OCCURRENCE AND RELATIVE IMPORTANCE OF POTATO TUBER DISEASES IN LEBANON

by

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A Thesis Submitted to the Graduate Faculty

of the School of Agriculture in Partial Fulfillment of

The Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Plant Pathology-Entomology

Approved:

In Charge of Major Work

Chairman, Graduate Committee

American University of Beirut

1958

POTATO DISEASE SURVEY

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ABSTRACT

This research was conducted for three years, 1955, 1956, and 1957 to survey tuber diseases present in Lebanon. Potato in Lebanon, as in other parts of the world is an important source of carbohydrate. It is planted extensively for human consumption.

Locally, potatoes are planted mainly in the Bekaa plain, where the summers are hot and dry. To a lesser extent, it is planted in the mountain region and as a winter crop on the coastal strip.

Many microorganisms are known to attack the potato plant and the tubers, in the field, and later the tubers during storage. Of these microorganisms, Phytophthora infestans, Actinomyces scabies, Erwinia atroseptica, Rhizoctonia solania, Spongospera subterranea, Bacterium solanacearum, Fusarium spp. and leafroll virus had previously been reported to be present. Macrophomina phaseoli, Pythium debaryanum, Corynebacterium sepedonicum, Fusarium spp. Erwinia carotovera, Actinomyces scabies, Penicillium spp. Phytopthora infestans, Spongospera subterranea and in addition, the following disorders, internal brown spot, vascular necroses, hollowheart and tuber deformities were observed and identified during the survey.

The diseases that were found to occur most extensively were; dry rot, caused by Fusarium spp. ; charcoal rot,

caused by *Macrophomina phaseoli*; vascular necroses and internal brown spot.

Storage losses caused by some of these microorganisms take a large portion of the farmers' profits. Injuries due to rough handling during harvesting and storage facilitate the initiation and spread of infection by many of the microorganisms that cause heavy losses in storage. Development and spread of disease are further increased by storage temperatures above the optimum.

Macrophomina phaseoli and *Fusarium* spp. cause the greatest post-harvest losses. The latter is much more important economically than the former. Vascular necroses and internal brown spot are not so important economically, because both are internal disorders which do not show externally and do not cause decomposition of tissue.

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INTRODUCTION

The potato (Solanum tuberosum) is one of the most popular crops planted for human consumption, especially in the Western world, where it is the main source of carbohydrate food for many people. It is grown throughout most of the world.

Potato production (3) in the world for the year 1954 was the highest of all field crops. The total world production for potatoes was 166.9 million tons followed by rice 162.2 million tons, wheat 151.5 million tons and corn 137.3 million tons.

Russia which is followed by Germany, Poland, France and the United States heads the list in potato production. Lebanon plants (3) an average area of 4.5 thousand hectares, yielding approximately 41 thousand tons annually*. The potato crop ranks third in area and second in total yield among the field crops, and first in area and yield among vegetable crops in Lebanon.

There are three main potato producing regions in Lebanon. Approximately 30 percent of the crop is produced in two of these regions, namely the Coastal Plain and the Mountain Region, and the remainder is produced in the Bekaa Plain.

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*Average yield for 1948-1955 inclusive.

The Coastal Plain comprises the strip along the coastline, however the bulk of the crop in this area is produced in the North, in the Akkar Plain. Here the potato is planted twice a year, the first planting takes place in February without irrigation. The second crop is planted in June and is irrigated. The growing season for each crop is approximately 120 days. The winter temperature is not cold, seldom reaching 0°C. Average annual rainfall is 34.66* inches (2).

The potato in the Mountain region is planted mainly in the Laklouk area and to a lesser extent around Bikfaya. In the latter area it is raised as a garden crop thus yielding excellent tubers, as a result of which, the potatoes receive a premium price in the market. Planting starts just after the danger of frost is over. Average annual rainfall in the mountain region is 51.1* inches (2); the summers are rather cool.

Approximately 70 percent of the potato crop is grown in the Bekaa Plain. It is planted from February to early July. Although in February there is danger of frost, the farmers take the risk in order to save on irrigation water and also to get an early crop to market. Normally five irrigations are given during the growing season. Harvesting is usually over by the middle of October. Average annual rainfall in this region is 27.97* inches (2).

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* Average rainfall for years 1950-1956.

There is a common procedure followed by most farmers in harvesting the tubers. After the vines are pulled the field is plowed by an ox-powered or pulled plow. The tubers are then picked in burlap sacks and dumped in a central pile in the field, where they are often kept for 3 to 4 days under the hot summer sun of the area; the pile is usually covered from direct sunlight. Later the tubers are sorted, sacked, and taken to warehouses where another sorting takes place. After 3 to 4 weeks, resorting is repeated after which the tubers are sold to the consumers.

The potato in Lebanon as in other parts of the world has many diseases and parasites. However, losses suffered by the Lebanese farmer are greater than by farmers in Europe and the United States. This excess in loss is due to a small extent to the seed potatoes used. Although a large number of the farmers plant certified seed, some still use their own seed potatoes. The certified seed for 1955, 1956, 1957, was imported mainly from Holland and Ireland, while for the year 1958, the bulk was imported from Germany and Yugoslavia, in the hope of having better yields and less loss due to tuberborne organisms.

There are many diseases which attack the vegetative parts and the tubers, both in the field and in storage. Not all of these diseases cause serious losses everywhere potatoes are grown. Nevertheless, there are few if any, of the known diseases of potato which do not assume economic importance in one or more of the potato growing areas of the world.

For the most part, the diseases of the aerial portions of the plant are rather obvious and, in many cases, control can be instituted after the first symptoms are observed thus preventing heavy losses. Unfortunately, many of the tuber diseases do not become apparent until after harvest and, in some cases, not until after the tubers have been stored for some time. Such diseases as these cause considerable loss in Lebanon, consequently, this survey was conducted to determine which tuber diseases are most prevalent in Lebanon, and which cause the most serious loss.

REVIEW OF LITERATURE

Although no systematic survey of potato tuber diseases has been previously conducted in this area, various diseases have been recorded by some workers in Lebanon.

Moubarak (44) has reported the following tuber attacking diseases on potatoes in Lebanon. Phytophthera infestans, Actinomyces divers, Fusarium sp., Erwinia atroseptica and Leafroll. Adel Abou-Nasser (1) reported the presence of Phytophthera infestans, Rhizoctonia solani, Alternaria solani, Spongospora subterranes, Actinomyces scabies, Bacterium solanacearum, and Leafroll.

The relative and potential importance of these and various other diseases cannot be properly determined without some knowledge and understanding of each disease, the causal organism, and the relation of environment and cultural practices to the incidence and severity of disease.

Bacterial Soft Rot: Erwinia carotovora (L.R. Jones) Holland.

Bacterial soft rot is worldwide in distribution. The organism lives in the soil on decaying plant residue and sometimes overwinters in the tubers.

Erwinia carotovora is the causal agent of the common soft rot found on many vegetables. A closely related organism, E. atroseptica, (Van Hall) Jennison, causes black-leg on the growing potato plant (65).

Infection takes place through the lenticels (57). Davidson (12) grew some potato tubers in a wet soil and found that the bacteria entered through proliferated lenticels, and the higher the soil moisture the higher was the lenticel infection. Infection occurred most frequently in the stem-end and involved approximately two thirds of the tuber.

The cork layer which is normally formed beneath the complementary cells is absent in actively proliferating lenticels in wet soils; therefore these proliferating lenticels are not protected against the entrance of such soft rot organisms. The actively growing cells are further predisposed to infection due to the insufficiency of oxygen in wet soils to suberize complementary cells and for cork formation. High nitrogen levels in the soil tends to increase lenticel infection, which is probably due to the increased rate of cell proliferation.

The development of lenticel infection is retarded by soil temperature of 18^{o}C or below and is increased at higher temperatures. All tuber initials on plants grown in saturated soils at 39^{o}C become infected within 24 hours, whereas the initials on plants grown at 4^{o}C and 18^{o}C required 96 hours for infection. In Davidson's study bacterial infection occurred only through lenticels.

Experiments conducted by Conroy (8) to determine the susceptibility of two potato varieties showed that Sebago was very susceptible while Sequoia was not as susceptible as Sebago, and the experiment revealed that tuber pieces from infected plants are not important as sources of infection provided there is reasonable care in the selection of tubers before planting.

Black Scurf of Potatoes: *Pellicularia filamentosa (Pat.) Rogers.*

Black scurf of potatoes was first described by Kuhn in Germany in 1858.

The fungus can survive in the soil, also can overwinter as sclerotia on the potato tuber. Elmer (16) studied the fungus with relation to temperature; he found that the fungus cannot survive in the soil during the hot dry summers of Kansas. The sclerotia had a germinating range from 8 to 30°C; the optimum was found to be 23°C.

Thirumalachar (63) reported that black scurf of potatoes was extensive in the plains and hills of India, where potatoes are grown.

Charcoal Rot: *Marcrophomina phaseoli* (Maub.) Ashby.

Charcoal rot of potatoes is a common disease in the Mediterranean region and Southern United States. It is of an economical importance in the Bihar region of India (63) where the loss ranges from 0 to 70 percent depending on the susceptibility of the variety and the predisposing factors. In Tennessee (17) 33 to 50 percent of Irish Cobbler and Kennebec potatoes were infected in 1952. In Palestine 5 percent of the potatoes were discarded in the field every year, this sometimes rose to 50 percent in storage (37).

The causal organism is Macrophomina phaseoli. It is a soil inhabiting fungus. The loss caused by the organism is determined by its presence in the soil, susceptibility of the potato variety and soil temperature (64). The amount of damage done increases in high temperature, and prolonged storage of the tubers in the soil after the soil temperature reaches 32°C. Storage at 5°C prevents the development of the rot. The fungus enters the tubers through the proliferating lenticels. Early planting seems to reduce the incidence.

According to Thirumalacar (64) charcoal rot is caused by Botryodiplodia phaseoli (Maub.) Thirm. It causes the appearance of charcoal color type involving the blackening of the lenticels and killing the eyes of the tubers. It may also cause a dry rot type in which black sunken areas on the tuber surface appear that could be mistaken for the dry rot caused by Fusarium coeruleum (Lib) Sacc.

According to Walker (65) lesions on the tubers appear as soft blackened areas. The decayed tissue is darker in color and the rot is usually confined to the periferal tissue of the tuber.

Common Scab: Actinomyces scabies (Thaxt.) Waks. and Henrici

In 1890 Thaxter (62) first proved that common scab of potatoes is caused by an inciting agent which was found to be Actinomyces scabies.

Rich (49) reported that common scab was a problem in Moses Lake Area, Washington during the growing season of 1949, it was specially important on white Rose variety. Warren (68) reported that scab was a major economic loss to growers in the Canal Point and Belle Glade areas from June 1945 to June 1950. According to Hooker and Kent (28) the pathogen Actinomyces scabies causes the most important disease of potatoes, specially in areas that have high calcarious soils. On the other hand it was reported that, in general, scab was less severe in acid soils. Gillespie and Hurst (22) consider a pH of 5.2 to be the critical level above which scab became severe. Steinmetz (60) found that the increase in scab to be in direct relation to the increase in pH level above 5.5. Cook and Houghland (9) found that scab was significantly more severe in plots where the pH level was from 5.2 to 6.0 than from a pH of 4.7 to 5.1. However, scab had been reported to occur in soil of pH 3.5 to 3.8. Blodgett and Cowan (5) demonstrated in an experiment with potatoes that the scab incidence was reduced by increasing relatively the acid conditions from a pH of 5.6 to 4.7 and that scab was progressively less severe as the pH increased from neutrality to 9.0. A field survey by Goss (24) showed a very consistant decrease in scabby tubers from pH 5.9 to 8.2

Stanford (59) found that potato scab increased with decrease in soil moisture. This latter finding was also confirmed by Martin (40). Terman et al (61) report that there was a more rapid and increased incidence of scab on potatoes grown in the poorly drained Washburn loam soils as compared to the potatoes grown on the highly colored and well drained Caribou loam soils.

Dippenaar (13) in his studies on temperature and moisture as related to scab development, found that the optimum temperature for infection was slightly above 20°C and that scab decreased with the increase of moisture content of the soil. Goss (24) later emphasized these factors in addition to the effect of aeration on the soil flora. He found that the absence of soil aeration before infection decreased the disease more than poor aeration after infection.

Control of scab was found by Menzies (42) to be obtained only when pH of soil was 8.1 and above. From the results obtained, by the latter investigator, it was deduced that scab in alkaline soil responds both to calcium and to pH levels and that when the pH is raised above 8.0 the control of the scab varies with the source of calcium used. The control correlated with the solubility of the calcium compound in that an increased solubility gave a better control. Later Menzies (43) experimented on certain soils in Yakima Valley in Washington and found that these soils were able to check the spread of potato scab even after infesting the soil with the pathogen. He believed that this suppressing factor was other than the pH of the soil.

A survey was conducted by Richardson and Heeg (51) to determine the incidence of potato scab in Southern Ontario during the years 1948 and 1949. This survey showed that common scab occurred from less than 1 percent in certain fields to more than 33 percent in other fields. They also found that there was a relationship between the disease incidence and the pH of the soil. The low scab incidences was associated with fields whose pH value were below 5.5. No association was observed with soil texture or amount of fertilizer added. This survey seems to support the previously reported experimental results.

Fusarium Rot: _Fusarium_ _spp_.

At the turn of the century investigators found several species of the genus _Fusarium_ (Links) to cause tuber rot of potatoes. Ramsey _et_ _al_ (48) were able to find two kinds of rot, a dry rot and a wet rot. The dry rot is formed by the slow work of several _Fusaria_ species and in the watery rot the causal organism decays the whole tuber in a short time. They also stated that all _Fusaria_ are soil inhabitants and cause infection through two main pathways during the growth of the tuber by growing into the stem-end from infected stolons and by entering through the eye, wounds and lenticels of the tuber. They also found that _F_. _radicicola_, _F_. _oxysprorum_, _F_. _eumartii_, _F_. _solani_, _F_. _avenaceum_ can attack the growing plant as well as the tubers.

Wollenweber (69) worked on the genus _Fusarium_. He was able to establish the pathogenicity and the infectious nature of _F_. _discolor_ var. _sulphureum_ (Lila) Sacc. Jamieson and Wollenweber (30) were the first to describe _F_. _trichothi_-

cioides as the causal organism of dry rot of tubers. In their experiments they found that most rapid penetration took place at a temperature of 10-12°C with low humidity. Later Wollenweber added three new species, F. ventricosum, F. rubiginosum and F. subulatum.

Carpenter (7) working with F. oxysporum, F. vasnifectum F. hyperoxysproum, F. radicicola and F. eumartii, found that these can cause potato tuber rot, and that the action of F. radicicola, F. eumartii and F. oxysporum were inhibited under constant storage temperature below 10°C. He also stated that most of the species of Fusarium which were able to destroy potato tubers belong to sections, Elegans, Martiella and Discolor, as established by Wollenweber (69). According to Ramsey et al most species require relatively high temperature for optimum growth. They grow best at 25 to 30°C and most of them grow very slowly below 10°C.

Goss (25) found that when tubers were inoculated with F. solani and kept in a moist chamber for 12 days the tissue of the tuber became light brownish in color.

McKee (41) extracted some sap from tissues near healed wounds in potato tubers which proved toxic to the spore of Fusarium coeruleum owing to the presence of solanine which accumulated rapidly in such tissue.

Internal Brown Spot

Internal brown spot is a nonparasitic disease characterized by brown spots scattered throughout the flesh of the potato tuber. This disorder is identical to "sprain" which is the English term used for it, "chocolate spot" is another synonym used in Lebanon.

Experiments were conducted by Friedman (20) to find if this disease predisposes the potato to tuber rots. No change was observed during the storage of Green Mountain potato tubers infected with internal brown spot. He concluded that it was unlikely for the occurance of internal brown spot to be conductive to the rotting of the potato tuber or that it predisposed the tuber to decay.

Later, Friedman (21) carried on another experiment to determine whether internal brown spot was associated with hot dry weather. He observed that internal brown spot was prevelant in long Island and New Jersey in tubers grown during the growing seasons of 1948, 1949 and 1953 and the disease was uncommon or absent during 1950, 1951 and 1952. During 1948, 1949, 1952 and 1953 one or more heat wave occurred followed by one day of little rainfall, in contrast, the heat wave of 1952 was followed by considerable rainfall. In 1950 there was no hot weather and rainfall was normal. Rainfall in 1951 was much below normal but there were no heat waves. In the summers of the 6 years from 1948-1953 Internal brown spot of potatoes was prevelant only when hot dry weather occurred, followed by one day of light rain.

Several experiments were conducted under different climatic conditions to determine the susceptibility of different potato varieties against the Internal brown spot.

Ellison (14) found under Long Island conditions and after 4 years of planting that Katahdin, Mohwak, Pontiac, Kennebec and Chippewa showed relative resistance, while Ashworth showed high consistent susceptibility; Sebago, Ontario, and Essex showed great fluctuation from year to year. Ellison and Jacob (15) showed that Green Mountain was more susceptible than Katahdin especially when planted early, in Long Island and under different cultural conditions and dates of planting.

In Lebanon, Smith (56) conducted an experiment to see if there was any correlation between the amount of sulphur and internal brown spot, results showed negative correlation.

Leak - Pythium debaryanum Hesse.

Leak, caused by Pythium debaryanum Hesse, is a soil inhabiting organism which invades the potato through harvest wounds. Rapid watery decay follows during which water is released through the tuber (65).

Pearson (45) was able to isolate a fungus from Triumph and Khatahdin varieties in Louisiana during a tuber rot outbreak in 1941. This fungus was found to be Phythium debaryanum. Later in 1943 Goss and Jensen (26) were able to isolate a Pythium fungus. When this was inoculated into healthy tubers "Leak" symptoms were observed. More infection was observed at a soil temperature of 22°C than at 30°C. Maximum tuber rot was observed at 25°C. Some rot was observed at 5°C, 10°C and 35°C.

Powdery Scab: Spongospora subterranea (Wallr.) (Lagerheim)

Powdery scab was first described by Wallroth in Germany in 1842 (65).

Spongospera subterranea is the inciting organism, it causes the formation of slightly brown raised areas which can enlarge to about 1/2 cm. in diameter. Later the diseased tissue becomes jelly like in texture (66).

The organism can persist in the soil, and has been known to survive for 14 years (39). Ramsey (47) studied the influence of temperature and moisture upon infection in Maine where he reported that in dry warm condition the disease did not appear in fields known to have the organism. He also found that in greenhouse experiments it developed on tubers when the soil moisture was relatively high and the temperature below $14^{o}C$.

Shultz (53) observed in Maine, that the blight-immune Kennebec potato has late blight infection when planted in fields known to be infested with Spongospera subterranea. Close examination showed that blight infected tubers to be closely associated with powdery scab lesions. Thirty percent of the powdery scab potatoes showed late blight infection, however none of the powdery scab free potatoes were infected. Thus it is thought that the nonsuberized powdery scab sori act like injuries serving as infection points in blight immune potato.

Ring Rot: Corynebacterium sepedonicum (Sieck. Kotth.) Skapt. & Burk.

Ring rot was first observed by Appel in 1906. Later was described by Spieckermann (65). The causal agent, Corynebacterium sepedonicum was first suggested by Jensen in 1934. In 1942 Skaptason and Burkholder proved it to be so (55).

Corynebacterium sepedonicum overwinters on the potato or in dried slime in sacks and crates. There is no evidence that it persists in the soil, but it is known to spread in the field by irrigation.

The disease may not be seen at harvest time, but may appear later in storage. Early symptoms show a slight vascular discoloration turning brown with age in the ring area. Bacterial ooze becomes evident which increases on squeezing the tissue. It's presence can also be detected by the use of an Ultra Violet light which gives a greenish fluorescence (29).

Larson and Walker (34) 1941, observed no top symptoms at 16°C while severe stunting was observed on plants grown from infected tubers at 24°C. Logson and Edide (38) reported that temperature was a major factor contributing to ring rot epiphytotics in Alaska where 10-15 percent of the total crop was lost. Optimum soil temperature in Minnesota was found to be 25°C. At this temperature 100 percent of the plants became infected, 87 percent of which wilted completely. Sherf (54) secured maximum infection of stolons and tubers in plants growing at a soil temperature of 18°C.

Ring rot if present in seed potatoes to the extent of one percent, will result in 50 percent or more of the crop being infected. In Aroostook County, Maine, the certified potato growers suffered the loss of 80,000 dollars in 1938 (4).

A survey conducted by Darlington in the fields of 15 states showed that the average loss due to ring rot from 1940 to 1947 to be 7.44 percent (10). The infection in the United States and Canada was 7.8 percent in 1940; 14.8 percent in 1946 and 7.3 percent in 1947 (11). In Ontario 1643 farms were inspected, 17 percent showed infection in 1947; 15 percent in 1944; 9 percent in 1949; 21 percent in 1946 and 11 percent in 1947 (35).

Bonde and Covell (6) conducted an experiment to test the susceptibility of various varieties to ring rot. They found that Katahdin and Green Mountain gave 70 and 22 percent of infected plants respectively when inoculated tubers were planted. President, Teton, Sebago x 334-114, Earlane, 336-114 and 10 other varieties gave resistant seedling with no loss in tuber rot.

Vascular Necrosis

Vascular necrosis is a general term used to indicate the symptoms caused by leaf-roll virus on tubers, vascular *Fusaria* or the disorder causing stem-end browning.

In an experiment conducted by Soliman (58) it was found that the incidence of net necrosis in the potato tuber was not affected by the presence of latent virus X of potato.

In the presence of leaf-roll alone, current season tubers showed 20 percent net necrosis. Mild strain of X virus plus leaf-roll virus resulted in 25 percent infection. The presence of either virus A or Y in addition to leaf-roll virus seemed to decrease tuber net necrosis. Leaf-roll virus plus virus A resulted in 5 percent infection and virus Y plus leaf-roll virus gave 8 percent infection.

It was observed that the percentage of net necrosis depended to a great extent on the time of infection. Maximum net necrosis seemed to appear when infection took place in the middle of the season.

Kendrick (33) reported that necrosis was definitely associated with current season leaf-roll infection. Stem-end browning was not caused by any known virus infection but was definitely associated with length of the growing season. Some varieties show very pronounced tuber net necrosis resulting from current season infection, while others remain entirely free.

Folsom (18) made an extensive study as to the relation of storage to the development of net necrosis during the first two months of storage. These two months were most important in determining the amount of necrosis. The most favorable temperature was found to be 45-50°C.

Folsom et al (19) studied the effect of railroad transit on certain tuber diseases. They found that leaf-roll, net necrosis and stem-end browning increase in severity in transit.

Ross et al (52) reported in 1947 that the amount of stem-end browning was positively correlated with the amount of chloride and potassium in the fertilizer and net necrosis with the amount of phosphorous and chloride. They reported that these factors were rather contributive than causative.

Late Blight of Potato: Phythophthera infestans (Mont.) DuBary

Jones et al (32) found no reference to any potato disease in Europe prior to 1830 when this disease was first recorded. Late blight of potatoes occur in the cool humid regions of the temperate zones of the world, where it causes severe losses, sometimes destroying the total crop.

Walker (65) reported four criteria necessary for late blight attack in any region, which are; night temperature below the dew point for 4 hours or more, night temperature not below 10°C., rainfall of at least 0.1 mm the following day and mean cloudiness not below 0.8 on the following day. A knowledge of the environment required for the appearance of late blight in an area has made it possible to foreworn farmers of the possibility of an epiphytotic by the establishment of forecasting stations.

Investigations in Scotland by Grainger (27) showed that late blight would appear 15 to 22 days after a period of 48 hours or more of a relative humidity of greater than 75 percent and a temperature above 10°C. Johannes (31) in 1953 reported that late blight in Germany will appear after a 33 hour period of a temperature between 12.8°C and 17.8°C and a relative humidity of 95 percent and above, with a maximum of not more than 4.5 hours of a relative humidity not less than 82 percent.

Wallin et al (67) reported that late blight prediction could be made with great accuracy in areas in which forecasting stations were established. These predictions depended greatly on the weather. Periods of 10 hours or more of a temperature of 23.8°C and a relative humidity equal to or more than 90 percent followed by a maximum temperature less than 35°C were used in the prediction of the occurrence of late blight.

MATERIALS AND METHODS

The survey was conducted over a period of three years, from 1955 to 1957, inclusive, in the Bekaa Plain where approximately 70 percent of the commercial potato crop is grown.

During the summer of 1955 several potato varieties were tested at the ICA/Lebanon Station at Terbol and at the University Farm at Housh Sneid. Both of these stations are in the Bekaa Plain. All plantings were kept under observation by the plant pathologist of the Faculty of Agricultural Sciences of the American University of Beirut throughout the growing season.

The potatoes at both locations were planted in mid-April and were harvested in mid-September. At both stations the supply of irrigation water was interrupted during the growing season, thereby contributing to reduction of yield.

At harvest time the tubers were stored for eight weeks in a noncooled room and then examined for the presence of bacterial, fungal and viral diseases.

During the summer of 1956, a second varietal experiment was conducted at the University Farm at Housh Sneid and at Terbol Station. The potatoes were planted during the third week of March and were harvested during the first week of August.

Samples were kept for about three weeks in noncooled storage before they were examined for the presence of diseases.

In addition to the samples from the University Farm and the ICA/Lebanon Station at Terbol, several more were obtained from commercial growers at Ameek, Bar Elias, Ab-Elias, Furzul, Taanayel, Housh-el-Umara and Kafar Zabad.

The samples obtained from Furzul, Housh-el-Umara and Bar Elias had been sorted once and had been in storage in the vicinity for two weeks. These samples were stored in non-cooled room for an additional two week period before any examination was conducted.

During the summer of 1957 the third potato varietal experiment was conducted at the University Farm and Terbol Station. The tubers at the University Farm were planted at the end of March and harvested during the third week of August. The plantings at Terbol Station were designed to test the effect of different planting dates on the rate of yield of each variety. Thus, the first planting was during the fourth week of March, the second, during the first week of April, the third about the middle of May, and the last planting was in mid-June. Harvesting started on August 20, and continued at one month intervals for each consecutive planting.

In addition to the potato tubers obtained from various experiments, samples were also obtained from commercial growers at Dalhamiah, Housh Halah, Bar Elias, Muallaka, Ameek and Terbol village. All samples were kept for two weeks in noncooled storage before they were examined.

Where possible the size of the sample was one hundred tubers; but, in many cases, samples were smaller due to the limited number of tubers available, especially in the varietal experiments.

In a few cases the number of tubers in a sample was greater than one hundred. In such cases the samples were a composite of samples in the area.

First, the tubers were examined thoroughly for the presence of external defects, abnormalities or disease symptoms on the tuber skin. After the thorough external examination the tubers were cut horizontally one cut at each end, followed by a longitudinal cut to observe the internal tissue for any disease symptoms that were present. The kinds of diseases were recorded. In case of doubt as to what the disease might be isolations were made in duplicate on potato dextrose agar and nutrient agar.

The organisms thus obtained in pure culture were identified, and known symptoms caused by them were compared with the symptoms observed in the sample.

It will be noted that, in all cases, tubers were stored in a noncooled room for a period prior to examination. As previously stated, the growers and buyers sustain rather heavy losses during storage in rather cool, but not refrigerated, storage rooms. It was felt that a two to three week period at room temperature would permit sufficient development of diseases present to allow for relatively rapid and easy identification without any appreciable amount of spread of disease within the sample.

RESULTS AND DISCUSSION

Examination of the data from table I through IX inclusive shows that infection due to Fusarium spp. was quite severe throughout the survey.

Internal brown spot shows in many varieties and locations. Close examination shows that the occurrence on Arran Banner is more than on any of the other varieties, except in one case where it shows on Professor Brockema; however, the latter was grown in only one plot in all the three years.

Charcoal rot, soft rot and ring rot are potentially and economically important diseases. In 1954, one year before this survey was started, ring rot was very severe. It was observed during that year on a 20-dunum field of potatoes; the field was not harvested due to almost 100 percent infection. In the adjoining 20-dunum field the plants appeared to be healthy and a normal crop was harvested. However, over fifty percent of the harvested crop was lost in storage due to the development of incipient infection which had not been evident to the grower at harvest. It was later found that the seed potatoes used in the first case were locally grown; but those planted in the adjoining field were certified seed potatoes. The loss in the latter field could be accounted for by the fact that both fields were irrigated at the same time and the irrigation started in the infected field and then continued to the lower clean field. Furthermore cultivation of both fields was done at the same time so that the equipment transmitted the inoculum from one field to the other. The benefits to be derived from the use of certified seed potatoes were nullified by planting non-certified potatoes in an adjoining field.

From the data, it is further seen that there was a high percentage of vascular necrosis. Although many of the tubers were infected, there was no loss to the farmer due to lower prices because this disease is an internal disorder and does not show externally.

Further examination of the data indicates no consistent differences between the results at Terbol and those at Hosh Sneid, year by year, except in the case of internal brown spot and vascular necrosis, which were consistently higher at Hosh Sneid than at Terbol; but which do not generally cause losses in storage.

In addition to the above named diseases there were also moderate incidences of potato tuber moth, Gnorimoschema operculella (Zell.), at time of harvest. The larvae of this moth tunnel through the tuber causing paths of infection and serving as agents of dissemination of micro-organism. In a non-refrigerated room these moths increase very rapidly, resulting in a very high percentage of damaged tubers. In general, deep planting is rather effective in controlling this insect in the field.

Table I. Incidence of Potato Tuber Diseases and Defects at Two Locations in the Bekaa Plain in 1955.

Variety	No. of Tubers	Location	Percentage of tubers exhibiting symptoms of: Fusarium rot	Internal Br. spot	Charcoal rot	Vascular necrosis
Alpha	200	Hosh Sneid	26	0	22	26
Alpha	50	Terbol	48	0	12	18
Ari	100	Hosh Sneid	19	5	13	50
Arran Banner	100	Hosh Sneid	32	25	5	37
Arran Banner	50	Terbol	90	0	0	8
Bintji	50	Terbol	70	0	4	32
Bintji	100	Hosh Sneid	16	0	12	29
Cherokee	100	Terbol	78	0	0	12
Delta	100	Terbol	24	0	0	2
Eigenhiemer	100	Terbol	44	0	4	32
Ergold	100	Terbol	80	0	0	26
Furore	100	Terbol	52	0	0	4
Graig's Defiance	100	Terbol	74	0	0	28
Ideal	100	Terbol	74	0	0	26
Industrie	50	Terbol	42	2	0	54

Table I. Cont'd.

Variety	No. Tubers examined	Location	Percentage of tubers exhibiting symptoms of:			
			Fusarium rot	Intemal Br. spot	Charcoal rot	Vascular necrosis
Katahadin	50	Terbol	54	8	2	26
Kennabec	50	Terbol	All were rotten before examination.			
McIntosh	50	Terbol	36	0	8	26
Rode Ersteling	50	Terbol	88	0	0	4
Sacco	50	Terbol	86	0	0	0
Up-to-Date	100	Hosh Sneid	14	0	16	54
Up-to-Date	50	Terbol	64	0	2	34
Voran	100	Hosh Sneid	32	8	10	44
Voran	50	Terbol	46	0	6	48
Wysfoborski	50	Terbol	96	2	0	32

Table II. Incidence of Potato Tuber Diseases and Defects at Two Locations in the Bekaa Plain in 1956

Variety	No. of Tubers	Location	Percentage of tubers exhibiting symptoms of:						
			Fusarium rot	Internal Br. spot	Soft rot	Charcoal rot	Vascular necrosis	Ring rot	Hollow heart
Alpha	50	Hosh Sneid	60	0	8	0	24	0	4
Ari	20	Hosh Sneid	22	28	16	0	11	0	16
Arran Banner	50	Terbol	14	20	0	0	30	0	4
Arran Banner	50	Hosh Sneid	68	8	12	0	36	0	4
Benji	20	Hosh Sneid	10	0	20	0	50	0	4
Benji	50	Terbol	18	0	6	0	22	0	0
Climax	50	Hosh Sneid	28	0	18	0	8	0	12
Elanox	50	Terbol	12	0	0	0	2	0	6
Ersling	50	Terbol	12	2	4	0	22	0	4
Prof. Broekema	50	Hosh Sneid	28	28	0	0	0	0	0
Sacco	50	Terbol	15	0	0	2	17	2	0
Up-to-Date	50	Hosh Sneid	32	2	14	0	48	0	2
Up-to-Date	50	Terbol	30	0	0	0	18	6	8
Urganta	50	Terbol	10	0	0	0	24	0	4
Voran	50	Hosh Sneid	6	0	2	0	58	0	0

Table IV. Incidence of Potato Tuber Diseases and Defects at Terbol Station found on the Tubers of the First Planting in March 1957.

Variety	No. of tubers	Location	Fusarium rot	Percentage of tubers exhibiting symptoms of: Internal Br. spot	Charcoal rot	Vascualr necrosis	Ring rot	Pythium "Leak"	Others
Alpha	25	Terbol	16	0	0	80	0	0	
Ari	40	Terbol	30	0	15	15	0	5	H.Heart 5 S.Rot 5
Arran Banner	40	Terbol	44	4	0	8	0	0	
Benji	40	Terbol	44	0	0	62	0	0	S.Rot 3
Cherokee	40	Terbol	25	0	3	15	18	0	
Climax	25	Terbol	48	0	0	16	0	8	S.Rot 4
Katahdin Baladi	25	Terbol	16	0	0	12	0	0	
Kennebec	40	Terbol	30	0	0	10	0	0	
Pontiac	25	Terbol	0	0	0	0	0	0	
Russet Burbanks	25	Terbol	24	0	0	16	0	0	
Sebago	40	Terbol	5	0	0	0	0	0	
Up-to-Date	25	Terbol	25	0	0	12	0	0	

Table V. Incidence of Potato Tuber Diseases and Defects at Terbol Station found on the Tubers of the Second Planting in April 1957.

Variety	No. of Tubers	Location	Percentage of Tubers exhibiting symptoms of: Fusarium rot	Internal Br. spot	Soft rot	Charcoal rot	Vasc. necr.	Pythium "Leak"	Ring rot
Benji	25	Terbol	36	0	8	4	56	0	0
Bierma	50	Terbol	8	0	2	0	20	0	0
Cherokee	40	Terbol	26	0	8	5	15	0	40
Climax	25	Terbol	28	0	4	8	20	12	0
Ergold	40	Terbol	13	0	0	0	25	0	0
Green Mountain	50	Terbol	12	0	0	0	28	8	7
Green Mt. Baladi	25	Terbol	40	0	0	0	68	12	12
Katahdin Baladi	25	Terbol	32	0	4	4	24	4	8
Kennebec	25	Terbol	4	0	0	0	8	4	0
Kennebec Baladi	25	Terbol	40	0	4	0	32	0	12
Profijet	40	Terbol	35	0	0	0	80	0	0
Raf Bucheney	25	Terbol	4	0	0	0	16	0	0
Tedria	25	Terbol	20	0	0	4	44	0	24

Table VI. Incidence of Potato Tuber Diseases and Defects at Terbol Station found on the Tubers of May Planting 1957.

Variety	No. of Tubers	Location	Percentage of Tubers exhibiting symptoms of: Fusarium rot	Soft rot	Charcoal rot	Vascular necrosis	Pythium "Leak"
Arran Banner	40	Terbol	2	8	0	40	3
Cherokee	40	Terbol	5	5	0	0	5
Green Mountain	40	Terbol	18	23	3	33	3
Katahdin	50	Terbol	8	4	2	30	0
Kennebec	25	Terbol	16	32	4	8	0
Pontiac	25	Terbol	12	16	0	40	0
Russet Burbanks	60	Terbol	7	10	0	40	0
Up-to-Date	25	Terbol	8	0	0	72	4

Table VII. Incidence of Potato Tuber Diseases and Defects at Terbol Station found on Tubers of June planting 1957.

Variety	No. of Tubers	Location	Percentage of Tubers exhibiting symptoms of: Fusarium rot	Internal Br. Spot	Soft rot	Vascular necrosis	Pythium "Leak"	Ring rot	Hollow Heart
Arran Banner	40	Terbol	1	5	0	25	0	15	0
Cherokee	25	Terbol	12	0	0	4	8	0	0
Green Mountain	70	Terbol	6	5	0	30	5	0	5
Kennebec	50	Terbol	0	0	0	10	0	0	0
Pontiac	40	Terbol	5	0	0	15	0	5	0
Russet Burbanks	40	Terbol	5	0	0	5	5	0	0
Up-to-Date	25	Terbol	16	4	4	28	8	0	4

Table VIII. Incidence of Potato Tuber Diseases and Defects at the A.U.B. Farm in Hosh Sneid and at Jabouli in 1957.

Variety	No. of Tubers	Location	Percentage of tubers exhibiting symptoms of: Fusarium rot	Internal Br. Spot	Soft rot	Char. rot	Vascular necrosis	Pythium "Leak"	Others
Alpha	80	Hosh Sneid	20	0	8	0	47	0	0
Ari	50	Hosh Sneid	8	16	4	0	48	0	0
Arran Banner	100	Hosh Sneid	16	2	0	0	12	2	H.Heart 2
Arran Banner	50	Jabouli	20	0	0	0	32	3	1
Bea	80	Hosh Sneid	18	5	10	0	27	0	0
Benji	80	Hosh Sneid	8	0	0	0	47	0	C.Scab 2
Bierma	40	Hosh Sneid	5	0	8	0	40	0	0
Climax	80	Hosh Sneid	3	0	3	0	50	0	0
Katahdin	40	Hosh Sneid	0	10	0	0	50	0	Ring R.10
Katahdin	25	Jabouli	14	0	0	4	40	4	0
Kennebec	40	Hosh Sneid	5	0	0	0	10	0	0
Kennebec	15	Jabouli	7	0	0	0	33	0	0
Pontiac	50	Hosh Sneid	4	0	4	0	4	0	Ring R. 8
Pontiac	33	Jabouli	13	0	0	9	18	0	0

Table VIII. Cont'd.

Variety	No. of Tubers	Location	Percentage of tubers exhibiting symptoms of: Fusarium rot	Internal Br. spot	Soft rot	Char. rot	Vascular necrosis	Pythium "Leak"	Others
Prof. Brockema	100	Hosh Sneid	5	40	4	0	0	0	0
Profijet	80	Hosh Sneid	15	0	0	0	50	0	0
Russet Butbanks	40	Hosh Sneid	9	3	0	0	13	0	0
Russet Burbanks	25	Jabouli	40	0	1	8	40	8	0
Sebago	10	Jabouli	10	0	0	0	40	0	0
Sebago	50	Hosh Sneid	17	20	1	7	13	2	0
Sertima	40	Hosh Sneid	13	12	0	0	17	0	H.Heart 1
Sientji	80	Hosh Sneid	0	0	0	0	37	25% had deformed shapes	
Tedria	80	Hosh Sneid	0	0	3	0	32	14% had deformed shapes	
Up-to-Date	40	Hosh Sneid	13	0	3	0	30	0	0
Up-to-Date	50	Jabouli	46	0	0	0	80	0	0

Table IX. Incidence of Potato Tuber Diseases and Defects on Arran Banner and Up-to-Date in Several Locations in the Bekaa Plain in Summer 1957.

Variety	No. of Tubers	Location	Percentage of tubers exhibiting symptoms of:						
			Fusarium rot	Internal Br. spot	Soft rot	Char. rot	Vasc. necr.	Hollow heart	Others
Arran Banner	100	Dalhamieh	18	29	5	1	26	0	0
Arran Banner	150	Hosh-Halah	10	3	1	0	25	0	0
Arran Banner	175	Muallaka	41	30	1	1	19	1	0
Arran Banner	80	Ameek	31	18	21	0	25	0	0
Arran Banner	100	Hosh-el-Umara	28	40	0	0	24	0	0
Arran Banner	225	Terbol vil.	13	16	7	2	32	0	Common Scab 1
Arran Banner	80	Bar-Elias	11	11	3	0	25	0	0
Arran Banner	100	Hosh Sneid	4	4	8	0	30	0	0
Up-to-Date	100	Terbol vil.	4	4	6	2	36	0	0
Up-to-Date	150	Dalhamieh	5	0	0	1	32	0	0
Up-to-Date	75	Hosh-Halah	12	0	10	0	36	0	Ring Rot 1
Up-to-Date	100	Bar Elias	20	0	4	2	48	0	0
Up-to-Date	100	Hosh Sneid	16	2	0	0	12	0	Penecillium 16

It seems apparent from table X that all varieties except Sientji show Fusarium rot. This variety was planted in a varietal experiment in one location and only once. It is evident that Fusarium rot is a widely-spread disease in Lebanon, attacking all varieties of potatoes, and in some cases taking a toll of 88 to 96 percent of the tubers.

Vascular necrosis also is a very widely spread disease occurring in all varieties except Professor Brockema and Sientji. The remainder of the varieties show incidences as high as 68 percent in Green Mountain, but the majority show incidences between 15 and 30 percent. Those that show low incidence rates are usually those planted in the varietal experiments.

Internal brown spot shows in only about one third of the varieties surveyed, and the incidences are highest in Professor Brockema, Arran Banner and Ari. We can say that this disorder consistantly shows on Arran Banner while Professor Brockema had been planted only twice.

Charcoal rot, ring rot and soft rot are not serious on any of the varieties, except for charcoal rot in Ari variety where it occures on 7 percent of the tubers and ring rot in Cherokee where it occurs on 11.6 percent of the tubers.

The rest of the diseases are not as important.

Checking individual varieties shows that Up-to-Date and Arran banner are the only two varieties planted commercially. It should be noted that all diseases observed occurred on these two varieties and often in greater severity than on the others.

Table X. Mean Percentage Infection by Various Diseases for Each Variety in All Years and Locations

Variety	No. of samplings	Mean Percentage of Tubers Exhibiting Symptoms of: Fusarium Rot	Internal Br. Spot	Char. Rot	Vasc. necr.	Soft Rot	Ring Rot	Phythium "Leak"	Hollow Heart
Alpha	5	34	0	6.8	39	1.6	0	0	0
Ari	4	19.7	12.25	7.0	31	5	0	1.25	5.25
Arran Banner	19	24.9	13.94	0.5	23.1	3.5	0.8	0.50	0.8 Scab 0.05
Bea	1	18	5	0	27	10	0	0	1
Bentji	7	25.8	0	2.8	42.6	5.3	0	0	6 Scab 0.3
Bierma	2	6.5	0	0	27.5	5	0	0	0
Cherokee	5	29.2	0	1.6	9.2	2.6	11.6	2.6	0
Climax	4	26.7	0	2	23.5	7.2	0	5	2.4
Delta	1	24	0	0	2	0	0	0	0
Denemarky	1	26	0	0	20	0	0	0	0
Eighnhiemer	1	44	0	4	32	0	0	0	0
Elanox	1	12	0	0	2	0	0	0	0
Ergold	2	46.5	0	0	25.5	0	0	0	0
Erstling	1	12	2	0	22	4	0	0	4
Furore	1	52	0	0	4	0	0	0	0

Table X. Continued

Variety	No. of samplings	Mean Percentage of Tubers Exhibiting Symptoms of: Fusarium Rot	Internal Br. Spot	Char. Rot	Vasc. necr.	Soft Rot	Ring Rot	Phythium "Leak"	Hollow Heart
Graig's Defiance	1	74	0	0	28	0	0	0	0
Green Mountain	3	12	1.6	1	30.3	7.6	2.3	5.3	1.6
Gr. Moun. (Baladi)	1	40	0	0	68	0	.1	12	0
Ideal	1	74	0	0	26	0	0	0	0
Industrie	1	42	2	0	54	0	0	0	0
Kahtahdin	4	19	2.5	2	36.5	1	2.5	1	0
Kahtahdin (Baladi)	2	24	0	2	18	1	2	1	0
Kennebec	7	7.8	0	.6	11.3	4.6	0	.6	0
Kennebec (Baladi)	1	40	0	0	32	4	12	0	0
Mc Intosh	1	36	0	8	26	0	0	0	0
Pontiac	5	6.8	0	1.8	15.4	4.0	2.6	0	0
Professor Brockema	2	16.5	34	0	0	2	0	0	0
Profijet	2	24.5	0	0	65	0	0	0	0
Raf Bucheney	1	4	0	0	16	0	0	0	0
Rode Erstling	1	88	0	0	4	0	0	0	0
Russet Burbanks	5	17	0.6	1.6	22.8	2.2	0	2.6	0

Table X. Continued

Variety	No.of samplings	Mean Percentage of Tubers Exhibiting Symptoms of: Fusarium Rot	Internal Br. Spot	Char. Rot	Vasc. necr.	Soft Rot	Ring Rot	Phythium "Leak"	Hollow Heart
Sacco	2	50.5	0	1	21.5	0	1	0	0
Sebago	3	10.6	6.6	2.3	17.6	.3	0	.6	0
Sertima	1	13	12	0	17	0	0	0	1
Sientji	1	0	0	0	37		(25 showed deformed tubers)		
Tedria	2	10	0	2	38	1.5	(14 showed deformed tubers)		
Up-to-Date	19	19.4	2.1	1.1	38.1	2.2	.37	1	.7
Urganta	1	10	0	0	24	0	0	0	4
Voran	3	28	2.6	5.3	50	.6	0	0	0
Wysfoborski	1	96	2	0	32	0	0	0	0

Table XI shows and compares the mean percentage infection of all varieties for three consecutive years. A study of this table reveals that Fusarium rot, internal brown spot, charcoal rot and vascular necrosis are the only diseases appearing for three consecutive years. Soft rot, ring rot and hollow heart appear in two of the three years, and Pythium rot, penicillium rot, common scab and deformed tuber appeared only once.

From the table it is seen that the mean percentage of infection by vascular necrosis was almost similar in the three years, the maximum difference between any two years being 6 percent. Although this disease is listed as vascular necrosis, because of several possible causes, it was found that in a high percentage of the instances this necrosis was of the net type, which is commonly associated with current season infection by the leaf roll virus.

Fusarium rot seems to fluctuate from one year to the other. The highest mean infection occurred in 1955 when it was about four times the occurrance of 1957 and a little less than three times that of 1956.

The Fusarium rot organism lives in the soil and may invade the tuber through wounds and, or the stem-end of the tuber (65). As described in the introduction of this thesis, the method of harvesting in Lebanon causes a large percentage of the tubers to be either cut or bruised thus making a route for infection of the tuber. Walker (66) reported that it is important to avoid the bruising or otherwise wounding of tubers because wounds are important avenues for invasion by microorganism. The Fusarial organism is present in the soil; and if potato tubers are wounded during harvesting, the possibility of infection is increased. Storage of the tubers at temperatures considerably above the optimum for potatoes, result in a rapid development of organism and increased spread of infection.

Internal brown spot as mentioned before, is not known to be caused by any disease causing organism, but is thought to be due to certain physiological or environmental factors.

The loss due to charcoal rot is determined by the presence of the organism in the soil, varietal susceptibility, soil temperature and prolonged retention of mature tubers in the soil at high temperature (64). In 1957 the potatoes were harvested later than normal due to the fact that it was not economically feasible to harvest and store the potato because of the very low prices obtained, which in most cases were less than cost of harvesting. In 1955 the tubers examined were from experimental plots that were harvested quite sometime after maturity. This extended time in the soil could be the reason that the incidence of disease in 1955 and again in 1957 was much greater than in 1957.

Soft rot, ring rot and hollow heart did not occur in the samples in 1955. Prior to 1954 and 1955 there were very great losses from ring rot in this country.

Hollow heart is a condition found at harvest time primarily in large tubers which are grown under very favorable

Table XI. Mean Percentage Infection by Various Diseases in all Varieties and at all Locations.

Disease	Year 1955	1956	1957
Charcoal Rot	3.8	0.2	1.5
Common Scab	0	0	0.02
Deformed tubers	0	0	1.5
Fusarium	56.1	21.2	14.5
Hollow Heart	-	42.4	0.2
Internal Brown Spot	1.8	6.3	4.3
Penecillium	0	0	0.6
Pythium	0	0	0.8
Ring Rot	0	0.2	2.2
Soft Rot	0	3.2	3.4
Vascular Necrosis	25.6	21.9	27.9

conditions for rapid growth (65).

Pythium, *actinomyces*, and *penicillium* were observed only in 1957 and not in the previous years. The mean percentage infection in the above cases falls below one, thus indicating that at present the economic losses caused by these organisms are insignificant.

The deformed tuber shapes àre known as bottle neck, dumbbell and knobbyness. These are due, more or less to the number and frequency of irrigations, and the amount of nutrients added.

In addition to all the observed diseases in the survey the writer has found two more tuber diseases on some field trips to the coastal plain. These were observed in the winter season. The diseases were later identified as late blight caused by *Phytophthora infestans* and black scurf caused by *Pellicularia filamentosa*. Late blight is generally controlled in the coastal regions by use of chemical sprays. Black scurf is extremely minor in occurrence and no control is used.

There are four main potato tuber diseases in Lebanon, namely *Fusarium* rot, charcoal rot, Vascular necrosis and Internal brown spot. Of these four diseases *Fusarium* rot is of great economic importance, charcoal rot could become economically important in some years. Both of these are caused by soil inhabiting fungi; and in both cases the fungi are long lived and attack a wide range of host plants. If crop rotation is practiced it will be only moderately successful. Both are favored by high soil temperatures and high soil moisture, therefore it is helpful to dig the tubers before very hot weather prevails and, if possible, to avoid excessive soil moisture. In the case of Fusarium rot care should be taken not to bruise the tubers unnecessarily at digging time, and the tubers should be stored in the shade at about 20°C and at fairly high relative humidity for one or two weeks after harvest to promote rapid healing of bruised areas. In no cases should wet tubers be stored. If storage rots continue to be a serious threat to the potato harvest of Lebanon, it may become necessary to make use of post harvest disinfectants before storage.

Internal brown spot and vascular necrosis do not cause post harvest losses to the growers, because the disorder does not show externally and there is no appreciable deterioration of tuber tissue. If the vascular necrosis is due to the leaf-roll virus it is most probable that there will be a loss in yield. Not much can be done to prevent this, except to develop virus resistant varieties, to harvest early, and to control insect vectors of the virus.

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ACKNOWLEDGEMENTS

The writer wishes to express his appreciation to Dr. F. O. Smith for his advice, suggestion and valuable help given during the survey and for the constructive criticism and correction of the manuscript. He also, is grateful to Dr. A. A. Ahmadi of the American University of Beirut and Dr. J. Osgothorpe of the United States Operations Mission to Lebanon for supplying many of the samples. He also wishes to thank Mr. Adib Sa'd for his helping during collection and examination of the samples. Acknowledgements are also due to Dr. R. H. Porter for re-reading and correction of the manuscript.