beetles clustered on stems of potato plants that they have defoliated.

Figure 10. Potato tuberworms feeding on potato leaves.

Figure 11. Potato tuberworms and their burrows in a potato tuber. Note the moth, the mature worm, and a pupa.

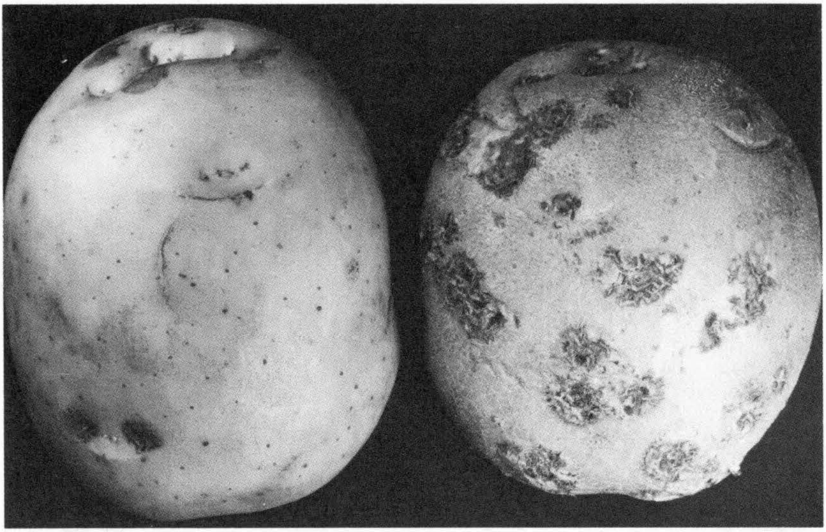

Figure 12. Potato scab is unsightly. A scabby crop keeps poorly in storage because the corky areas allow the water of the tuber to escape. Shrinkage and, finally, wilting of the tuber occurs. Scab pustules can be numerous enough to involve nearly all of the tuber surface. Variety on left is scab resistant.

Figure 13. Potato tuber in an advanced stage of destruction by blackleg bacteria. Infection took place at the stolon end of the tuber. The central portion is first to be destroyed, in contrast to ring rot bacteria that spreads around the tuber's vascular network.

Figure 14. Blackleg bacteria from the potato seed piece have multiplied, moved up into the stem and produced the black stem that is rotten. The mushy stem interior distinguishes this disease in Alaska from all others.

Figure 15. Yellow leaves developing on one or more stems of a hill of black-leg-infected potato are one early symptom of the disease. If only an occasional plant is found, roguing is worthwhile to prevent further spread in harvesting and storage.

Figure 16. Ring rot bacteria have invaded this tuber through the stolon. Some of the vascular ring is yellowish, while other portions have turned brown from the destructive pest.

Figure 17. When ring rot has progressed to this stage, pressure applied to the tuber forces a cheesy mass of decaying tissue out of the vascular ring area. This is strong evidence that the breakdown is being caused by ring rot bacteria in contrast to the damage resulting from other kinds of pests.

Figure 18. One wilted potato stem in a hill should alert a grower that ring rot bacteria may be present and that such a condition warrants a laboratory test to learn if ring rot is present.

Figure 19. Potato plant showing advanced stage of destruction by ring rot bacteria that have caused plugging of the water-conducting tubes in the stems and earlier wilting of the leaves.

Figure 20. Damage to potato by *R. solani* fungus is shown on the second plant from the left as a shrunken, brown, woody stem, whereas the main stem of the plant on the extreme right has been girdled at the point indicated.

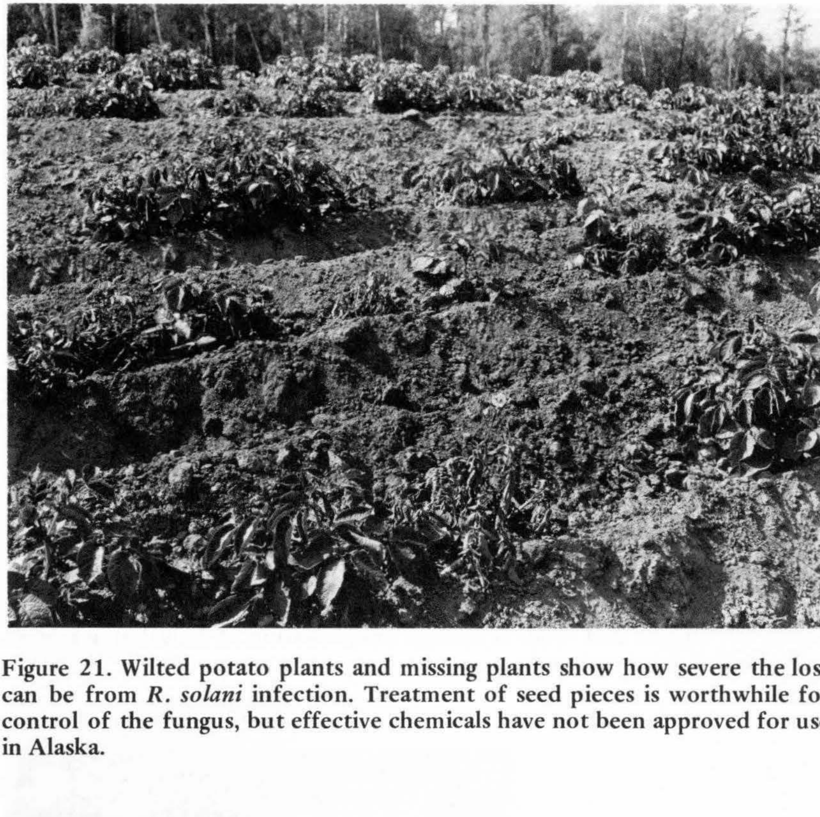

Figure 21. Wilted potato plants and missing plants show how severe the loss can be from *R. solani* infection. Treatment of seed pieces is worthwhile for control of the fungus, but effective chemicals have not been approved for use in Alaska.

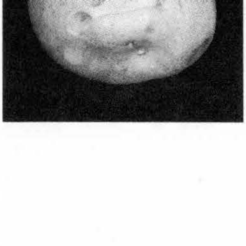

Figure 22. Eye cankers remain from *R. solani* damage of basal-eye-leaf scar tissue. Four roots that persisted from the root initials of the tuberizing stolons were girdled, leaving the circular scars. These scars on some clones develop Y-checks.

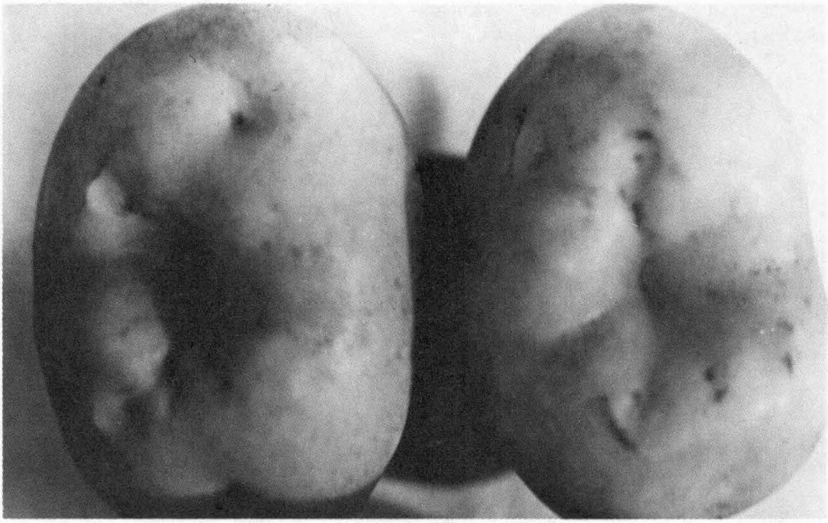

Figure 23. Dimple end tuber is another manifestation of fungal attack at an early stage of tuber ontogeny.

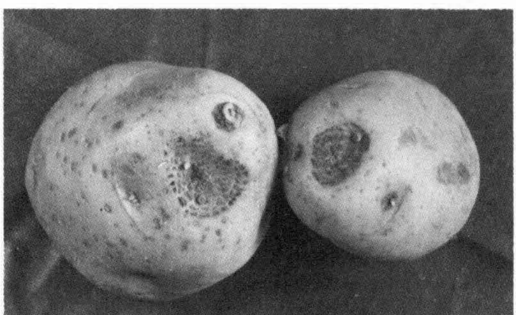

Figure 24. At a late stage of tuber development, scar tissue remains from what would have been dimple end.

Figure 25. Symptoms of a very late fungal attack of the apical buds of a large tuber. No other eyes of the tuber are affected.

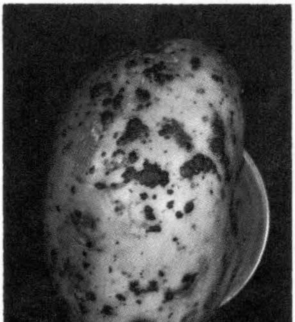

Figure 26. Black scurf, the resting or overwintering stage of *R. solani*, is unsightly, and tubers so affected emit a musty odor specific to the fungus. Storage life and eating qualities are not modified by these patches of mycelium called sclerotia. When a crop is planted with such seed tubers, the culture of fungus germinates and begins its destructive cycle.

Figure 27. Brown staining of vascular tissue in the tuber is usually associated with stolon girdle. Top-killing practices may aggravate vascular staining in some varieties.

Figure 28. Lance-shaped leaves in the apical region of the plant and leaf curling that expose the light undersurface are symptoms characteristic of potato plants badly damaged by *R. solani*.

Figure 29. Silver scurf caused by a soil fungus that infects the skin and produces superficial silvery patches. Note that the cut tuber shows no discoloration within the flesh.

Figure 30. Potato tuber showing breakdown by "leak" fungus. The flesh becomes uniformly light gray with a water-soaked appearance. Slight pressure will cause the nearly clear juice of the flesh to leak through pores in the skin.

Figure 31. Skin spot of potato tubers is produced by a fungus which functions in storage under cool, moist conditions but which requires several months to cause conspicuous blisters on the skin.

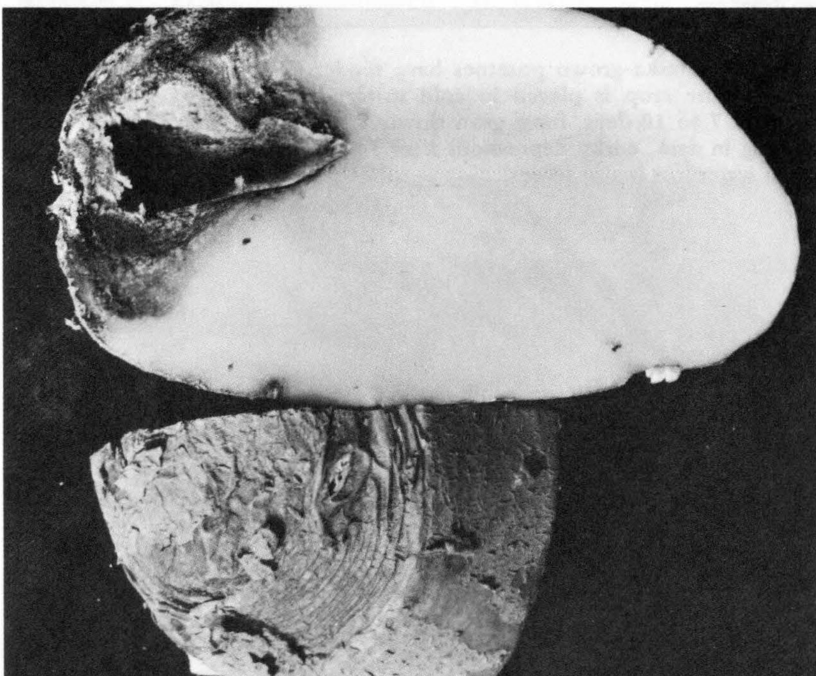

Figure 32. Dry rot of potato tubers is due to *Fusarium* species of fungi that enter the potato through breaks in the skin resulting from bruising at harvest. *F. coeruleum* commonly produces the wrinkled skin of this decaying tuber.

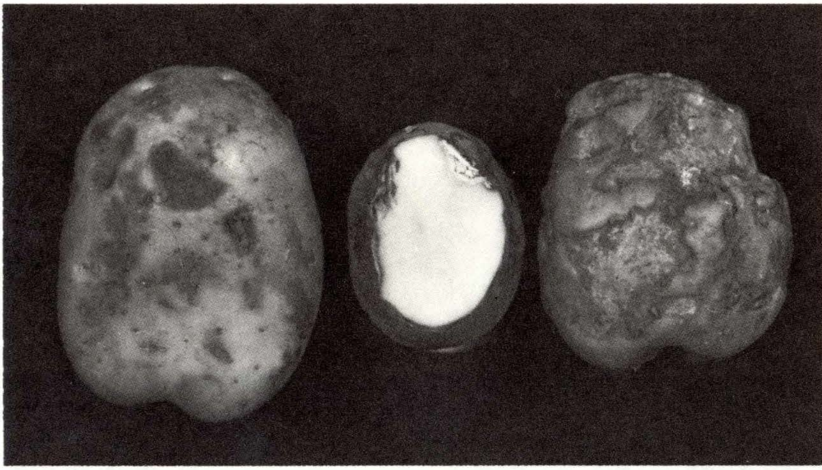

Figure 33. Alaska-grown potatoes have tender skins at harvest that bruise easily. If the crop is placed in cold storage without a warm suberization period of 7 to 10 days, fungi grow slowly in the bruised and feathered spots, resulting in dark, corky depressions after 3 to 6 months of storage. Skrinkage due to water loss is also severe.

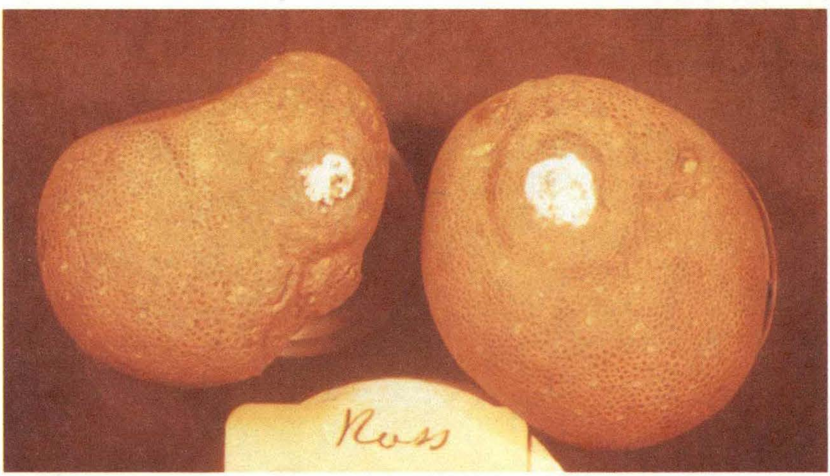

Figure 34. An uncommon fungus that produces a scablike pustule with a raised area around it is a disease of potato not previously recognized in Alaska. Russet-skinned varieties seem to be more susceptible to it than white- or red-skinned varieties.

Figure 35. Diseased Alaska 114 flower cluster on the left is small and nearly white, whereas normal cluster size and dark-lavender flowers are produced by the healthy plant on the right. Removal of potato viruses X and S from diseased tubers resulted in the return of normal flower color in subsequent plantings.

Figure 36. Mild mosiac mottle varies in intensity by variety. Plants in Alaska are seldom killed by the virus, although tuber production is reduced materially. It can be a serious problem for seedsmen who use or market small tubers for seed purposes.

Figure 37. Rugose mosaic produces buckling, chlorosis, and wavy leaf margins. If it begins on the lower leaves, veins on the underside of the early-maturing leaves appear to be stained with black ink. These leaves droop and wither, but frequently remain attached to the main stem.

Figure 38. Leafroll is a serious virus infection that produces inward rolling of all leaves of the potato plant, chlorosis of apical leaflets, and dwarfing of the entire plant.

Figure 39. "Giant hills" is illustrated here by the several flowering plants that tower above normal plants in the field. They flower late and remain green late. Tubers may be few and very large or they may be few and quite normal in size, but usually the eyes are quite deep.

Figure 40. Two hills of a type of witches' broom potato abnormality. Ridging of the leaves, chlorosis, and beaked condition of leaves of plants on the left are typical of witches' broom. The late emergence of the small plant at right is another distinguishing feature of the trouble.

Figure 41. Witches' broom in a tuber unit planting shows the many-stemmed growth habit produced by the infection. The one hill of witches' broom on the right is a part of another tuber unit indicating that not all seed pieces of a tuber cut into four pieces and planted consecutively produce the broom-type growth. Neither the obviously infected nor the normal hills of such a tuber unit should be used for seed.

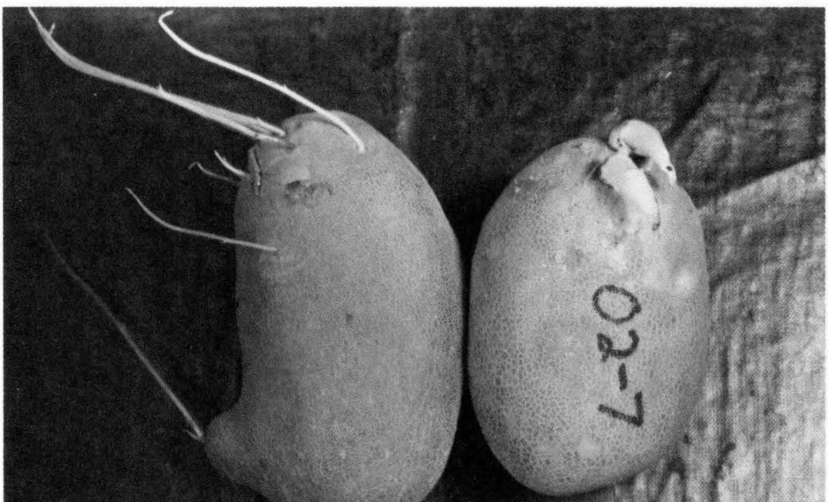

Figure 42. Hair sprout of potato is another of the maladies that occur sporadically. The tuber on the left with long, slim, weak sprouts should not be used for seed.

Figure 43. Holes in a potato tuber from wireworm feeding. They may penetrate a half inch into the flesh of the tuber. Soil gathers in these holes but tubers seldom rot because of the damage.

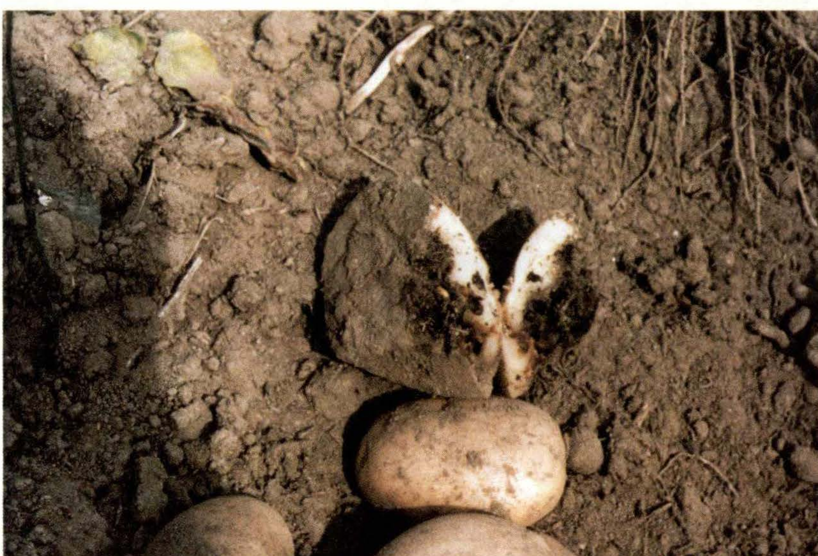

Figure 44. Wireworm in a seed piece is strong evidence that new tubers will be damaged by other wireworms. The orange spot in the broken seed piece is a portion of a wireworm protruding from the damaged seed piece.

PESTS OF POTATO IN ALASKA

Pests are classified as bacterial, fungal, and viral diseases; insects; and animals. The first three have been imported in or on seedstock, equipment, or supplies used in the potato enterprise. They have been observed in or on various parts of potato plants and tubers at planting, during growth, or in storage. Imported bacterial and viral diseases have been the most troublesome and difficult to eliminate. They are not indigenous to Alaska and have no known native host plants on which to carry them from season to season. Damage to potatoes caused by feeding insects has been minimal – the principle damage having been from cutworms, slugs, aphids, leafhoppers, and grasshoppers. Mice and shrews can be quite destructive in small plantings.

Bacterial Diseases

Common scab (*Streptomyces scabies*) and Blackleg (*Erwinia atroseptica*, or *carotovora*) are the only indigenous soil-borne bacteria that have damaged potatoes. Once the scab organism is established in the soil, it remains very infectious to the tubers (Figure 12). As in other potato-growing regions, fields receiving a dressing of fresh manure generally produce very scabby tubers. It seems more than a coincidence that the scabbiest areas of most fields are the low spots in which snowmelt water accumulates and at which migratory waterfowl gather in great numbers during the course of their spring flight northward. These fields attract the fowl because of the grain remaining on the ground from harvest operations of the previous fall. Droppings left by these birds provide the fresh manure which intensifies the scab infection of potato tubers. Flower of sulfur applied at a minimum of 1000 lbs. per acre to small garden areas that produce very scabby potatoes may prevent some scab damage. A scab-resistant variety such as Alasclear[2] is a simpler way to minimize scab damage.

[2] Alaska potato seedling 14-70-1-72 bred and selected at the Matanuska Research Center, University of Alaska, Agricultural Experiment Station.

Blackleg is a serious bacterial disease of the tuber (Figure 13). Bacteria in the seed tubers are the principal source of infection. It has been my experience over a 30-year period that a crop grown from seed that is free of blackleg at planting does not contract blackleg in the field. Blackleg in commercial plantings probably originates in the seed piece from contaminated planting equipment. Occasionally, a grower attributes blackleg infection to damage caused by moose, cattle, or horses that passed through the field and trampled the crop severely. It is conceivable that *E. carotovora* might move into such damaged stems or tubers; however, I have not seen blackleg where moose have traveled through crops planted with blackleg-free seed tubers. The chances of infection from the potato soils of Alaska are minor compared to those associated with contaminated seed stock; this is borne out by blackleg-infected plants in trampled fields in which no animal stepped near a plant (Figure 14). Furthermore, varieties whose tubers shatter crack early in the field are not prone to blackleg infection.

With blackleg infection, some tubers in the hill may already have decayed at harvest while others appear to be normal. Infected tubers in storage may break down rapidly if heavily infected or they may carry through to the next planting without being detected. Some areas of fields occasionally produce bright yellow foliage symptomatic of blackleg (Figure 15), and in each case the evidence indicates that the seed rather than the land was the source of the infection. When these areas were planted two years later with clean seed, blackleg symptoms were not present on the foliage or in the new tubers.

"Ring rot," *Corynebacterium sepedonicum*, the most serious bacterial disease of potato that has been brought to Alaska (Figure 16), moves from the infected seed piece into the stem, out through the conducting tissues of the stolon, and into the vascular ring area of the new tuber. The infected vascular ring, from which the disease was named, softens as the bacteria multiply. If pressure is applied to the tuber, a cheesy, creamy mass appears at the cut surface as shown in Figure 17. When the infection has progressed to this stage, cortical tissue turns brown and no longer supports the skin. It, too, turns brown and develops small cracks, the edges of which roll outward. In the field, one of the first symptoms is a wilted stem of an otherwise-healthy hill of potatoes (Figure 18). As the season progresses, leaflets on other stems of the hill wilt, turn brown, and finally die prematurely (Figure 19). If an infected crop is taken to storage, ring rot-infected tubers will begin to break down and the temperature of the storage will rise in spite of an air-conditioning system. Other rot organisms will add to the rate of decomposition, and the stored potatoes will be unmarketable after 5 months of storage.

Ring rot bacteria may be spread to tubers from contaminated equipment, cutting knives, and storage containers. Varieties differ in their susceptibility to ring rot. Some carry it with no visible symptoms. Frequently, seed stocks carry a trace of the bacteria not detectable to the eye and, under field conditions favorable to the bacteria, a crop shows up heavily infected. Great care should be exercised in choosing a seed source in order to avoid infected seed tubers. Thus far, there has been no evidence to indicate that ring rot has survived in Alaskan soils from season to season, although it is recognized that, in coastal areas where volunteer potatoes emerge from the previous season's crop, ring rot, if present, could be carried over in the surviving seed tubers and stems.

Fungal Diseases

Fungal diseases of potato in Alaska are soil borne and consist of: Black scurf, *Rhizoctonia solani,* "the dirt that won't wash off;" Silver scurf, *Spondylocladium atrovirens*; Leak, *Pythium* spp.; Skin spot, *Oöspore pustulans;* and *Fusarium* spp.

Damage to potatoes by "black scurf" fungus is manifested in numerous ways. It may attack the sprout near the seed piece and cut it off below the ground line, or the sprout may emerge and show a girdled area at the ground line (Figure 20). Below ground, the stem may be shriveled and brown. Stolons and roots are affected similarly. Weakened plants may be broken off at the ground line by wind or the tops may wilt and finally die (Figure 21), leaving many blank spaces in the rows. The damage from missing plants is twofold. The production of the hill is lost and adjacent plants, without competition, produce numerous oversize, knobby, or hollow heart tubers, reducing further the yield of marketable potatoes per acre. If the top is not killed, small, rough tubers form above the girdle and aerial tubers develop in the axils of the lower leaves. Damage to tubers underground takes several forms, among which root growth and canker at the eye (Figure 22) are the least objectionable. When the fungus attacks the apical bud group, dimple end tuber (Blodgett and Rich, 1949) results (Figure 23); when the attack comes later in tuber growth, an ugly scar tissue remains (Figure 24) or the eye is partially girdled (Figure 25). As the season progresses, the fungus goes into a resting or overwintering stage on the tubers prior to harvest and remains on them through washing and storage (Figure 26). Although the tubers are unsightly and have an odor identified with the black scurf, their storage life and eating qualities remain normal for the variety. Vascular staining (Figure 27) is frequently associated with partial girdle of the stolon at its junction with the tuber and is a serious defect of some varieties. Tubers that show vascular staining generally ooze some sticky fluid that results in a stolon cavity full of mud at harvest. If the plant reaches the flowering stage of growth, leaves in the upper portion of the plant become lance shaped, roll toward their midrib, and show their light-colored underside (Figure 28).

"Silver scurf," another fungus of the soil, has not been a problem to commercial producers. It occurs most frequently in wet, sandy soils along the coast where conditions have not favored commercial production. High soil moisture permits the fungus to enter the lenticels and produce silvery patches (Figure 29). If other fungal diseases such as "leak" do not enter, only the skin area is involved; however, the infected skin loses its capacity to hold moisture in the tuber.

"Leak," common in many soils, is most troublesome when tubers have reached an advanced stage of skin maturity and are harvested and stored wet and cold during the first few weeks after harvest. The fungus infects the bruised areas and causes a softening of the whole tuber in a very short time (Figure 30). It is called leak because the tuber leaks water if squeezed a little.

"Skin spot" is not commonly encountered in Alaska. It has been of importance to only two commercial growers. It consists of unsightly spots on the skin of tubers in storage (Figure 31). The fungal spores come into the storage on the tubers and, providing the storage atmosphere is cold, wet, and lacking in air circulation around the tubers, germinate and penetrate the skin.

"Fusarium" form genus fungi in the soil enter bruised potatoes in storage similarly and produce dry rot. Tuber bruises that crush tissues below the skin, in contrast to feathering, are more likely to contract *Fusarium coeruleum* that produces wrinkling of the skin above the affected area (Figure 32). Other *Fusarium* species, over a period of 3 to 6 months, produce dark depressions that seldom penetrate more than the cortical tissue (Figure 33). The latter condition can be prevented by raising the storage temperature to 60° F with accompanying high humidity immediately after storing and maintaining these conditions for 7 to 10 days. During this period, the young, tender skins suberize rapidly, thus walling off penetration of germinating fungal spores.

"Uncommon fungus" has been recognized and investigations are presently underway[3] to identify the skin infection that resembles scab but which affects the tuber somewhat differently (Figure 34). The first time I observed this problem was on the variety Peconic in 1968. Several early attempts were made to determine the cause of the pustule produced. Lesions are few and resemble common scab until after the tubers have been in cold storage for a few weeks. The corky tissue of the ruptured periderm hydrates and turns black. Under prolonged cold storage, the tissue around the pustule becomes raised, and a white mold develops in the crater. Russet-skinned clones are significantly more susceptible to this infection than white- or red-skinned clones.

Viral Diseases and Mycoplasmas

Viruses, as with most other potato troubles, come to Alaska in potato tubers. So far, there is no evidence to indicate that any indigenous host plants exist in Alaska on which potato viruses overwinter; therefore, if one starts out with only virus-free seed of every variety to be grown, there is reason to believe that the varieties will remain virus free. Our experience with the variety Alaska 114, cleared of viruses in 1972, supports this contention.

Potato variety Alaska 114, released in 1959 as a main-crop potato, normally produces several clusters of showy, dark-lavender blossoms with cream-colored tips. In 1963 a few white-flowered potato plants in a field of Alaska 114 were conspicuous among the lavender-flowered plants and were rogued in the belief that a varietal mixture had been planted (Figure 35). A few plants in the 1964 planting from the same seed source produced essentially white flowers and were removed in the usual manner before

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any tubers had reached seed size. When white-flowered plants developed again from the same seed source in 1965, several were labeled and detailed notes made of their characteristics. It was then apparent that these were Alaska 114 plants with white flowers or with flowers with only a faint trace of lavender color. These plants differed from healthy Alaska 114 plants. There were fewer flowers per cluster; flowers opened 3 to 5 days later; fewer fruits formed; the foliage was a dull gray-green color; and some areas between the lateral veins of mature leaves were raised, giving the leaf a ridged appearance.

In 1966, tuber-unit plantings of Alaska 114 with normal flower color and with abnormal flower color were made to learn if the flower color of the plant from each of the four seed pieces of each tuber would produce flowers of the same color. All plants arising from white or pale lavender parental seed pieces produced white or pale flowers, whereas seed pieces from plants with normal flower color produced normal, showy, dark lavender flowers.

A commercial planting of approximately 5 acres of Alaska 114 was made in 1967 from a lot with mixed flower colors. All seed tubers were cut by machine and planted in the conventional manner. At the peak of flowering, it was estimated that 40 per cent lacked the deep-lavender color of Alaska 114 potato. White-flowered plants were labeled and dug by hand at the usual harvest time in mid-September. White-flowered plants that had made normal to luxuriant top growth produced tubers with very deep eyes in the apical bud group, whereas tubers of stunted plants had shallow eyes like those of the dark-flowered plants. The low yield of marketable potatoes from this planting, due to a high percentage of small tubers and culling of large tubers with deep eyes, made clear the need for preventing these growth changes in Alaska 114 potato.

In 1968, tubers from normal and abnormal color plants of Alaska 114 were shipped to virologists[4] at Vancouver, B. C., to learn if viruses were present in the tubers. Their tests revealed potato virus-S (PVS) in the white-flowered sample and potato virus-X (PVX) in both samples. Latent mosiac is attributed to PVX. They noted that the flowers of the PVS-infected plants were

[4] Dr. N. S. Wright and associates, Canada Department of Agriculture, 6660 N. W. Marine Drive, Vancouver, B. C.

bleached considerably compared with those of the S-free plants when grown in the Canadian environment.

An interesting experience gained through this cooperative effort with Dr. Wright and his associates seems appropriate to relate. Tubers of Alaska 114 were indexed for PVX and PVS at Vancouver and found to give a response in the test plant indicating their presence in Alaska 114. Since their laboratory had stock samples of cultures of PVX and PVS from other potato plants, no samples of the material in Alaska 114 were retained. Finally when the time came to demonstrate that a virus-free plant of Alaska 114 with dark normal flower color would be diluted to a pale flower color by the introduction of these same two viruses, the cultures from stock were used. To our surprise, the flower color remained normal. Just what the original virus-infected Alaska 114 contained in addition to PVS and PVX that affected flower color is not known. We do know that the virus-removal process removed the flower-color inhibitor and brought yields of the variety back to what it had been when released as a variety. For this, Alaskans are deeply grateful to our Canadian colleagues. Virus-free stocks of some varieties being grown in Alaska are presently available.

Plant or tuber symptoms, supported in some cases by laboratory tests, have revealed that numerous viruses and mycoplasmas have been present in potatoes in Alaska. Latent mosiac, PVX alone, has been observed in several varieties. The leaf mottle, characteristic of PVX although not strongly shown, is most evident in good light conditions following several days of cloudy weather. Yields of affected and PVX-free plants in Alaska are not conspicuously different; however, yields of plants carrying latent mosaic may decline significantly, as with Alaska 114, if the plants contract other viruses.

"Mild mosaic," attributed to A-virus, produces a definite, conspicuous mottle, a tendency toward a beaked leaf tip, and stunting of the potato plant early in growth (Figure 36).

"Rugose mosaic" attributed to Y-virus is, in Alaska, a self-eliminating malady, in that it usually comes with imported seed tubers and either kills the plant or dwarfs it so that it can be recognized and rogued out (Figure 37). Tubers that are formed carry the virus through winter and infect a new crop if such tubers are used for seed.

"Leafroll" is another serious virus infection carried in tubers (Figure 38). It differs from the leaf curling caused by black scurf, in that leafroll begins on the lowest leaves and works up the entire plant. A yellowish mottle of the leaves of the apical region is common. Affected leaves are brittle and rattle if brushed. Imported varieties that have been rogued of leafroll for several years no longer manifest the leaf symptoms. The malady is normally transmitted by aphids feeding first on infected plants and then on healthy plants.

"Spindle tuber" is caused by a viroid. The tubers are long, slender, and rough, compared to healthy tubers of the variety. It, too, causes dwarfing of the plant and yield reductions, but is not easy to identify. Erectness of plants, pale gray leaf color and twisting of basal leaves may aid in recognizing the problem; but the only sure way at present is to graft a portion of the plant to a susceptible tomato plant that shows specific recognizable symptoms.

"Giant Hills" is a plant manifestation of troubles within the clone (Figure 39). Plants so affected tower above normal plants, flower late, and the leaves remain green long after vine senescence of normal plants. It has been more prevalent in Green Mountain, Ontario, and Kennebec than in other well-known varieties. Roguing minimizes its occurrence, but does not eliminate it. Since virus-free stocks of Ontario have been grown, giant hills has not been seen in that variety.

"Witches' Broom" is a reaction of the potato plant to a dwarfing effect carried within the tuber (Figure 40). The many stems that emerge are frail, dwarfed, and chlorotic, but the trouble is not self eliminating, as can be seen in Figure 41. The tuber unit on the left, four hills from the parent tuber, is totally affected. Tubers, if any are produced, will be less than an inch in diameter. The tuber unit on the right has one plant of the four that is affected. Seed from the three apparently normal hills probably also harbor some of the trouble and it would show up in the next crop. All tubers from both tuber units should be discarded.

"Hair sprout" is another manifestation of poor seed-stock material (Figure 42). It cannot be recognized until the tuber sprouts and produces the slender, hair-like sprouts. Seed of this type usually does not produce a crop of tubers and frequently the plants are so weak that they are covered and killed in the hilling operation. Plants of a tuber unit from such a tuber are all small in contrast to Witches' Broom where only one hill may be abnormal.

Insects

Potato vines and tubers are relatively free from insect attacks in Alaska, mainly because most of the very destructive species are not present. Alaska does not have Colorado potato beetle, May beetle (white grub), stalk borer, or potato tuberworm. Several species of grasshopper, mainly the small-bodied types, are present in Alaska but their numbers have been insignificant in potato fields. Aphids, leafhoppers, and plant bugs are present, but their numbers have not warranted control measures.

Wireworms, the larval stage of chick beetles, are present and have been quite destructive but were controlled earlier with aldrin or dieldrin. They could still be a problem as they bore into tubers and leave unsightly punctures that disqualify the crop for market (Figure 43). Wireworms in seed pieces (Figure 44) attract ravens and sandhill cranes that dig up the seed pieces, creating poor plant stands.

Cutworms can be destructive in the home garden when the ratio of worms to plants is high. Commercial plantings normally absorb the damage because the worms move to new plants as others are cut off. New sprouts then emerge that produce a crop of tubers. In small plantings, however, the worms remain and destroy the second crop of sprouts also. In the latter case, cutworm control should be practiced early.

Slugs have not been of commercial importance to potato growers; however, gardeners in coastal areas, particularly during wet seasons, have had considerable potato leaf damage from slugs. This feeding injury is conspicuous by the round holes in the leaves. Their chewing action on the tubers differs from rodent damage as the rasping action leaves a smoother surface than that left by rodents.

Animals

Mice and shrews tunnel into the potato hill and gnaw tubers sufficiently to destroy their market value. Small plantings in the Arctic are especially susceptible. Not only do these rodents eat the tubers underground, they uncover some, exposing them to greening; they also carry away small tubers.

Nematodes

This group of pests has not caused damage to commercial crops of potatoes in Alaska. In fact, no nematode damage has been reported on potatoes in Alaska. Golden nematode is one of the worst potato pests in Europe and was discovered attacking potatoes on Long Island, New York, in 1941. Strict quarantine measures were practiced but the nematode has been found recently in upstate New York and in Canada. Now, nearly 40 years later, the records indicate that it is 14 to 20 years from inoculation of a field until the pest is prevalent enough to be conspicuous and from then on its numbers are adequate to reduce yields significantly. Soil from other potato-growing regions that comes to Alaska on the roots of nursery stock, or that which accompanies potted plants, should be handled with the realization that it could contain golden nematode.

OPPORTUNITIES FOR THE POTATO ENTERPRISE IN ALASKA

A region as remote as Alaska from other commercial potato-growing areas and as free from potato maladies should be utilized for its potential to produce clean seed economically. Other regions that are attempting to produce clean seed have a tremendous investment in laboratory facilities and personnel to check potatoes for cleanliness. They also have a continuing fight with pests to keep them out of their foundation potato stocks.

An educational campaign to acquaint the public with the clean aspect of this region for potato growing is highly desirable. The enforcement of an inspection service to prevent contamination and the surveillance of imports to prevent further contamination is essential to maintaining this environment.

Even though there is a well-supported movement in the lower latitudes to produce potatoes from direct seeding in the field of true seeds, not seed pieces, there remains a vast part of the world in which the growing season is too short to produce a potato crop in the field from true seeds. These areas need clean seed tubers. The potential and know-how exists for such production in Alaska.

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FIGURE CREDITS

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