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Supplement 59

Plant Diseases in Utah in 1927

May 15, 1928.

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PLANT DISEASE REPORTER
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WASHINGTON, D. C.

PLANT DISEASES IN UTAH IN 1927

A report of a plant disease survey
conducted with cooperative support of
the Utah Agricultural Experiment Station
and the Bureau of Plant Industry of the
United States Department of Agriculture

prepared by

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Plant Disease Reporter
Supplement 59

May 15, 1928

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INTRODUCTION

This report is based chiefly on the findings of a field to field survey conducted by the writer from June 15 to September 15, 1927, with joint support of the Utah Agricultural Experiment Station and the Office of Mycology and Disease Survey of the United States Bureau of Plant Industry. The purpose of the undertaking was to determine as accurately as possible the nature and extent of plant pathological problems throughout Utah. Accordingly, a large part of the time was spent in making field observations with appropriate notes and collecting specimens in as many of the agricultural areas of the state as time allowed. Travel by automobile permitted the carrying of necessary equipment at all times, including trowel, spade, small pick, pruning saw, vasculum, plant press, tallying register or mechanical counter, and portable microscope. The writer worked largely by himself, but he was graciously assisted at many times by members of the experiment station staff, county agricultural agents, state agricultural inspectors, representatives of canning companies, and others.

Notes were taken on especially prepared cards, four by six inches, bound in books of 25 cards each. They were printed on buff stock to relieve the glare of intense sunlight. In infested fields, counts of percentages of diseased plants or diseased heads were made wherever this was feasible.

In the relatively compact agricultural areas of the north-central counties where travel was not a limiting factor, some of the more important crops were given individual attention. In this way peas, wheat, potatoes, and tomatoes were, one at a time, given almost exclusive attention for a limited period when each was at the most suitable stage for examination. In the outlying counties, distances made such procedure impracticable. Generally, therefore, the survey covered each area only once, at which time the attempt was made to examine as nearly all the crops as possible. Obviously it was not possible, in this way, to see each crop at the most desirable time.

Of the 29 counties in the state, six were not entered: Rich, Summit, Daggett, Tooele, Wayne, and San Juan. All the major and many minor crops, totalling 64, were included in the observations, and 218 diseases are discussed in this report, although not all of them were seen in 1927. During the survey, 1024 separate note cards were utilized, recording observations from a somewhat greater number of observations. Specimens, both wet and dry, numbered 192, many of which were duplicates, as in the case of bunt of wheat of which specimens were gathered from 36 fields for a comparative study of the causal organisms. Notes and specimens are deposited in the Department of Botany and Plant Pathology, Utah Agricultural Experiment Station, with duplicates of the more important specimens in the Office of Mycology and Disease Survey, Bureau of Plant Industry, Washington, D. C.

An attempt is made in this report to list all the diseases known to occur on each important crop, whether seen during the survey or not. In small part the writer has drawn this supplementary information from his own earlier collections and his experience as student and assistant at the Utah Agricultural College. Of the utmost importance, however, has been the fund of accumulated experience of Dr. B. L. Richards, Experiment Station Pathologist, and of Mr. H. L. Blood and others now or formerly associated with plant pathological work at the Utah Experiment Station. The cooperation of these workers has not only aided in completing the lists of diseases but has provided a background for interpreting the observations made during this survey. In several instances information concerning rusts and smuts has been drawn from the work of Mr. A. O. Garrett of Salt Lake City. A list of diseases in Salt Lake County and vicinity, prepared by the department of agricultural research of the American Smelting and Refining Company under the earlier direction of Dr. P. J. O'Gara, and now of Dr. George R. Hill, has been used freely. Credit is given in the text by reference to the A. S. & R. Co. The "Check list of diseases of economic plants in the United States" (U.S.D.A. Bul. 1366) has proved very useful.

The writer wishes to express his gratitude not only to those who have thus contributed information, but also to those colleagues whose active cooperation and encouragement have contributed largely to both the conduct of the survey and the preparation of this report. The writer alone, however, is responsible for any errors of interpretation and judgement that may be recorded herein. The writer is keenly aware of the inadequacy of this survey, unavoidably limited in thoroughness by the brief period of the study and by the extensive and agriculturally diverse areas involved. The findings recorded here cannot be considered ultimately complete nor exact in all detail, but it is hoped that this report may be serviceable until a more thorough field study of plant diseases in Utah has been made.

NEW OR LITTLE KNOWN DISEASES

Several diseases observed during the survey which appear to be hitherto unrecorded are presented in the following list, with reference to the pages on which they are discussed. Numbers 5 and 6 are known fungi on new host species. In the text, several other diseases are discussed which have been observed in Utah for several years but which have not been recorded formerly. Needless to say each of these diseases, even though apparently minor, merits close observation and, as far as possible, research.

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7. Strawberry, bacterial leaf-blight..... 109
8. Sunflower, wilt..... 114

OTHER DISEASES NOW REPORTED FROM UTAH FOR THE FIRST TIME

Diseases known to occur elsewhere but now reported from Utah for the first time are listed below. Numbers 5, 13, 15, 17 and 19 were known to the experiment station workers but had not been reported in the past. The remainder were found and identified as a direct result of the survey. In addition to the following should be mentioned the finding of Protomyces pachydermus on Taraxacum officinale, identified by Dr. J. J. Davis. This European fungus is very rare in North America if, indeed, it has been reported from any other state.

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16. Pea, <u>Ascochyta</u> foot-rot	92
17. Rhubarb, <u>Phyllosticta</u> leaf-spot	99
18. Sunflower, downy mildew	114
19. Tomato, bacterial canker	100
20. Wheat, black-chaff	78

PLANT DISEASES OF OUTSTANDING IMPORTANCE

For emphasis, a few of the most important disease problems observed during the survey are here given special mention. Each is discussed more fully on the page indicated. Some problems are of long standing while others are newly recognized; but each, because of its actual or potential economic importance, is demanding either research or extension work or both.

Of most general importance is chlorosis of woody plants (p. 115) which affects numerous fruits and ornamentals throughout the state. Fundamental investigation of cause or causes and also attempts at control through experimental application of control measures found helpful in other areas are imperative. This problem is now being attacked by Dr. F. B. Wann of the Experiment Station.

Root and crown-rot of alfalfa (p. 72) caused in part by winter injury is a particularly important cause of low productivity outside of the intensive, diversified farming areas of the north-central counties, and needs both research and extension work.

Barley stripe (p. 74) is causing important losses which might be eliminated through effective extension work. The smuts of oats (p. 77) and wheat (p. 79) are also demanding chiefly extension work. The need is especially acute in oats for the losses are needlessly great and very little effort is now being expended for control.

A bacteriosis of bean (p. 82) has proved potentially destructive and has now assumed great actual importance in Cache County. Close observation and investigation of underlying causes of the 1927 outbreak are needed. Bean mosaic (p. 83) is a generally present cause of low productivity for which adequate control measures are not available.

Pink-root of onion (p. 89), recently discovered in Davis County, requires study as to cause and control.

As in other parts of the West, curly-top of sugar beet (p. 85) continues to be an outstanding disease not yet under control. The cause and control of beet seedling-blight and root-rots (p. 84) demand more intensive study. Dr. C. M. Tompkins of the United States Department of Agriculture is now working upon these latter problems with the cooperation of the Experiment Station.

The potato, a crop notoriously susceptible to the ravages of disease, was affected in 1927 by the new psyllid-yellow disease (p. 95) which assumed gigantic proportions as a destructive force. This disease is the outstanding new plant pathological problem of recent years in Utah, and demands research almost to the exclusion of other potato diseases. At the same time the need for extension work in the control of mosaic (p. 94) and allied diseases continues.

Bacterial-canker of tomato (p. 100) has come to the front abruptly as a problem demanding both fundamental research and immediate extension work. The tomato wilts (p. 102) caused by Fusarium and Verticillium should be differentiated and both be taken into account in the control work now in progress. Like curly-top of beets, yellows (yellow blight) of the tomato (p. 102) presents a disease control problem not yet solved.

Among fruit crops the disease problems in addition to chlorosis which most need attention are fire-blight of pear (p. 103) and apple (p. 105), and winter injury and die-back of peach (p. 107) and cherry (p. 106).

DISEASES OF FORAGE AND CEREAL CROPS

ALFALFA (Medicago sativa)

Hay*/: 495,000 acres; 1,609,000 tons.
Seed: 69,000 acres; 17,300,000 pounds.

BACTERIAL BLIGHT (Bacterium medicaginis). Bacterial blight was prevalent in first-crop alfalfa in the north-central counties this year as usual. Here it was observed in all fields examined before the first crop was harvested, generally occurring on a large percentage of stems. In Morgan County losses of 40 per cent of the first crop were seen in a few fields, such losses resulting from both reduction in numbers of stems per plant and destruction of the lower leaves on affected stems. In the seed fields of Millard, Uintah, and Duchesne counties this disease was of no importance in 1927. A bacterial leaf-spot that may be distinct from this disease was observed several times in different parts of Utah, causing no significant injury.

BACTERIAL WILT (Aplanobacter insidiosum). This was first collected in Cache County by the writer in 1925, and the pathogen was isolated by Dr. Fred R. Jones from specimens collected at that time. It was later collected by B. L. Richards in several fields in Salt Lake County. During 1927, however, this disease was found only in a single field in Juab County where but a trace was observed. The seed-producing counties were searched for it in vain. Under Utah conditions it appears to be of very slight importance.

CROWN-WART (Urophlyctis alfalfae). Crown-wart occurs widely in Utah. In 1924, Richards (Plant Disease Reporter 8: 127) reported it from seven north-central counties and also found it in Kane County, and it is now reported from three additional counties (see fig. 3). Several counties, including the two major alfalfa-seed areas, appear to be free. Observations in 1927 failed to find crown-wart as severe or widespread in infested counties as in 1924. Infested fields often contained plants apparently damaged in former seasons but this year free from fresh galls. The potentially destructive nature of this disease demands that future spread or increased severity be followed closely.

*/ All crop statistics are based on 1926 figures, except where noted.

Fig. 3. - Distribution of crown-wart of alfalfa in Utah as observed to end of 1927 (X- present; O- several fields examined in 1927 without finding the disease).

DOWNY MILDEW (*Peronospora trifoliorum*). This disease is practically coextensive with alfalfa culture in Utah, occurring most abundantly in the spring on the first crop and again assuming prominence on the third crop. During 1927, losses of 2 to 5 per cent of the first cutting were observed frequently; the maximum loss observed was 15 per cent in one field. In the lower and warmer valleys, mildew is rarely present during mid-summer even in fields infested before the first cutting. In Uintah and Duchesne counties, however, this disease was found most frequently in fields that had been clipped once for hay before being allowed to set seed. In Garfield and Piute counties, at high elevation, the disease became severe in late summer and caused an average loss of about 5 per cent of the second cutting in these counties. In Sevier and Sanpete counties many fields suffered losses of 2 to 5 per cent of the third crop. In other counties, the second and third crops of alfalfa were almost wholly clean.

LEAF-SPOT (*Pseudopeziza medicaginis*). After the middle of July this disease was found in almost all fields examined, occurring chiefly on the older leaves and generally causing no appreciable damage. It reached its most conspicuous development in alfalfa seed fields in Duchesne and Uintah

counties where nearly every field was heavily infested long before the seed was mature. This resulted in early defoliation, the effects of which upon the setting and maturing of seed should be determined. Even in the immediate locality of heavily infested seed fields, fields cut at the proper time for hay seldom showed heavy defoliation. Seed fields in Millard County were almost completely free from this disease when examined. The heaviest losses in hay fields were observed in Piute and Garfield counties, but here they seldom exceeded 2 per cent of any cutting.

YELLOW LEAF-BLOTCH (Pyrenopeziza medicaginis). Widespread but of very minor importance in 1927. A maximum defoliation of 5 per cent was observed in a single field grown for hay. In abandoned orchards and on ditch-banks much more severe injury was noted than in any cultivated fields. In 1926 important injury was observed by B. L. Richards in Utah and Cache counties.

LEAF-SPOT (Cercospora medicaginis). Collected in Utah for the first time this year. It occurred sparingly in mixture with other leaf diseases in Uinta County.

LEAF-SPOT (Ascochyta spp.) Two types of leaf-spot bearing Ascochyta pycnidia were collected several times in different counties, but neither was causing economic injury. The more common type is a light tan or gray spot, irregular in outline, margined with a dark brown line or banded with several lines. Pycnidia were usually clearly visible in these spots. The less common type of spot is dark brown, roughly circular, and not margined, with inconspicuous pycnidia. The two are probably distinct since intergrading types were absent even when both occurred on the same plant.

DODDER (Cuscuta spp.) Widespread. Most destructive in areas in Duchesne County. See page 115 for further discussion. (Plate III, fig. 1)

STEM NEMATODE (Tylenchus dipsaci). Reported only from Salt Lake County by Richards (Plant Disease Reporter 8: 91) in 1924. Not observed during 1927 although the known infested area was not searched. This disease should be watched closely for its appearance in new localities.

MOSAIC or CALICO (cause undetermined). What appears to be a mosaic or calico disease affects scattered plants all through the state but notably in the Uinta Basin and in south-western Utah. Affected plants besides showing a pronounced mottling are lacking in vigor and yield poorly but the disease has caused no considerable losses due to the lightness of infestation. Possibly part of this mottling is associated with a decay of the roots.

ROOT AND CROWN-ROT (winter injury in part). Alfalfa growers in Utah are sustaining heavy losses annually through their failure to break up and replant their fields when the stand of plants becomes too thin to be profitable. It is a common boast among some growers that their fields have stood eight, twelve, or more years without replanting, and many of these old fields are producing only a fraction of what a young stand of

vigorous plants would yield. Utah soils and climate do favor longevity of alfalfa, and in some fields from which a seed crop has been harvested annually, natural reseeding has kept the stand in good condition for decades through the constant replacing of the old, weak plants by young, vigorous ones. Outside of the seed-producing areas, and the better agricultural districts in which diversified farming leads to crop rotation, fields which are yielding only 50 to 75 per cent of what they should are numerous. Such reductions in yield come sometimes from a very thin stand alone, and sometimes from a reasonably thick stand of weak plants.

The causes of weakening and dying of the plants are several and are not well understood. In fields infested with the crown-wart disease, that appears to be an important cause of low productivity or early death of plants. In several fields in Duchesne County, particularly on the lighter soils, plants affected with a dry root-rot of undetermined cause were found sparingly. Such plants were sometimes merely weakened by partial destruction of the root system. In other instances they were found wilting abruptly. The cause of this disease needs to be determined. In Kane, Washington, and Iron counties, a root and crown decay characterized by rather firm, purplish brown lesions, was found to be the chief cause of early dying of plants in several fields, chiefly, however, fields of great age (six years or over). Several species of *Fusarium* were isolated from specimens of this rot.

The most prevalent type of crown injury in fields in which plants are not making vigorous growth is a type regarded by Weimer, Jones, and others, as probably winter injury. This includes injury to the cortical and phloem tissues as well as to the heart of the crown and upper taproot. Such injury may be found sparingly in nearly all parts of Utah, but it is nearly always more evident in old fields and in fields that have suffered from drouth. Under Utah conditions, plants outgrow this injury more fully than in some other states, and alfalfa grown under irrigation on suitable soils appears to suffer relatively little. Fields that have suffered from drouth for several years have been seen to recover almost entirely in a single season when given proper irrigation.

In some counties where livestock production is the chief industry, alfalfa fields are frequently ruined by too close pasturage, particularly with sheep. Some growers, in fact, make a practice of using sheep to help kill the alfalfa plants in advance of plowing up a field. Alfalfa fields that are pastured carelessly are easily ruined for hay production.

The causes of dying of alfalfa in Utah need study, but, in the meantime, effective relief from losses can be secured by closer attention to crop rotation and to the breaking up of alfalfa fields after they have stopped yielding profitably.

WHITE-SPOT (cause undetermined, associated with unbalanced water supply). This non-parasitic disease which is produced under some conditions by the application of irrigation water, has been observed in several localities in Cache County and locally in Salt Lake County. Losses to individual growers are sometimes heavy, but in the state as a whole this trouble is of minor importance. (Richards, *Phytopath* 18:136-137)

ANTHRACNOSE (Gloeosporium medicaginis). Reported from Salt Lake County by American Smelting and Refining Co. Not seen 1927.

RUST (Uromyces medicaginis). Collected in Salt Lake County in 1920 by Garrett (*Mycologia* 13: 212).

BARLEY (Hordeum vulgare)

20,000 acres; 800,000 bushels.

BACTERIAL BLIGHT (Bacterium translucens). This disease, reported from Utah for the first time this year, has been found in five fields in the same number of counties, - Cache, Boxelder, Weber, Piute, and Garfield. A more thorough survey would doubtless find it to be general throughout the state. In one of these fields there was a mere trace of the disease, but in each of the others serious losses occurred, estimated to be 4, 30, 75, and 95 per cent respectively. If the fields examined this year are considered representative of the state, then the average loss from this disease was 4 per cent of the crop in the state. This figure is probably much too large, since these infested fields were all smaller than the average barley field.

STRIPE (Helminthosporium gramineum). Stripe is the outstanding disease of barley in Utah. It was found in 21 of the 47 fields of barley searched, with an average infestation in these 21 fields of 10.7 per cent, and an average in the total of 47 fields of 4.8 per cent. The highest percentage of affected plants counted, 51 per cent, was in a small field said to have been planted with seed from Colorado. The heaviest single loss from the disease occurred in an 80 acre field of dry-farm barley in which 25 per cent of the plants were completely crippled. The growers are doing practically nothing to rid their barley of this disease.

SPOT-BLOTCH (Helminthosporium sativum). This is of minor importance in Utah. The writer observed a little of it in three fields, but was told of a few fields in Tooele County that had suffered severely, with many plants failing to head. B. L. Richards found it destructive in some fields in Salt Lake County in 1926 and 1927.

COVERED SMUT (Ustilago hordei). Barley smut occurs generally throughout Utah but the infestations are seldom heavy. It was seen in 46.8 per cent of the fields examined in 1927, with an average infestation of 0.9 per cent of heads. The five most heavily smutted fields gave counts of smutted heads as follows: 4, 5, 5, 7, and 15 per cent.

STEM RUST (Puccinia graminis). This rust was observed in a few fields late in the season, but nowhere doing serious damage. The heaviest infestation was seen directly adjoining a rusted wheat field near Price, Carbon County.

LOOSE SMUT (Ustilago nuda). Not collected in 1927. Reported from Salt Lake County by the A. S. & R. Co.

KENTUCKY BLUEGRASS (Poa pratensis)

POWDERY MILDEW (Erysiphe graminis). General, especially in waste places. Seldom conspicuous in lawns or closely pastured fields.

RUST (Puccinia poarum). Probably general throughout Utah late in the season in tall grass in moist places. Of no importance. Collected by writer in Uinta and Cache counties. Reported by Garrett (Mycologia 2: 292) from Salt Lake County.

ALSIKE CLOVER (Trifolium hybridum)

SOOTY SPOT (Phyllachora trifolii). Collected in 1927 only in Cache County where the writer and the Experiment Station workers have collected it other years. Of no importance.

ANTHRACNOSE (Colletotrichum destructivum). Not seen 1927. Reported from Salt Lake County by A. S. & R. Co.

RED CLOVER (Trifolium pratense)

POWDERY MILDEW (Erysiphe polygoni). Observed in 1927 only in Uinta County. Not looked for elsewhere. Has been observed widely during the last two years by B. L. Richards, but has not been seen to cause important loss.

RUST (Uromyces trifolii). A trace of this rust was collected in Cache County in 1925. Not seen in 1927.

ANTHRACNOSE (Colletotrichum destructivum). Reported by O'Gara from Salt Lake County. Not seen 1927.

WHITE CLOVER (Trifolium repens)

LEAF-SPOT (Cercospora zebrina). Collected in Uinta County where it occurred on about four per cent of the leaves in the only pasture examined. This appears to be the first report from Utah.

SOOTY SPOT (Phyllachora trifolii), and RUST (Uromyces trifolii): Not seen in 1927, but reported from Utah in former years.

CORN (Zea mays)

18,000 acres; 432,000 bushels.

SMUT (Ustilago zeae). General in Utah where corn is grown, but frequent only in the central agricultural counties where corn is an important silage crop. B. L. Richards reports it more severe on sweet corn than silage corn. Where corn is grown sparingly, fields with more than one per cent of smutted stalks are rare. In Utah, Salt Lake, Davis, Weber, and Boxelder counties, and in small areas in other counties infestations of 5 to 10 per cent are frequently found. The heaviest infestation counted in 1927 was 27 per cent of the stalks. Under Utah conditions, smut usually occurs late enough in the season not to reduce the yield of silage corn seriously, although it does diminish returns from ear corn materially in some instances.

RUST (Puccinia sorghi). A single uredinium, presumably of this fungus, was collected in Duchesne County in 1927. Careful search of the surrounding plants revealed no more. This appears to be the first record of rust on corn in Utah.

PURPLE LEAF-SHEATH-SPOT (caused by miscellaneous bacteria and fungi). This disease, described by Durrell (Phytopath. 10: 487-495) as a universal disease of corn, was observed widely in Utah, but it did little if any damage.

OATS (Avena sativa)

54,000 acres; 2,160,000 bushels.

LEAF-SPOT (Helminthosporium avenae). This disease was general in fields of late oats in Sanpete and Sevier counties but was not seen elsewhere during 1927. In former years it has been observed in the north-central counties. In several fields extensive foliage destruction resulted in losses estimated at five to ten per cent of the yield. Apparently the same fungus was found on wild oats near an infested field.

POWDERY MILDEW (Erysiphe graminis). This has been observed by B. L. Richards in past years but was not collected during 1927.

SMUT (Ustilago avenae and U. levis). Smut constitutes the most destructive disease factor in oat production in Utah. Both covered and loose smut are present but in this survey no attempt was made to distinguish between them. Of a total of 44 fields examined in all parts of Utah, only four were found smut-free, and the average infestation for all 44 was 7.6 per cent of heads. Losses exceeded five per cent of the crop in 46 per cent of these fields, and exceeded ten per cent of the crop in 25 per cent of the fields. The heaviest infestation counted was 50 per cent of heads in a single field, although several other fields suffered losses of 20 per cent or more.

Such losses are occurring in the best agricultural counties in the state, and at present smut control is receiving very little attention. In the area of Juab County where covered smut of wheat has been controlled almost completely in recent years through the community treatment of seed, oat smut is at its worst and nothing is being done about it. Six fields in this county in which counts were made contained 7.5, 8.5, 9.5, 20.5, 21.5, and 23 per cent of smutted heads, with an average of 15 per cent. In general, infestations were lightest in Garfield, Piute, Sevier, and Sanpete counties. The occurrence of such heavy, preventable losses demands prompt attention of the Extension Service.

STEM RUST (Puccinia graminis). This rust occurs in all parts of Utah but it was seen during 1927 in only eight oat fields. One of these contained a general infestation, but the lateness of infection prevented any considerable injury to the crop.

REDTOP (Agrostis palustris)

LEAF-SPOT (Ovularia pulchella). This leaf-spot was found in the only pasture examined at Vernal, Uinta County. It was patchy in its distribution, affecting approximately 50 per cent of the leaves of this grass and apparently diminishing the productivity markedly. This is the first report of this disease from Utah, and appears to be the first report of the fungus on this species of grass anywhere although it has been described on several other grasses.

SUGAR SORGHUM (Holcus sorghum saccharatus)

BACTERIOSIS (Bacillus sorghi). This disease has been reported from Salt Lake County by the A. S. & R. Co. Not observed 1927.

HEAD SMUT (Sorosporium reilianum). This smut occurs sparingly in Washington County where it was collected in 1927, and has been reported from Salt Lake County by the A. S. & R. Co. It is unimportant in Utah.

COVERED KERNEL SMUT (Sphacelotheca sorghi). Reported from Salt Lake County by the A. S. & R. Co. Found other years by Experiment Station workers but not observed in 1927.

SWEET CLOVER (Melilotus alba)

LEAF-SPOT (cause undetermined). Of frequent occurrence in very small amounts. Probably more than one causal agent is involved. Unimportant.

WHITE-SPOT (cause undetermined, associated with unbalanced water supply.) Sweetclover develops a spotting similar to white-spot of alfalfa under conditions which favor the alfalfa trouble. On sweetclover, however, the spotting is not white but rather gray-brown. Very minor. A trace only was seen in 1927, in an affected alfalfa field. Produced by B. L. Richards in 1926 by experimental irrigation.

MOSAIC (cause undetermined). Not seen in 1927, but reported by H. L. Blood to occur in northern Utah.

WHEAT (Triticum aestivum)

Winter wheat: 149,000 acres; 3,129,000 bushels.

Spring wheat: 88,000 acres; 2,376,000 bushels.

All wheat: 237,000 acres; 5,505,000 bushels.

BLACK-CHAFF (Bacterium translucens undulosum). The leaf-blight phase of this disease was collected in three fields about the middle of July, two in Boxelder and one in Millard County. All three fields were of irrigated, Dicklow wheat, and in two of them the disease was almost confined to the lowest, wet parts where irrigation water had been impounded. Elsewhere the disease occurred only as a sparse streaking of the lower leaves, in which little injury was done. This appears to be the first report of a bacteriosis of wheat from Utah.

POWDERY MILDEW (Erysiphe graminis). Only a trace of this disease was seen in Utah this summer. The disease is known to occur generally throughout the irrigated wheat districts and has sometimes been the cause of important losses in individual fields where, favored by abundant moisture, it has led to the early death of the lower leaves.

FOOT-ROT (Helminthosporium sativum). Not observed during 1927; the period of this survey did not favor study of seedling troubles in wheat. This was first recognized by the Experiment Station staff about 1922 when it was the cause of heavy losses in some fields in Morgan County. Its range in the state is not known.

SCAB (Fusarium culmorum). Not observed 1927. Reported from Salt Lake County by A. S. & R. Co.

SEEDLING BLIGHT (Podosporiella verticillata). Reported from Salt Lake County by O'Gara. Not seen 1927.

LOOSE SMUT (Ustilago tritici). Loose smut occurs generally in spring, irrigated wheat, commonly affecting from one to five per cent of heads. In dry-farm wheat, on the contrary, it is seldom abundant and many fields are entirely free from it. The average loss in spring wheat exceeds two per cent in the state as a whole, while in winter wheat it is probably less than half of one per cent. The worst infestation observed was 15 per cent in a single field; the next highest six per cent in three different fields. It is said that in Sevier and Uinta counties, loose smut is more troublesome than in most other counties. Losses of four to ten per cent of the irrigated wheat crop are said to be common some seasons in Sevier County. Little effort is being made by the growers to reduce losses from this disease.

COVERED SMUT or BUNT (Tilletia laevis and T. tritici). This is the most generally destructive disease of wheat in Utah. In 1927 it caused an average reduction of yield estimated, on the basis of calculations from survey notes, at 2 per cent, besides lowering the market value of much otherwise high grade grain. This disease was especially troublesome in 1927 in the dry-farm wheat sections of Cache and Boxelder counties (see table 20). B. L. Richards reports it very severe also in the Coalville district. In some other sections, notably the famous Levan Ridge of Juab County, it was almost wholly absent. Irrigated wheat was generally somewhat less affected than the dry-farm crop, although many fields were badly smutted.

Of the 160 wheat fields examined for disease, 148 were sufficiently matured to permit the detection of this smut, and 80 of them (54 per cent) were infested. More than a trace of smut was found in 46 fields (31 per cent of the 148 fields). The heaviest infestations were 37 per cent in a field of dry-farm wheat in Boxelder County and 36 per cent in an irrigated field in Utah County. The average infestation in the 148 fields was 2.2 per cent of heads.

Both the smut fungi, Tilletia tritici and T. laevis, occurred in these fields. To determine the relative importance of each, samples of smutted heads were collected from 72 fields, and several heads from each sample, usually ten, were examined microscopically. T. tritici occurred in 23 of these, and T. laevis in the same number. Both fungi occurred together in samples from fifteen fields. Samples from two of the three fields which contained the highest percentages of smut proved to be predominantly

T. tritici. The two fungi appear to be of almost equal importance in this state. No geographical differences were detected.

TABLE 20. - Covered smut of wheat in Utah, 1927, by counties.

County	Number fields exam- ined <u>a/</u>	Fields infested	Fields with more than a trace of smut	Maximum infestation per cent	Average in- festations per cent
		no. : per cent	no. : per cent		
Boxelder	49	33 : 67	18 : 37	37	2.9
Cache	39	29 : 74	22 : 56	23	3.9
Juab	17	4 : 24	0 : 0	trace	-
Millard	14	1 : 7	0 : 0	trace	-
Utah	14	7 : 50	3 : 21	36	3.
Uinta	6	3 : 50	2 : 33	12	2.3
Duchesne	5	2 : 40	1 : 20	2	0.4
Other counties	4	1 : 25	0 : 0	trace	-
Total	148	80 : 54	46 : 31	37	2.2

a/ Fields examined when plants were too young to detect covered smut if present are not included in this tabulation.

STEM RUST (Puccinia graminis). Stem rust was not seen until July 19, when a mere trace was found in a single field in Millard County. Very little more was seen during the rest of the month, and dry-farm wheat throughout the state was harvested almost entirely free from rust. During early August, however, rust quickly became widespread on late irrigated spring wheat. In several localities it was observed in nearly every field but in such sparse infestation or on wheat so nearly matured that the injury was negligible. In a few fields the injury was much more severe. In Utah, Duchesne, and Iron Counties several fields suffered reductions in yield estimated at five per cent or above, the heaviest losses being in the region of Price, Utah, where with extreme shrinkage of the kernels, yields were reduced as much as 20 per cent in a few very late plantings. In the state as a whole, both spring and winter wheat, losses from stem rust did not exceed 0.2 per cent.

LEAF RUST (Puccinia triticina). This rust was all but absent from winter wheat, and occurred only sparingly in spring wheat in 1927. A trace of it was observed in the first wheat field examined, on June 29, but no fields were seen during the survey in which losses amounted to as much as one per cent. Other years it has been relatively more abundant, and B. L. Richards reports that generally it is more severe than stem rust in the northern counties.

STRIPE RUST (*Puccinia glumarum*). This rust was not seen during the survey. It has occurred in Cache County during several years past, but during 1927 the infested area was not surveyed.

TERMINAL BLEACHING (cause undetermined; associated with water supply). A physiological disturbance leading to the abrupt dying and bleaching of the apical portion of the uppermost leaf or leaves has been observed in irrigated wheat in several of the north-central counties. The cause and importance of this trouble have not been determined.

TABLE 21. - Summary of losses in forage and cereal crops.

Crop	Disease	Cause	Estimated loss per cent
Alfalfa	Bacterial blight	<i>Bacterium medicaginis</i>	1.3
	Crown wart	<i>Urophlyctis alfalfae</i>	.5
	Downy mildew	<i>Peronospora trifoliorum</i>	1.0
	Root and crown rots	Winter injury, in part	15.0
	Other diseases		.5
	Total		18.3
Barley	Bacterial blight	<i>Bacterium translucens</i>	0.5
	Stripe	<i>Helminthosporium gramineum</i>	4.8
	Spot-blotch	<i>Helminthosporium sativum</i>	0
	Covered smut	<i>Ustilago hordei</i>	1.
	Stem rust	<i>Puccinia graminis</i>	0
	Total		6.3
Corn	Smut	<i>Ustilago zeae</i>	2.
Oats	Smuts	<i>Ustilago avenae</i> & <i>U. levis</i>	7.6
	Leaf-spot	<i>Helminthosporium avenae</i>	t
	Stem rust	<i>Puccinia graminis</i>	0
Wheat	Bacterial blight	Undetermined	t
	Loose smut	<i>Ustilago tritici</i>	1.
	Covered smut	<i>Tilletia tritici</i> & <i>T. laevis</i>	2.2
	Stem rust	<i>Puccinia graminis</i>	.2
	Leaf rust	<i>Puccinia triticina</i>	t
	Total		3.4

DISEASES OF VEGETABLE AND ROOT CROPS

BEAN (Phaseolus vulgaris)

BACTERIOSES (chiefly Bacterium phaseoli). This year, for the first time, bacterial diseases of beans assumed notable importance in Utah, particularly in green beans grown for canning. The most severe losses were experienced in Cache County where bacterial stem girdle was widespread, killing from 5 to 95 per cent of plants in numerous fields. When first seen, on July 26, before picking had begun one field had suffered the loss of 75 per cent of plants. At this time some of the remaining plants appeared healthy while others were in various stages of the disease. After a single picking the field was abandoned; only a few plants, none of them free from the disease, survived through the season. No other fields as badly diseased as this were encountered but in the county as a whole this stem blight took about fifteen per cent of the canning beans. Green Refugee is the variety grown in this district.

Unlike the usual stem girdle caused by B. phaseoli, this disease was not limited to any one or two nodes of the stem. Numerous points of infection, especially at the nodes (apparently working down from the pulvini of the leaf petioles) but also in the internodal region, led to longitudinal cracking of the enlarging stem. Such cracking was sometimes apparent several inches below the soil line and well up onto the aerial stem. Water-soaking of lesions was generally to be seen, but usually not conspicuous. Spotting of the leaf laminae was rare. Vascular invasion extending through several internodes was observed in a number of plants studied.

Bacterial blight of more usual nature was seen sparingly in other sections, usually as a sparse spotting of leaves, but reaching maximum severity on stems and pods in two gardens, one in Emery County where the loss was 50 per cent, and one in Washington County where the loss was about 20 per cent of the crop. The disease was found also in Beaver, Sanpete, Utah and Boxelder counties.

A very heavy infestation of a different bacterial disease characterized by abundant spotting of leaves and pods of both common bean and Lima bean was observed in Boxelder County in trial grounds of a seed company. A single row of Hodson Wax appeared to have carried the infection, and from this row the disease spread laterally to several adjoining rows. Miss Florence Hedges, to whom the writer showed this material, expressed the opinion that it is different from the ordinary bean blight (B. phaseoli) if not from all the described diseases of the bean, but similar to a collection she had made in Montana this summer.

POWDERY MILDEW (Erysiphe polygoni). Late market beans in the south and of Davis County were damaged by an outbreak of powdery mildew which affected not only leaves and stems but also pods, deforming them and rendering them unfit for market. Owing to the limited production of late beans this caused no extensive losses. One small grower, however, was forced to abandon his planting. A similar severe development of mildew was noted in Utah County in 1926 by B. L. Richards.

ROOT-ROT (Corticium vagum, Fusarium spp.). Rhizoctonia and species of Fusarium were isolated several times from specimens of root-rot and stem-rot of bean from different counties. A field was seldom searched in any part of the state without finding some plants with decay of subterranean parts, but in most instances such plants were few and losses were therefore minor. In several fields in Utah County, however, and one garden in Washington, losses were considerable, as high as 12 per cent of the plants wilting from the disease in one commercial field.

MOSAIC (cause undetermined). Mosaic is coextensive with bean culture in Utah, generally occurring in heavy infestations and with moderate severity. Thirty-two fields in which mosaic was counted, fields distributed in ten counties, had an average infestation of 31 per cent. In some fields the affected plants appeared to yield fairly well but, in canning beans, affected plants produce fewer pods of desirable shape and bear through a shorter season.

CURLY-TOP (cause undetermined). Not observed during 1927, but recorded in former years.

BEETS (Sugar beets, mangels, and table beets)
(Beta vulgaris)

Sugar beets: 69,000 acres; 1,064,000 tons^{2/}

LEAF-SPOT (Cercospora beticola). Only a trace of this disease was observed during 1927, in sugar beets in Utah County where it has been known for many years and sometimes has caused important losses.

LEAF-SPOT (Phoma betae). Phoma leaf-spot was found sparingly in all sugar beet areas examined after mid-summer. Even in the most heavily infested fields, however, losses were so slight as to be negligible. Phoma root-rot was not observed during 1927 but has been prevalent during some seasons (see discussion under Late Blight, below).

^{2/} Figures given are for 1925. The 1926 crop was seriously reduced by disease.

DRY-ROT CANKER (Corticium vagum). This disease assumed greater importance this year than ever before, and demonstrated its potentialities as a root decay. It was first seen August 1 at which time it had caused only slight thinning of stands in infested fields in northern Cache County. During September, however, C. M. Tompkins reported a two-acre field in Cache County to be a total loss from this disease, and a four-acre field in Weber County in which 50 per cent of the plants had been destroyed, with the disease still progressing. A number of other fields in these counties and Utah County were seen to suffer losses of from one to 10 per cent. Beets are still being grown on the farm at Cornish, Utah, where this disease was first seen and from which the original description by Richards was published. This particular field is now in alfalfa, but in adjoining fields the disease was destructive in small areas. The farmer on this place states that the severity of the disease has varied widely from year to year.

LATE BLIGHT (water relationships). A disease of sugar beets attributed to irregular supply of moisture, apparently chiefly a protracted drouth with inadequate applications of irrigation water, has a few times in past years and notably in 1921, caused heavy losses. This condition shows itself in a general retardation of growth. Associated with dwarfing, the leave blight irregularly with the formation of dead spots, sometimes zonate, with which no parasitic organisms are associated. The roots undergo various types of decay but predominantly, in 1922, a firm, black root-rot caused by Phoma betae. This disease was not seen during this survey.

SEEDLING-BLIGHTS (causes imperfectly known). Cause important losses annually. Not included in this survey.

Diverse ROOT-ROTS (cause undetermined). Sugar beet root-rots of diverse types caused very severe losses in Utah in 1927. With the exception of the dry-rot canker discussed above, the causes are unknown and have not yielded readily to study. Dr. C. M. Tompkins of the United States Department of Agriculture, with headquarters at the Utah Agricultural Experiment Station, is now giving them his attention.

These troubles are of widely different nature. Some are soft rots, others are firm (the dry-rot canker appears to be the only characteristically spongy dry rot among them); some are almost black and others show little alteration from the color of the normal beet. Some occur chiefly at the lower extremity of the beet root, while others are found predominantly in a lateral position. These several types of decay are sometimes found intermingled, but they may occur separately, and usually in any one field there is a marked similarity in the types of decay found on different beets.

During 1927 root-rots were beginning to be apparent by August 1. At the end of September, Dr. Tompkins estimated that in Cache County alone, 500 acres of sugar beets were severely affected with one or another of these rots. On August 8, the writer was in a six acre field in Utah County where 50 per cent of the beets were already fully decayed and nearly all those remaining were somewhat affected.

Root-rots appear to be almost coextensive with beet culture in Utah. They were noted during the survey in all counties where beets were examined carefully: Cache, Boxelder, Weber, Utah, Sevier, Sanpete, and Carbon, but were most prevalent in the first four named. The opinion has been expressed by one competent observer that no small part of the loss attributed to curly-top in 1926 in some parts of Utah was really due to root-rots.

One special type of root trouble that appears to be distinct from the others may be designated provisionally as "wilt". It is frequently but not always associated with conspicuous root decay. This disease first manifests itself by a flagging of the leaves during the heat of the day, in wet soil even more than in relatively dry. In extreme cases the foliage may lie prostrate, but at night or during cloudy weather, turgor is regained unless complications have set in. When such beets are removed from the soil with care to preserve the tip of the long taproot intact, this root usually shows an increased brittleness and a water-soaked appearance on the fractured surface. From this condition, all steps may be found to a soft rot of the apex of the fleshy root. When the decay is only beginning, internal browning or blackening, clearly distinct from the curly-top blackening, may extend far into the heart of the beet. This symptom has suggested the name "blackheart" sometimes applied to this trouble.

Even when rotting does not follow, affected beets make little growth. A two acre field of sugar beets in Cache County showed 18 per cent of wilting plants one bright day in late July. A few plants were rotting at that time, but at the end of September the majority of the plants were still alive and counts of wilting plants never again reached the high mark of 18 per cent. Almost none of the beets in this planting developed to a normal size.

This wilt appears to occur almost wholly in poorly drained fields or parts of fields. In this respect it agrees with most of the soft-rots of the beet, but not with all beet root decays. It is not closely correlated with the previous growth of beets; the only record of its occurrence in Carbon County was in a field growing its first crop of beets. Wilt has been seen in Cache, Boxelder, Utah, Sevier, and Carbon counties.

MOSAIC (cause undetermined). Has been known in Utah for several years but has nowhere proved important. During 1927 the writer observed it sparingly in Cache County only: B. L. Richards reported it from Utah County.

CURLY-TOP (cause undetermined). This disease developed tardily in 1927. For a time it looked as if the crop might escape severe injury, for the early season infection was very light, but in late July and early August the disease increased rapidly in importance until many fields throughout the state suffered losses of 25 to 90 per cent of the crop. Some fields not worth digging were abandoned to pasturage. The most severe development of the disease noted was in Sevier and Sanpete counties where the average yield would not exceed 50 per cent of normal. Garden beets and mangels were affected as well as sugar beets; some market growers lost their late plantings entirely.

NEMATODE (Heterodera schachtii). No special study of this trouble was undertaken in this survey.

ROOT-KNOT (Heterodera radicicola). Not observed during 1927. This has been seen in past years in Weber and Davis counties, particularly on sandy soils in tomato-growing districts, causing heavy losses in the seedling stages.

CABBAGE (Brassica oleracea)

LEAF-SPOT (Alternaria brassicae). This is the only disease of cabbage noted during the survey, and it is of no importance. It was found on only two occasions; once in Emery County on defective plants in a field of early cabbage that had already been harvested, and once in Washington County where cabbage was being grown on a small scale under conditions of too high temperature. Only small amounts of the disease could be found in either place.

CANTALOUPE (Cucumis melo) (including honeydew melon)

POWDERY MILDEW (Erysiphe cichoracearum). This was highly destructive in the Green River district in Emery County in 1925 and 1926, but was not found during the 1927 survey.

LEAF-BLIGHT (Macrosporium cucumerinum). At Green River, where the cantaloupe is an important crop, this disease occurs widely and in 1927 caused serious losses in some fields. In one five-acre tract there was almost 100 per cent leaf infection and 20 per cent defoliation. Here the yield was estimated by the grower to be only 30 per cent of normal in number of fruits. The melons were small and of poor shape, and complaints from the markets indicated that they were of inferior quality. Cantaloupes were grown in this field in 1925 and 1926 but the disease was not observed either year, probably because it was obscured by the presence of powdery mildew.

Cantaloupe, honeydew melon, and cucumber were affected almost equally, and watermelon and squash somewhat less severely at Green River.

CARROT (Daucus carota)

SOFT-ROT (Bacillus carotovorus). Heavy losses from this trouble are reported from Utah and Salt Lake Counties by B. L. Richards. Frequently associated with the following.

ROOT-ROT (Corticium vagum, and others). Root-rot of carrots was found in nearly every planting of this vegetable examined, including Cache, Davis, Salt Lake, Utah, Uinta, Grand, and Sevier counties. Usually less than five per cent of the plants were affected; at the worst, 30 per cent of the roots were decayed in the ground. *Rhizoctonia* was isolated freely from the only collection cultured.

ROOT-KNOT (Heterodera radicum). This was found in a single planting of carrots in Utah County, affecting a small percentage of plants.

CURLY-TOP (cause undetermined). What appears to be the same disease as the curly-top of sugar beets was observed affecting an occasional plant in carrot patches in several places, notably in one garden in Garfield County. Its importance is negligible.

CELERY (Apium graveolens)

LATE-BLIGHT (Septoria apii). This disease was seen only twice during the survey, and most fields were entirely free from it. In a commercial planting in Beaver County where it was seen August 27, all plants were affected severely. No control measures had been applied, and the crop appeared definitely lost. Seedlings of remaining in the seed-bed at a distance from the field were also infected, indicating that seed-borne infection was the probable cause of this outbreak. Other fields in the neighborhood were clean. In a field in Utah County only a trace of this disease was seen. Locally severe outbreaks have occurred in other localities in past years, especially in Cache County.

MOSAIC (cause undetermined). A mere trace of this disease was seen in one field in Utah County.

BLACK-HEART (cause undetermined). This trouble which results, apparently, from irregular supply of soil moisture during periods of high temperature in midsummer, is a serious factor limiting the production of early celery in all but the wettest soils in the Ogden trucking district. Where growers plant on suitable soils and irrigate with care, losses are light, and late celery is grown successfully even on soils which would give trouble with the early crop.

YELLOW (cause undetermined). (Plate III, fig. 3) This disease was seen this year for the first time. Though it caused no great injury, its nature is such as to demand study to determine its cause and potential importance.

It is characterized by a dwarfing and rosetting of the plant with marked shortening of the petioles, by a yellow or pinkish yellow color of the leaves, and by increased brittleness of the leaves. The phloem portion of the vascular bundles in the petioles is necrotic and discolored while the xylem portion remains normal in appearance. These symptoms suggest a relation

to the insect-borne, virus diseases, but this is not supported by the field occurrence of the disease. Affected plants occur in groups; sometimes a single row will be affected for several yards in length. In such instances, the plants in the middle of the affected strip are the most severely damaged, and at either side there is close intergrading with the healthy individuals. Plants that show clear symptoms are worthless for market, and plants at the center of affected strips are sometimes dead by the end of the season.

This disease was seen in Salt Lake and Weber Counties, in the latter of which it is said to be widely distributed although affecting relatively few plants in any field. This appears to be distinct from the yellows disease of celery caused by a species of *Fusarium*, a disease not recorded in Utah.

CUCUMBER (*Cucumis sativus*)

ANGULAR LEAF-SPOT (*Bacterium lachrymans*). This disease which was reported from Utah for the first time during 1927, was found in a small market garden in Piute County where it caused complete failure of the cucumber crop. Nearly every leaf was spotted, and the young fruits, becoming infected early, dropped from the vines before attaining usable size.

LEAF-BLIGHT (*Macrosporium cucumerinum*). At Green River, where the disease was prevalent on cantaloupe, cucumbers were affected almost as severely, but cucumbers are not grown on sufficient scale for this to constitute a serious economic problem.

MOSAIC (cause undetermined). Cucumber mosaic was not seen during 1927, but it is reported by B. L. Richards to have been seen in Cache County several years ago.

EGGPLANT (*Solanum melongena*)

WILT (*Verticillium alboatrum*). Wilt was found in all of the five plantings of eggplant examined after August 1, in Weber, Davis, and Washington counties. In these plantings, infestation ranged from a trace to 50 per cent. The heaviest loss was in a market garden in Weber County where the yield was reduced at least 40 per cent. B. L. Richards reports that in 1926 this disease was severe in Davis County and that in the Magna district of Salt Lake County there was 100 per cent infestation in two fields. The eggplant is a minor crop in Utah, but this disease constitutes a great handicap to its profitable culture in the trucking districts.

ANTHRACNOSE (*Colletotrichum atramentarium*). Reported from Utah by O'Gara, but not seen during 1927.

HORSERADISH (Radicula armoracia)

LEAF-SPOT (Ramularia armoraciae). This leaf-spot has been collected in late summer at Logan during several past years. None was observed during this survey. Very minor.

LEAF-SPOT (Alternaria brassicae). Collected in a single garden in Carbon County where it occurred only sparingly. This is its first recorded occurrence in Utah.

MOSAIC (?), CURLY-TOP (?) (cause undetermined). An incompletely diagnosed disease was found destroying a small commercial planting at Price. The symptoms suggested both mosaic, in the leaf mottling, and curly-top, in the leaf distortion and prominent veins. The roots showed conspicuous internal browning or blackening, and in late stages were decaying, but in early stages the discolored tissue appeared to be sterile. This was the third successive year that this disease had been troublesome, increasing each year until all plants were affected and most of them dead. In other localities complaints of similar trouble were heard.

LETTUCE (Lactuca sativa)

TIP-BURN (cause undetermined). Tip-burn was found sparingly in Weber County in the locality where black-heart of celery was troublesome, occurring under apparently the same conditions of unequal water supply. It is said to cause heavy losses some years and to be a factor restricting lettuce culture to moist soils.

LIMA BEAN (Phaseolus lunatus macrocarpus)

BACTERIAL BLIGHT (cause undetermined). As noted on page 26, under the discussion of bacteriases of common bean, Lima beans were found carrying bacterial spotting in small trial grounds in Boxelder County late in the season. The infection apparently had spread from an adjoining row of common beans. Miss Florence Hedges regards this, tentatively, as distinct from the bacterial diseases that have already been described on beans and Lima beans.

ONION (Allium cepa)

PINK-ROOT (cause disputed: probably either Fusarium malli or Phoma sp.). Pink-root was first observed in the state this year by members of the Experiment Station staff before a survey of onion fields was begun. The observed occurrence of the disease indicates, however, that it had been present for several years. It caused heavy losses to onion growers in the

Woods Cross and Bountiful trucking district of Davis County, especially in the low lying fields. The severity of pink-root here is such that in infested parts of fields, large percentages of the bulbs fail to attain marketable size, and maturity, and some fields this year were infested in two-thirds of their area. The production of sweet Spanish onions is a young and growing industry in this county that is seriously threatened by this disease.

NECK-ROT (Botrytis spp.). The period during which this survey was made was such that observations on this disease were not possible. Neck-rot, however, is a factor wherever onions are grown in Utah, causing important losses particularly in years when wet weather interferes with proper curing of the bulbs. B. L. Richards reports that two or more species of Botrytis are involved.

MOLD (Macrosporium porri). Not seen in 1927. Reported from Salt Lake County by A. S. & R. Co.

PARSNIP (Pastinaca sativa)

LEAF-SPOT (Cylindrosporium pastinacae). This was observed in two plantings of parsnips in Utah County. At Provo, a half-acre planting was sparingly affected; at American Fork a garden planting was thoroughly infested but only slightly damaged. In both instances, parsnips growing wild in the vicinity carried what appeared to be the same fungus. It may be questioned whether this is to be regarded as Cylindrosporium pastinacae (West.) Lind; a European species, or as C. heraclei Ell. & Ev., which was described from a collection of Heracleum from Ogden, Utah, collected in 1888.

MOSAIC (cause undetermined). Observed sparingly in Utah County in 1927. Also seen in Cache County in the past.

PEA (Pisum sativum)

BACTERIAL BLIGHT (Bacterium pisi). Traces of this disease were found frequently in Alaska variety peas and less often in late varieties. Of 73 plantings examined, chiefly canning peas, 11 plantings or 15 per cent contained this disease. These were distributed in Cache, Weber, Salt Lake, Utah, Morgan, Carbon, and Piute counties. Infection was generally limited to the lower leaves and the base of the stem, and occurred sometimes as a leaf-spot and sometimes as a stem-blight. The only severe development of the disease observed this year was in a home garden where home-grown seed which had not been entirely separated from the chaff had been planted earlier than the usual planting date for canning crop peas. Here, early spring rains had permitted severe injury to the lower leaves, but the plants outgrew this and yielded well. The sparing and widespread occurrence of this disease

is clearly the result of planting infected seed. Adverse weather conditions ordinarily prevent the disease from becoming destructive.

ROOT-ROT (Aphanomyces euteiches). Pea root-rot occurs rather generally in canning crop fields in Salt Lake, Weber, and Morgan counties, but it was not found in Wasatch and Utah Counties where considerable numbers of fields were examined. Of the 73 fields inspected in the state 17, or 23 per cent, contained this root disease. Losses ranged from frequently a mere trace up to 75 per cent of the crop in one two-acre field. The average loss in all fields examined is computed at 3.7 per cent, a figure that is somewhat too high for the state as a whole since in some localities the assistance of canning company representatives led to selection of the worst fields for observation.

This disease appears to be less generally destructive than in Wisconsin, and to be less closely correlated with repeated cropping with peas. Irrigation water appears to function importantly in distributing the causal agent, and excessive irrigation provides conditions favorable for development of the disease. In some instances, at least, the disease affects only part of a root system, developing, apparently, while the soil is wet during irrigation, and stopping with the later drying of the soil before involving the entire root system.

Canners and growers in Utah commonly refer to the decay of long vines, lodged and matted on wet soil, as root-rot. This is a separate trouble which is encountered especially with the tall varieties such as the Admirals, when grown on rich soil. The vines, becoming closely matted together on the ground, decay readily when wetted by heavy rains or by irrigation, in the absence of any specific parasite.

DOWNY MILDEW (Peronospora viciae). This disease was observed in Cache, Weber, Morgan, Utah, and Wasatch counties, in a total of 13 fields in only two of which there was more than a trace of injury. In the remainder the mildew occurred chiefly in small, scattered spots as is usual for this disease, but in these two fields it developed in the "systemic" manner, completely overrunning the affected shoots and either killing the plant or forcing the production of secondary shoots. This resulted in a loss of about one per cent in one field and a much heavier loss in another. In this latter field, in Wasatch County, five per cent of plants were completely crippled or killed by the disease and an additional four per cent showed a crippled primary shoot and the production of one or more lateral shoots which were relatively clean. Other plants were heavily spotted. A conservative estimate places the loss in this field at eight per cent of the crop, a record severity for this disease in the experience of the writer.

POWDERY MILDEW (Erysiphe polygoni). Of no importance this year. Observed in only four garden plantings late in the season, in Cache, Emery, Iron, and Garfield counties. This does not represent the total range of the disease in Utah. It is probably general throughout the state, especially in the higher valleys, but it seldom develops until after the canning crop is harvested.

BLACK-LEAF (Fusicladium pisicola). Mere traces of this disease were found in 1927 in Cache and Weber counties. The disease has been known to occur in northern Utah since 1921 and has been found in Cache, Weber, and Morgan counties. It rarely affects plants before they are in blossom. After this time it may cause heavy defoliation, but the lateness of attack prevents heavy reduction of yield. Morgan County, this year, was surveyed too early to expect this disease.

ASCOCHYTA LEAF-SPOT (Mycosphaerella pinodes (micro" form). Of the three types of Ascochyta described by Linford and Sprague (Phytopath. 17: 381-397) as parasitic on peas, this is the only one that was found during the 1927 survey in Utah. Traces of it were collected in Cache, Davis, and Piute counties on leaves that either rested on the ground or hung near it. This is identical with the foot-rot fungus mentioned below.

FOOT-ROT (Mycosphaerella pinodes "micro" form, and Fusarium spp.). A widespread but minor disease. Isolations made during the survey from plants showing this injury yielded chiefly the Mycosphaerella (Ascochyta), although Fusarium martii pisi and other species of Fusarium were also obtained. Infestations in different fields ranged from a trace up to 15 per cent, with one outstanding field in which 50 per cent of the plants were affected. Only ten of all the fields examined contained enough of the disease to be significant, but very few fields were entirely free from this trouble. Generally, affected plants suffered little reduction in vigor. The loss in the state as a whole is a trace.

SEEDLING BLIGHT and STEM CANKER (Rhizoctonia). This survey was begun too late to observe the earliest seedling injury. Stem-canker in young plants was observed in nine fields, and cultures of a Rhizoctonia were readily obtained from specimens collected in two localities. In two fields, losses of eight per cent of stand resulted; in one, a loss of 15 per cent. Some of the losses caused by Rhizoctonia may be included under the head of "undetermined root-rots".

Undetermined ROOT-ROTS. In old pea fields in all the older canning districts surveyed, fields were found in which pea roots were damaged by some sort of cortical decay which differed from those discussed above. In four fields 50 per cent or more of the plants were affected, with a resultant reduction of yield of 10 to 35 per cent. Symptoms were not alike in all instances. At least one undetermined disease resembles the Aphanomyces root-rot in the appearance of affected roots, but affected tissues lack the oospores so characteristic of that parasite. This disease weakens the plants but seldom kills them outright. In Morgan County, however, many fields are suffering from a disease that resembles Rhizoctonia stem-canker in its tendency to cut the stems off above the cotyledons, but differs in the absence of the characteristically rich brown color of the Rhizoctonia lesion. Also it severs the stem with less evident corrosion. This form of root injury causes rather abrupt death of scattered plants, frequently taking from five to ten per cent of the stand, and sometimes much more. It is most frequently seen when the plants are only a few inches

tall, but may continue to thin out the stand up to harvest time. The causes of these root and stem diseases should be determined.

ROOT-KNOT (Heterodera radiciola). This nematode disease was found in a single field of Admiral peas on sandy soil in a tomato-growing section in Weber County. It affected 25 per cent of the plants, reducing the yield about 10 per cent.

MOSAIC (cause undetermined). Mosaic was found in eight fields in Cache, Weber, and Utah Counties, affecting peas of Alaska, Horsford, and Green Admiral varieties. The heaviest infestation was a trace, and the injury was insignificant.

PEPPER (Capsicum annuum)

SUNSCALD (cause undetermined). Injury which appears to be sunscald primarily, followed by the secondary invasion of several saprophytic fungi, has caused important losses in market garden plantings of the large fruited peppers in Salt Lake, Davis, Weber, and Boxelder counties. A maximum severity of eight per cent of damaged fruits was noted in a Davis County field. This scald develops before the green peppers are ready for market, and is limited to the side of the fruit that is exposed to the sun.

POTATO (Solanum tuberosum)

17,000 acres; 2,465,000 bushels.

(The widespread prevalence and destructiveness of the new psyllid-yellows discussed below rendered almost futile detailed observation of the other diseases of the potato. The following summaries, admittedly very inadequate, are presented for what little value they may possess.)

BLACK-LEG (Bacillus phytophthorus). This was seldom found in more than slight traces. In a single field in Weber County a loss of ten per cent of plants was counted, and in two fields in Davis County the loss amounted to seven per cent. In the vast majority of fields none of this disease could be found.

SCAB (Actinomyces scabies). The survey closed before the main potato harvest began, and consequently observations on potato scab were limited to a few early fields in Davis and Weber counties. Here, in some fields, scab was present on as high as 90 per cent of the tubers, but the majority of fields were entirely free from it. Other sources of information indicate that scab occurs widely throughout the state. B. L. Richards reports it especially severe in Davis and Weber Counties.

WILT (Fusarium spp. and Verticillium albo-atrum). Both Fusarium and Verticillium wilts were found in Utah during 1927. Isolation studies were not sufficiently thorough to determine the relative importance of the two, but the Fusarium disease appeared to be the most widely present and usually most destructive. It was found sparingly in nine representative counties and would doubtless have been detected elsewhere had not necrosis from yellows rendered diagnosis doubtful. Infestations were generally only a trace, but maximum counts of 26 and 40 per cent were obtained in Uinta and Boxelder counties respectively. Verticillium wilt was positively identified in collections from Cache, Uinta, and Salt Lake counties. In the last named, this disease was the cause of losses amounting to eight or ten per cent in numerous fields of late potatoes in the estimation of B. L. Richards and H. L. Blood.

EARLY BLIGHT (Alternaria solani). Almost wholly absent during 1927, or hidden by leaf necrosis caused by the yellows disease. Collected only in slight traces in Cache, Uinta, and Iron counties. Sometimes severe locally.

ANTHRACNOSE (Colletotrichum atramentarium). Has been reported from Utah, but was not seen during 1927 survey.

STEM-CANKER (Corticium vagum). Perhaps more than usually destructive this season. Coextensive with potato culture, but highly variable in severity. The most extreme development noted in 1927 was in the alfalfa seed producing area of Millard County where potatoes are planted chiefly on the lightest soils after a crop of alfalfa has been turned under or after heavy applications of manure. Of seven fields examined here, five were severely infested; and on the basis of all seven there was an average of 22 per cent of plants affected with deep stem cankers and damaged stolon tips. At Oak City, only a few miles away, where the crop is grown under very different soil conditions, this disease was very minor. The loss in the state as a whole is estimated at three per cent. The sclerotial stage of the parasite which disfigures the tubers was not seen because the survey was limited to the summer months. It is known, however, to occur generally on late potatoes.

MOSAIC (cause undetermined). Potato mosaic, chiefly the rugose mosaic, is, next to the new psyllid-yellows, the most generally destructive disease of potatoes in Utah. The more progressive potato growers are now avoiding this disease very effectively through the planting of certified seed potatoes or other potatoes of known freedom from mosaic, but in so doing they are incurring extra expense which becomes serious in seasons such as 1927 in which other diseases assume destructive proportions. The majority of potato growers, however, are still planting common stocks for seed, with the result that infestations of 20 to 60 per cent are frequently seen, and still heavier infestations may be found. The prevalence of psyllid-yellows prevented counts of mosaic in most fields, but of 56 fields examined up to August 8 in which it was possible to count mosaic, the disease was found present in 50, and the average infestation in the whole 56 was 26.2 per cent. This was chiefly rugose mosaic, but mild mosaic when present was included in the count. This average would be too high for Utah as a whole, for it

did not include many of the early potato fields in Davis and Weber counties where certified seed is used extensively, nor Piute County where certified seed potatoes are being produced. Twenty per cent infestation would perhaps better represent the entire state.

LEAF-ROLL (cause undetermined). Leaf-roll was particularly difficult to distinguish from some of the psyllid-yellows symptoms, but in the 56 fields selected for the calculation of average mosaic infestation, an average of 2.3 per cent of plants were affected. Leaf-roll occurs wherever potatoes are grown in Utah.

CALICO (cause undetermined). Traces of calico were seen in Cache, Salt Lake, Utah, and Millard counties.

SPINDLE-TUBER (cause undetermined). Potato spindle-tuber has been observed in northern Utah for several years, but the prevalence of yellows prevented additional observations in 1927. What was probably this disease was seen several times in Cache and Davis counties.

PSYLLID-YELLOWS (cause undetermined). A state-wide outbreak of psyllid-yellows, a new and highly destructive potato disease, was the outstanding plant pathological event in Utah in 1927. This disease (Plant Disease Reporter 11:93-94 and 110-111, and Phytopathology 18:140-141) in its maximum severity led to complete destruction of the crop in some areas and, in the state as a whole, caused the heaviest losses ever known to have resulted in Utah from a single potato disease.

This disease first came to the attention of plant pathologists on June 12 of this year when H. L. Blood observed it in experimental plantings at Farmington. On June 15, B. L. Richards found it prevalent in fields of early market potatoes at Bountiful, Davis County. Its serious nature was apparent even at that early date. When the writer began his survey of potato fields on June 29, early potatoes in Weber and Davis counties were generally infested, and before the survey was concluded on September 15 this disease had been found in every county where potatoes had been examined for it.

It became apparent during the survey that this was not the initial outbreak of psyllid-yellows which had thus been observed. Early in the spring of 1927 this same disease had caused the complete failure of potatoes in Washington County in the extreme southwest corner of the state. Furthermore, it is reported by County Agent O. R. Madsen, and by growers, that this disease had occurred locally in destructive form at Green River, Emery County, during 1925 and 1926. This is confirmed by the writer's memory of having examined a specimen plant at the Utah Experiment Station while visiting there in 1925, a specimen sent in by Mr. Madsen, which showed the characteristic symptoms of this disease but which was then diagnosed as probably a form of Rhizoctonia injury because of the tuberization of aerial parts.

The local occurrence of this disease during two former years, together with its widespread occurrence during 1927, makes it appear probable that psyllid-yellows may have occurred in other outlying areas in years past. Evidence on this point is lacking, but it is very clear that no appreciable amount of it had occurred in recent years in the more important potato areas of Utah. Detailed study of potato virus diseases in several of the northern and central counties by the Experiment Station, and seed potato certification work by the State Department of Agriculture extending into south central counties as well, have involved such close observation of potatoes in the important producing areas that this disease would surely have been detected had it been present in more than traces.

Symptoms have already been described briefly in the notes cited above, but it is essential here to state the nature of the losses incurred by this disease. Such losses were of two types: reduction in gross yield, and lowering of quality of the product. Plants which were affected early, before tuber formation had begun, yielded almost no tubers of usable size. At the other extreme, if the tubers were already well developed at the time the disease appeared, the market quality of these tubers was lowered by the development of knobby growth or by the sprouting of the eyes with the formation either of leafy shoots or of stolons which in turn set small tubers. Between these two extremes the usual condition prevailed: the yield of tubers of marketable size was greatly diminished, and these tubers were frequently malformed and were beginning to sprout when harvested. (Plate IV).

Almost universally the disease developed earliest and attained the greatest severity in the earliest planted potatoes in any locality. This included everywhere the home garden crop and in certain areas the chief market crop as well. In these early plantings the disease first affected scattered individual plants and then rapidly spread until all plants were affected. For a time it appeared as if the late crop would escape injury, but the disease spread progressively throughout the season as long as healthy plants remained in any locality. Field observations suggest that the initial outbreak on early potatoes occurred almost simultaneously throughout the central counties, but much later here than in Washington County.

All varieties appeared susceptible to yellows. Symptoms varied with the variety of potato, both on the vines and the tubers, and, as a result of differences in time of planting there were sometimes apparent differences in the severity of injury. Where planted side by side on the same date, however, the varietal differences that could be seen appeared to result chiefly from the interaction of the seasonal development of the disease and the different rates of maturity of the varieties. No indication of immunity was observed.

When other conditions were equal, the disease developed with equal freedom in potatoes grown from seed from diverse sources. This appeared to be true even at Green River where the disease had occurred before. Seed-borne infection could not, therefore, be held responsible for this outbreak.

As reported in the notes cited above, a species of psyllid, reported by Richards to be Paratrioza cockerelli Sulc., was found almost constantly associated with plants showing early stages of this disease. This relationship appears first to have been observed on June 29 when the writer in company with H. L. Blood of the Utah Agricultural Experiment Station and County Agent A. L. Christiansen began the survey of early market potato fields in Weber County. A disturbance of tomato plants in this county had been attributed to psyllids, and accordingly potato plants affected with the new disease were searched for this insect. From the very first plant examined, a diseased individual was rarely searched that day without being found to carry either psyllid nymphs or their casts, and although numerous healthy plants were examined similarly in the same fields, the insect was rarely found upon them. Before the survey was concluded on September 15, this relationship had been observed by the writer and others in the geographic extremes of the state. Plants which appeared healthy rarely carried the insect, while diseased plants, except in late stages, almost always harbored the nymphs or their casts. As far as circumstantial evidence can be relied upon, field observations convict this insect of being in some way responsible for potato psyllid-yellows. See the note by Richards (Phytopathology 18: 140-141) for experimental confirmation of this.

At the close of the survey psyllid-yellows appeared to coextensive with potato culture throughout Utah. Table 22 lists the 23 counties in which it was found during the survey. Potatoes were not examined in the remaining six counties of the state. It is significant of the thoroughness of distribution of psyllid-yellows that in all but three of the 19 counties for which figures are presented in the table the disease was found in every field examined, and that in at least two of these three exceptions, Cache and Salt Lake counties, nearly every field was infested before harvested. The severity of injury, however, was by no means equal in the different counties, but varied widely with the earliness of inception of the disease even where the thoroughness of infestation was essentially equal at the close of the season,

The maximum severity of this disease, total destruction of the crop, was seen many times in 1927, most frequently in early potatoes. Home garden potatoes which generally represented the earliest plantings in their respective localities were practically a failure throughout the state. In the commercial potato crop, the most conspicuous losses were sustained by the producers of early market tubers. Recital of a few special examples will serve better than generalizations to make clear the importance of potato psyllid-yellows in Utah in 1927.

In Washington County potatoes are said to have been a complete failure. This county was surveyed late in August, long after potatoes normally are harvested, but there had been no harvest. Plants which remained alive at this time showed late stages of psyllid-yellows. Inquiry among growers failed to find a farmer or home gardener who had eaten new potatoes from his own plantings this year. Such a total failure of the crop is without precedent in this county.

TABLE 22 - Psyllid-yellows of potato in Utah, 1927, by counties. a/

County	Number of fields examined	Fields infested number	per cent	Heaviest infestation per cent	Average infestation per cent
Cache	16	9	56.2	100	53.1
Carbon	15	15	100	100	61.1
Beaver	5	5	100		84
Boxelder	5	5	100	100	53.2
Davis	32	32	100	100	56.6
Duchesne	5	5	100	100	91
Emery	1	(disease said to be prevalent throughout)			
Garfield	4	4	100	100	61.2
Grand	1	1	100	100	100
Iron	21	21	100	100	83.8
Juab	1	1	100	10	10
Kane	4	4	100	100	70
Millard	17	9	52.9	87	24.2
Morgan	(disease reported prevalent late in season)				
Piute	11	11	100	100	38.2
Salt Lake	24	13	54.2	100	21.7
Sanpete	12	12	100	100	95.8
Sevier	10	10	100	100	80.8
Uinta	6	6	100	100	68
Utah	9	9	100	100	44
Weber	11	11	100	100	74.9
Wasatch	(disease present)				
Washington	(crop a total failure from this disease)				

a/ The figures in this table include data from many fields that were examined before the disease had reached its maximum spread. The different times at which different counties were surveyed thus make comparisons of figures in this table from different counties somewhat misleading.

In Duchesne and Uinta counties potatoes were not a complete failure but losses were far more severe than average for Utah. With about a 50 per cent crop in prospect the inhabitants of the Uinta Basin were facing the necessity of substituting some other carbohydrate food for potatoes, since freightage costs from the nearest railroad make importation of so heavy a product almost prohibitive.

Davis and Weber counties, producing chiefly early market tubers, suffered perhaps the most acute financial losses, amounting to approximately 60 per cent of the crop. Numerous commercial fields were not even dug, and yields of 10 to 20 per cent were frequent among the better fields of early potatoes that were harvested. Yields of even late potatoes rarely exceeded 75 per cent of the normal production of marketable tubers. Many of the progressive growers in this area plant chiefly certified seed, and seed costs generally are higher here than in most other parts of the state.

Severe losses from reduction in yield of the market crop occurred in Utah and Sanpete counties, and from reduction in quality of tubers in almost every producing area. Reduction in quality and marketability was most acute in the seed-producing centers, particularly in Piute County where the production of certified seed is a young and thriving industry. Because of the uncertain advisability of using tubers from affected plants for seed, much otherwise valuable seed stock was refused certification and forced into the common market.

A summary estimate of the total loss to the state from this disease is hard to formulate. "Crops and Markets" for November 1927 indicates an acre yield in Utah for 1927 that is 19 per cent below the ten-year average, and a quality ten per cent below the ten-year average. These figures, however, probably do not allow fully for the failure of garden potatoes and potatoes grown solely for home consumption in the outlying districts. On the basis of observations made during the survey, an average reduction for the entire state of 25 per cent of the total crop appears to be a conservative estimate. Even this figure fails to reveal the potential menace of psyllid-yellows to profitable potato culture and even to agricultural prosperity in certain parts of the inter-mountain region. In areas where potatoes are now a chief cash crop, frequent repetition of the 1927 outbreak would be disastrous.

RHUBARB (Rheum rhaponticum)

LEAF-SPOT (Phyllosticta straminella). Traces collected at Price and Logan, Utah. B. L. Richards reports it present in Cache County and abundant in Davis County in 1926. Probably widespread in the state, but very minor.

ROOT-ROT (cause undetermined, probably Phytophthora sp.). A soft root-rot caused 95 per cent loss of stand in one new planting in Davis County.

ROOT-KNOT (probably Heterodera radicum). A one-acre field of rhubarb at Bountiful, Davis County, was reported completely unproductive. The plants, which were two years old, supported only a few small leaves. Every plant dug was found to have its roots affected with galls of varied form and size, apparently those of the root-knot nematode. This field was planted from home-grown plants: examination of the parent field revealed

some of the same condition, but not nearly as much. No similar condition was seen elsewhere in the state.

SPINACH (Spinacia oleracea)

CURLY-TOP (cause undetermined). The only field of spinach examined contained one per cent of plants affected with what appeared to be the curly-top disease. The plants were dwarfed, the leaves crinkled with prominent and malformed veins, and the phloem in leaf petioles was necrotic.

DOWNY MILDEW (Peronospora effusa). Not seen in 1927. Reported earlier from Salt Lake County by A.S. & R. Co.

SQUASH (Cucurbita maxima and C. pepo condensa)

BACTERIAL WILT (?) (cause undetermined). Plants affected with what appears to be a bacterial, vascular disease distinct from that caused by Bacillus tracheiphilus, were frequently found associated with attacks of the squash bug in Salt Lake, Davis, and Weber counties. B. L. Richards reports having seen a similar condition in the absence of the insects. A bacterial culture has been obtained from such plants several times by the Experiment Station workers. This opens the question as to whether part of the deadly action of the squash bug may be due to the transmission of a bacterial disease.

POWDERY MILDEW (Erysiphe cichoracearum). Collected only in Grand County in 1927. Minor. Has been reported from Salt Lake County by A. S. & R. Co.

LEAF-BLIGHT (Macrosporium cucumerinum). This disease was somewhat less severe on squash than cantaloupe at Green River, the only locality found infested.

CURLY-TOP (cause undetermined). This disease varied from a trace up to a maximum infestation of 12 per cent. Affected plants produced almost nothing. Aside from the questionable bacterial disease, this is the most important disease of squash observed in Utah. In the state as a whole it caused less than one per cent of loss.

TOMATO (Lycopersicum esculentum)

BACTERIAL CANKER (Aplanobacter michiganense). (Plate III, fig. 2) This disease first came to the attention of Experiment Station workers in Davis County in 1923, but its identity and serious nature were not recognized

at that time. A survey of tomato fields by these workers for virus diseases in 1923 failed to record any considerable amount of this disease. Upon its identification in 1927, confirmed by Miss Mary K. Bryan of Washington, D.C., the Experiment Station began active investigation of this problem.

In 1927 bacterial canker proved the most destructive disease of the tomato in the state as a whole and was particularly prevalent in canning crop tomatoes. It was collected in nine of the 17 counties in which tomatoes were examined, and in 37 of the total of 82 fields and gardens examined, or 45 per cent of the plantings. The average infestation in these 82 plantings was 10.5 per cent of plants. In Boxelder, Weber, Davis, Salt Lake, and Utah counties, the counties where tomatoes are grown for canning, 41 fields were examined and of these, 32 fields or 78 per cent, contained the disease. In these five major tomato counties the plantings examined contained an average of 18.2 per cent of affected plants. The maximum loss in any field was 95 per cent of the plants.

Bacterial canker was not entirely limited to canning crop tomatoes, but these were characteristically more affected than were garden tomatoes. While final evidence is not yet available it is highly probable that this disease is carried in the seed, and the field evidence in Utah this year indicated that the seed stocks used by the canners in 1927 were badly infested. This seed was grown almost wholly within the state in 1926 under the canners' supervision. The seedlings set in the field were sometimes home grown and sometimes imported from Nevada and California. Severe outbreaks of the disease could not be traced exclusively to either source, but there was clear evidence of great differences in the amount of disease in seedlings from different seedbeds. Hope for control of this disease would seem to lie in the planting of clean seed and in the prevention of seedbed infection.

Fig. 4. - Distribution of bacterial canker of tomato in Utah as observed in the 1927 survey (O - absent; x - present).

WILT (Fusarium lycopersici and Verticillium albo-atrum). Tomato wilt in Utah is caused by both the fungi named, and available information is inadequate to indicate the importance of each. Both fungi were isolated during 1927, and apparently the *Fusarium* is most abundant in the major tomato counties but, in view of the work now being done by the Experiment Station aiming towards the perfection of tomatoes resistant to the *Fusarium*, it is important that the relative importance of these diseases be determined more precisely and the range of each be charted. Besides the five major tomato counties named above, wilt was found in Uinta, Grand, and Washington counties representing the geographic extremes of the state. Ten per cent of plants was the maximum infestation counted. The loss for the state as a whole is estimated at 2 per cent of the yield.

FRUIT ROTS (Corticium vagum and others). Tomato canners complained of more loss than usual through the decay of ripening tomatoes in the field. This rot was most prevalent in old tomato fields. Irrigation is probably an important factor in wetting the fruits and starting the decay.

BLOSSOM-END ROT (cause undetermined). Less than usual this year. Was observed in a single field in Boxelder County on a gravelly soil.

YELLOW (YELLOW BLIGHT) (cause undetermined). This disease was co-extensive with tomato culture in Utah in 1927. Like curly-top of the sugar beet, it was relatively late in appearing in heavy infestation and was less destructive throughout the state than in 1926. It is said to have been practically absent in 1925. Of 82 fields examined, 58 were found infested, or 70.7 per cent of fields; and the average infestation computed for the 82 fields was 11 per cent of the plants. This latter figure is deceptive, for most of the fields in which very high percentages of diseased plants were counted were small fields or home garden plantings outside of the commercial tomato producing areas. The 41 fields examined in the five tomato canning counties showed an average count of only 5.7 per cent affected plants, and many of these developed the disease after they had already begun to produce. The heaviest infestation recorded was in a small garden planting in Emery County where 70 per cent of the plants were affected.

MOSAIC (cause undetermined). In addition to the tomato canning counties, mosaic was observed in Grand, Sanpete, and Cache counties, and in the last two named the diseased plants had been shipped from Davis County where the disease is abundant. At Moab, in Grand County, as frequently in the central counties, Physalis plants growing near the tomatoes carried a mosaic disease. In the three south-west counties, Washington, Kane, and Iron, a total of sixteen plantings showed no trace of the disease. The extreme variation in infestation, from 0 to 60 per cent in commercial plantings, indicates the operation of local factors that are not fully understood. In one field with an average of 25 per cent mosaic, many of the plants showed symptoms on only the uppermost leaves, indicating relatively late infection. An outside row in this field gave a count of only 4 per cent mosaic. Here the spread was clearly not limited to the seedbed, but, in some other instances, seedbed contamination has appeared to be responsible for heavy

infestations in the field. The maximum infestation observed was 60 per cent of plants in a commercial field in Utah County. The vast majority of fields even in the tomato-canning counties were practically or wholly free from mosaic.

STREAK (cause undetermined). Streak was found sparingly over approximately the range covered by mosaic, but less abundantly than mosaic in any given field. The maximum infestation observed was in a home garden planting in Sanpete County where 8 per cent of plants were affected. In this garden 50 per cent of plants showed mosaic, and potatoes were directly adjoining the tomatoes on two sides.

ROOT-KNOT (Heterodera radicicola). Known to occur in Utah, Davis, Weber, and Cache counties. Not observed during 1927.

TURNIP (Brassica rapa)

POWDERY MILDEW (Erysiphe polygoni). A single collection was made in Boxelder County near the town of Garland. Doing slight damage late in the season.

LEAF-SPOT (Alternaria sp.). Reported from Salt Lake County by A. S. & R. Co.

WATERMELON (Citrullus vulgaris)

WILT (Fusarium niveum). Has proved a serious handicap to melon production in the south end of Davis County. Not reported elsewhere in the state.

LEAF-BLIGHT (Macrosporium cucumerinum). Observed in two fields at Green River. In the worst field, adjoining badly diseased cantaloupe, the loss was estimated at 15 per cent of yield. The crowns of the plants were nearly defoliated, and even the younger leaves were affected.

BLOSSOM-END ROT (cause undetermined). Several plantings at Sandy, Salt Lake County, were troubled with a blossom-end withering and decay of undetermined cause. The loss was not serious.

BLACK ROOT-ROT (Thielavia basicola). Reported from Salt Lake County by A. S. & R. Co.

TABLE 23. - Summary of losses in vegetable and root crops.

Crop	Disease	Cause	Estimated loss per cent
Bean	Bacterioses	Bacterium phaseoli (and others?)	1.
	Root-rots	Corticium vagum and Fusarium spp.	1.5
	Mosaic	Undetermined	8.
	Total		10.5
Sugar beets	Root-rots (in field)	Chiefly undetermined	2.5
	Curly-top	Undetermined	15.
	Other diseases		3.
	Total		20.5
Pea	Root-rot	Aphanomyces euteiches	3.
	Other root-rots	Miscellaneous and undetermined	2.
	Other diseases		.2
	Total		5.2
Potato	Yellows	Undetermined	25.
	Stem-canker	Corticium vagum	3.
	Black-leg	Bacillus phytophthorus	.1
	Wilt	Fusarium and Verticillium	1.5
	Mosaic	Undetermined	10.
	Leaf-roll	Undetermined	2.
	Other diseases		.2
	Total (misleading: losses overlap)		41.8
Tomato	Bacterial canker	Aplanobacter michiganense	12.
	Wilt	Fusarium and Verticillium	2.
	Yellow blight	Undetermined	6.
	Mosaic	Undetermined	1.
	Total		21.

DISEASES OF FRUIT CROPS

ALMOND (Amygdalus communis)

BLIGHT (Coryneum beijerinckii). Not collected during 1927. Reported by B. L. Richards.

APPLE (Malus sylvestris)

BLIGHT (Bacillus amylovorus). Found sparingly in all apple growing districts. Body cankers of serious extent are rarely found on the apple, but in a few instances severe blossom and twig blight was seen to have prevented fruiting almost wholly. Said to have been more destructive other years than in 1927.

CROWN-GALL (Bacterium tumefaciens). Said by nurserymen to be rare. Still generally confused with the non-parasitic excess-callus growth at poorly fitted grafts.

POWDERY MILDEW (Podosphaera leucotricha). Collected only twice this year; in an abandoned home orchard in Iron County, and in a nursery in Salt Lake County. Minor.

CANKER AND DIE-BACK (Cytospora sp.). This fungus is frequently found associated with die-back and canker in uncared-for apple trees, but it has not yet been shown to be an aggressive parasite. Most frequent on trees that have suffered from drouth or frost.

COLLAR-ROT (cause undetermined). Causes the death of scattered trees in orchards generally. At Hurricane, Washington County, one small orchard has 95 per cent of the trees affected - a very unusual condition.

CHLOROSIS (cause undetermined). One of the most serious menaces to apple culture. Widely prevalent. See page 115.

JONATHAN SPOT (cause undetermined). Frequently troublesome with Jonathan apples in storage.

INTERNAL BREAKDOWN (cause undetermined). A general or sometimes local internal browning and necrosis developing sometimes just before but usually soon after the apples are placed in storage. Has proved very troublesome in some seasons, particularly in large apples of the Jonathan variety.

WATER-CORE (non-parasitic). Sometimes present but negligible.

ROOT-KNOT (Heterodera radicicola). Occasionally collected by nursery inspectors. Very minor.

APRICOT (Prunus armeniaca)

BLIGHT (Coryneum beijerinckii). Frequently the cause of disfiguring spots on the fruits.

CHERRY (Prunus sp.)

BODY-CANKERS and DIE-BACK (cause undetermined). In Utah and Boxelder counties and in the counties which lie between, the older sweet cherry orchards and some younger are suffering from the rapid and irregular dying of scattered trees. A tree which blossoms freely in the spring may wilt even before the oldest leaves are mature. Sometimes a single large branch is first affected followed by other branches; sometimes an entire tree dies at once. This trouble is most serious in the older orchards, but young trees in their first to fourth years have also been seen to die in apparently the same way. The cause of this trouble has not been studied. Doubtless it is in part a form of winter injury, but it is not wholly that. Cankers, apparently of parasitic origin, have been detected on aerial and underground parts, but their importance and relation to the death of the tree is not known. Some growers hold that proper care to keep the orchard clean and in good tilth, and the trees free from mechanical injury solves the problem for all but the oldest trees. These they expect to replace when they begin to lose vigor. The susceptibility of younger trees, however, demands that the nature and cause of these losses be determined if possible.

BLACK-KNOT (Flowrightia morbosa). Not observed on cultivated cherry nor plum in Utah, but prevalent on the native chokecherry. Many old cankers and relatively few new ones were seen in 1927.

LEAF-SPOT (cause undetermined). A shot-hole leaf-spot resembling the disease caused by Coccoomyces hiemalis was observed several times on wild and cultivated cherry, but no fungus was found associated with the lesions.

GOOSEBERRY (Ribes spp.)

POWDERY MILDEW (Sphaerotheca mors-uvae). Was seen during the survey only at Castle Dale, Emery County. Reported by B. L. Richards to have occurred in serious form in Boxelder and Weber counties for years.

GRAPE (Vitis sp.)

CROWN-GALL (Bacterium tumefaciens). Occurs locally in Davis and Utah counties. Seriously weakens affected vines.

POWDERY MILDEW (Uncinula necator). Occurs in all important grape areas. Said to be much less severe in 1927 than in some former years. B. L. Richards reports that it destroyed the entire crop in unsprayed vineyards in Davis County in 1925.

CHLOROSIS (cause undetermined). A serious limiting factor, restricting grape culture to soils and localities where it occurs least destructively and reducing the vigor and yield of many home garden and some commercial plantings. Much less frequent in the southern counties than the northern.

PEACH (Amygdalus persica)

CROWN-GALL (Bacterium tumefaciens). Reported to occur sparingly in nursery stock.

LEAF-CURL (Exoascus deformans). Known in only a single orchard in northeastern Boxelder County.

BLIGHT (Coryneum beijerinckii). Almost totally absent this year. During some seasons it has been prevalent in the northern counties, damaging the young twigs and marring the fruits. Its range apparently covers the state.

BODY CANKER and DIE-BACK (cause undetermined; winter injury in part). In home orchards throughout all but the most southerly counties and in commercial orchards particularly in Boxelder and Utah counties, peach trees are conspicuously disfigured with body cankers of diverse types, and weakened to extremely low productivity. The almost complete freedom from this condition which prevails in Washington County, together with the known relation of much of this injury to certain particularly severe winters makes it apparent that much if not most of this is winter injury, either directly or indirectly. This has already been studied descriptively by Mr. Abel of the Experiment Station, but it merits further investigation looking to possible prevention.

CHLOROSIS (cause undetermined). Chloroses of two types have been observed affecting the peach. Chlorosis as observed in the northern counties generally affected other woody plants in the immediate vicinity as severely as the peach. Grapes especially usually were more severely affected. In several localities in the southern part of the state peaches showed a different injury which appeared to affect the peach almost solely.

In a number of instances grapes adjoining affected peach trees were entirely free. This chlorosis, characterized by a more golden yellow color than that in the northern counties, leads eventually to death of the tree. Fruits are not affected in size or time of maturity except in the last stages when they may fail to mature. Apparently this is different from any of the known infectious chloroses of the peach; the opinion was expressed by some growers that it is infectious, but clear evidence of this was not seen during the survey. This is the most destructive disease of the peach at Moab, Grand County and throughout Washington County, where it is worse at Toquerville and LaVerkin than at Hurricane and St. George.

POWDERY MILDEW (Podosphaera oxyacanthae). Has been reported from Utah but was not seen during 1927.

PEAR (Pyrus communis)

BLIGHT (Bacillus amylovorus). This is the one destructive disease of the pear in Utah. It has driven out commercial pear culture from all but a few localities and is demanding constant vigilance on the part of the remaining pear growers. Blight occurs wherever pears are found in the state but since commercial pear culture is now largely limited to Utah County it has become chiefly a local problem. Here some orchards were found almost clean and others with every tree affected. Some of the more vigilant and skillful growers are holding their own, but others are losing valuable wood in trees which they save, or losing entire trees. The severity of blight apparently varies widely with irrigation and other cultural practices. In home gardens throughout the state one still finds isolated pear trees, chiefly of the poorer varieties, which are holding up without any particular care to protect them from disease.

CANKER (cause undetermined). A type of canker apparently distinct from that caused by Bacillus amylovorus has been observed by B. L. Richards.

RASPBERRY (Rubus sp.)

CROWN-GALL (Bacterium tumefaciens). Reported occasionally in nursery stock. In one home garden in Logan it has proved very destructive. Its prevalence in commercial plantings in the state is unknown.

CHLOROSIS (cause undetermined). The most widespread and destructive disease of raspberry throughout the state. See page 115.

POWDERY MILDEW (Sphaerotheca humuli). Reported from Utah but not seen during 1927.

STRAWBERRY (*Fragaria* sp.)

BACTERIAL BLIGHT (cause undetermined). A leaf blight which shows the characteristics of a bacterial disease and which appears different from all known diseases of the strawberry was found widely distributed in northern Utah in 1927. It is characterized by small, angular, dark green, watersoaked lesions, first visible from the lower side of the leaf or by transmitted light, but later marked on the upper surface by a reddish or brownish color. The spots enlarge but remain angular, delimited by the veins of the leaf. Sometimes they elongate along the larger veins. The lower surface of these lesions characteristically bears, when wet, a copious milky bacterial slime; when dry, a thin scale of exudate. (Plate V.)

No detailed survey of strawberries was attempted, but this disease was found in eight of the 13 fields or gardens examined, and in four out of five counties: Cache, Weber, Davis, and Utah (not in Uinta). In parts of three of these fields, the disease had reduced the leaf surface markedly. Present indications do not place this as a very destructive disease but it is the most important disease of the strawberry seen in the survey.

LEAF-SPOT (*Mycosphaerella fragariae*). Occurs widely on wild strawberries in northern Utah. Collected sparingly in a single patch of cultivated berries at Logan, Cache County.

TABLE 24. - Summary of losses in fruit crops.

Crop	Disease	Cause	Estimated loss per cent
Apple	Blight	Bacillus amylovorus	0.2
	Chlorosis	Cause undetermined	2.
	Other diseases		1.
	Total		3.2
Cherry	Die-back	Undetermined	2.
Grape	Chlorosis	Undetermined	5.
Pear	Blight	Bacillus amylovorus	8.
Raspberry	Chlorosis	Undetermined	12.

DISEASES OF ORNAMENTAL PLANTS

BOXELDER (Acer negundo)

LEAF-SPOT (Septoria negundinis). Collected in Logan Canyon, at Logan, and at American Fork. Occurs very sparingly.

BUFFALOBERRY (Shepherdia argentea)

LEAF-SPOT (Cylindrosporium shepherdiae). Collected only at Vernal, Uinta County. This appears to be the first collection of this fungus on this species of Shepherdia.

CARNATION (Dianthus caryophyllus)

RUST (Uromyces caryophyllinus). Always present and troublesome in the greenhouses.

CHINA-ASTER (Callistephus chinensis)

WILT (Fusarium conglutinans callistephi). Aster wilt, hitherto not reported from Utah, was found in Iron, Beaver, Utah, Salt Lake, and Davis counties. At Cedar City, seven out of eight gardens examined contained the disease, and several gardeners reported having given up aster culture because of it. In Davis and Salt Lake counties, several commercial florists have abandoned aster culture and home gardeners are turning to other flowers which are more dependable. The maximum severity observed was in a one-fifth acre planting near Salt Lake City where, at blossoming time, 85 per cent of the plants were wilted and many others weakened.

YELLOW (cause undetermined). First observed in Utah September 9, 1927, at Murray, Salt Lake County. It was seen in four localities in Salt Lake and Davis counties, with a maximum severity of 3 per cent.

CLEMATIS (Clematis ligusticifolia)

LEAF-SPOT (Didymaria clematidis). Observed only on the native species of clematis. Collected in Duchesne and Cache counties.

LEAF-SPOT (Cerospora squalidula). Collected in Duchesne and Cache counties.

RUST (Puccinia clematidis). Widely and sparingly distributed.

DELPHINIUM (Delphinium sp.)

POWDERY MILDEW (Erysiphe polygoni). Collected only at Logan on some of the plants affected with the following disease.

YELLOW (cause undetermined). In a single garden at Logan almost 50 per cent of the plants of tall perennial delphinium were affected with a disease apparently not described on that plant. Some of the plants became chlorotic in advance of blossoming, but the characteristic feature of the disease was the leafy proliferation of floral parts. All degrees of this transformation were present from slightly greenish flowers to expansive leafy structures which could be recognized as floral organs only by their arrangement on the axis. Carpels, stamens, petals, and sepals were equally affected. On some plants, the severity of injury varied widely from spike to spike. As noted above, several affected plants were overrun with powdery mildew, but many were free from any discernible fungous infection. Delphinium is not known to be susceptible to aster yellows.

GOLDEN GLOW (Rudbeckia laciniata)

POWDERY MILDEW (Erysiphe cichoracearum). Observed in home gardens in Iron, Beaver, and Salt Lake counties.

HOLLYHOCK (Althea rosea)

RUST (Puccinia malvacearum). Collected in 1927 only in Utah County, but known to occur more widely in the past.

HYDRANGEA (Hydrangea sp.)

POWDERY MILDEW (undetermined). Collected only in one commercial greenhouse in Davis County.

IRIS (Iris sp.)

LEAF-SPOT (Didymellina iridis). Abundant in a garden at Logan. Many iris plants were examined elsewhere without finding it.

JUNIPER (Juniperus utahensis)

MISTLETOE (Phoradendron juniperinum). Along the highway from Kanab to Mt. Carmel, Kane County, over 50 per cent of the juniper trees including nearly all the older ones bear conspicuous growths of mistletoe, and many of the remainder are affected less conspicuously. Junipers in local areas on the north slope of the Kaibab Plateau in Arizona are likewise heavily infested. (Plate III, fig. 4)

PEONY (Paeonia sp.)

ROOT-ROT (cause undetermined). A commercial florist in Davis County lost 25 per cent of his half-acre of peony plants from a root-rot of undetermined cause.

PLANE TREE (SYCAMORE) (Platanus spp.)

ANTHRACNOSE (Gnomonia veneta). Less new infection than usual this year. Trees damaged by this disease in past years are in evidence widely through the state, notably in Provo where the American species has been planted extensively.

BODY CANKER (cause undetermined). Body cankers apparently distinct from anthracnose were observed on the European plane tree at Farmington. They appeared different from winter injury which was also present; parasitic origin was indicated especially by progressive development through the summer.

POPLAR (and COTTONWOOD) (Populus spp.)

LEAF-SPOT (Marssonina populi). Collected on narrow-leaf cottonwood (P. angustifolia) at Peterson, Morgan County.

LEAF-SPOT (Septoria musiva). On common cottonwood (P. occidentalis) at Roosevelt, Duchesne County and Green River, Emery County.

LEAF-SPOT (Septoria sp.). A Septoria with elongate, non-septate spores was collected on narrow-leaf cottonwood in the Sevier River canyon, Piute County.

LEAF-SPOT (Sclerotium bifrons). Has been prevalent in the Cache National Forest and perhaps elsewhere. Not seen during the survey.

LEAF AND TWIG BLIGHT (cause undetermined). A blight which bears close resemblance to fire-blight of the pear in its general characteristics has swept through the native stands of narrow-leaf cottonwood in the vicinity of Logan during some past years. It was not seen during 1927.

CANKER (DIE-BACK) (Cytospora chrysosperma). This disease occurs throughout Utah, attacking especially the introduced poplars when they are weakened by age or unfavorable culture or environment. Drouth, alkali, careless pruning and dehorning are among the factors which encourage this disease. Winter injury may be another factor, if indeed it can be separated from the above named. Rarely is a young, vigorous tree attacked by this fungus in advance of severe wounding.

POWDERY MILDEW (Uncinula salicis). Widely but sparingly distributed. Sometimes abundant locally late in the season.

CROWN-GALL (Bacterium tumefaciens). Of rare occurrence in the state.

PRIVET (Ligustrum sp.)

ROOT-KNOT (Heterodera radicicola). Not seen during survey. Reported by B. L. Richards.

LEAF-SPOT (cause undetermined). A leaf-spot, apparently an undescribed bacterial disease, was observed in Cache, Utah, and Beaver counties. In Utah County, chiefly in Provo, where 18 hedges were examined, the disease was found in nine. At its greatest observed severity it caused disfigurement of the hedge through the production of a brownish color; in most instances it occurred in traces only. Not wholly limited to leaves, this infection sometimes spreads down through the succulent tip of growing twigs, but few twigs are killed in this manner. The presence or absence of this disease in other parts of Utah has not been established.

ROSE (Rosa spp.)

CROWN-GALL (Bacterium tumefaciens). Rarely detected in nursery stock.

BLACK-SPOT (Diplocarpon rosae). Most serious disease of greenhouse roses. No adequate control measures. Seldom observed on cultivated roses out-of-doors, but prevalent on native roses in late summer.

POWDERY MILDEW (Sphaerotheca pannosa). Coextensive with rose culture in Utah, but highly variable from year to year. In greenhouses it is often present but yields readily to sulphur treatment. Garden roses, particularly the climbing varieties, are frequently overrun, but control measures are rarely attempted.

RUST (Phragmidium sp.). Rare on cultivated roses but abundant on native species.

SNAPDRAGON (Antirrhinum majus)

RUST (Puccinia antirrhini). Said to be difficult to control in greenhouse culture where plants are started from cuttings but seldom present where only seedling snapdragons are grown. In one home garden at Logan seedlings were found thoroughly infested and plants weakened to less than half their full vigor.

SUNFLOWER (Helianthus annuus)

DOWNY MILDEW (Plasmopara halstedii). Collected on wild sunflower near Price, Carbon County. Not reported from Utah until 1927. Apparently systemic on some plants.

POWDERY MILDEW (Erysiphe cichoracearum). Widespread on the wild sunflower.

STEM-ROT (Sclerotinia sclerotiorum). Observed on double-flowered sunflowers in a garden at Logan. Has been seen in Cache County in years past.

WILT (cause undetermined). A wilt disease, apparently undescribed, characterized by fungous invasion of the xylem vessels extending high into the stem, was found on a few plants of double-flowered sunflower at Logan.

RUST (Puccinia helianthi-mollis). General on the wild sunflower.

SWEET PEA (Lathyrus odoratus)

POWDERY MILDEW (Erysiphe polygoni). Occurs widely both in the greenhouse and in gardens. Only slight traces were observed during 1927, but the disease sometimes proves very destructive in gardens late in the summer.

ROOT-ROT (cause undetermined). A decay of roots and basal internodes of stem frequently causes heavy losses to home gardeners and commercial growers. The cause has not been investigated. Apparently it is distinct from the *Aphanomyces* root-rot of the common pea.

ZINNIA (Zinnia elegans)

WILT (cause undetermined). A wilt and basal stem rot comparable to the wilt of china asters occurs on occasional plants very widely throughout the state. Fungous invasion of the xylem vessels does not extend far in advance of the decayed portion. No detailed study has been attempted.

DISEASES COMMON TO SEVERAL PLANTS

DODDER (Cuscuta spp.). Dodder parasitizes numerous plants, both native and cultivated, but is known chiefly as it affects alfalfa. Because of its being distributed with alfalfa seed, it may be found almost everywhere that crop is grown but, fortunately, as increasing attention is being given to clean seed the alfalfa dodder problem is declining until it now is rarely the cause of important losses.

The one area in which dodder was seen to be an outstanding problem was in Duchesne County, notably near Ioka and Mt. Emmons. In one six-acre field of alfalfa, 75 per cent of the area was completely overrun; in many other fields dodder covered 10 or more per cent of the plants. A few fields in other counties contained large infested areas which spoke of no effort at control, but generally infestations were in the nature of scattered foci from which little spread had occurred. (Plate III, fig. 1.)

Other crop plants attacked by dodder were observed during the survey, but in each instance the injury was slight. In several tomato fields young plants had been strangled by dodder soon after being set out. One potato field in Davis County showed numerous conspicuous bright yellow patches of dodder; elsewhere only an occasional potato plant was found overrun. Beets of all kinds, - table, sugar, and stock, - were seen attacked, but no heavy infestation was noted. Carrots, peas, and onions, likewise, were found attacked by dodder, but never to a serious extent.

SULPHUR DIOXIDE INJURY. This is strictly a local problem in Utah in the vicinity of smelting plants that liberate quantities of waste sulphur dioxide gas. Numerous plants, native and introduced, including both ornamentals and crop plants, are susceptible to burning and present characteristic symptoms. Heavy losses are reported annually by growers in the affected territory, probably in excess of actual injuries from this cause, but an adequate study of this problem was clearly impossible during the survey and therefore no details of the chance observations that were made can wisely be presented.

CHLOROSIS (cause undetermined). Because of the large numbers of economic plants affected and the severity of injury to some of them, chlorosis is one of the outstanding plant pathological problems in Utah. Chlorosis is predominantly a disease of woody plants, and as such is, with few specific exceptions, the worst disease of fruit crops and ornamental

trees and shrubs in the state. More than most other diseases, it is of direct concern to town and city dwellers, for it frequently mars the beauty of home grounds, city parks, and planted streets. Chlorosis is prevalent in almost every irrigated section of the state, but is subject to wide local variation in frequency and severity. Often only part of a garden plot is affected.

Several crops which suffer notably, including raspberry, grape, peach, and apple, have already been mentioned under the appropriate heads, and it will be impossible to present a complete list of susceptible plants at this time. Such a list would be unsatisfactory at best, for chlorosis appears to result from several different sets of causes, and the plants affected differ in each. It appears that different plants are affected differently by chlorosis induced by different causes, and that susceptibility to chlorosis differs widely with the kind of plant under any given set of conditions.

Chlorosis sometimes is attributable, apparently, to excess of soil alkali. This condition, observed especially in Millard and Duchesne counties, affects nearly all introduced plants in different degrees, and is probably a very different phenomenon from chlorosis induced in poorly drained soils which are less charged with soluble alkalis. Even in well-drained soils, particularly, it appears, those of limestone composition, it sometimes prove very troublesome. Chlorosis in the better agricultural areas of the north-central counties appears to be associated chiefly with these last two conditions. At the other extreme, chlorosis is sometimes severe where the soil is sandy and apparently drained fairly well. At Elsinore, Sevier County, on such soil chlorosis was seen at its maximum prevalence and severity. From survey observations alone it is impossible to say whether or not the fundamental cause of chlorosis may be the same in all these cases, induced in the plant by these different environmental conditions, but the suggestion is that there are several kinds of chlorosis in Utah.

Under the influence of irrigation and faulty drainage, chlorosis is clearly on the increase in some areas. The immediate cause may be poor drainage as such or the accumulation of soil alkalis. Where irrigation and drainage are combining to alleviate the alkali problem, chlorosis is on the decline, but over the state as a whole no important change is perceptible. A searching inquiry into the causes of chlorosis and the means of control is one of the outstanding needs of irrigation agriculture in Utah.

EXPLANATION OF PLATES

III.

- Fig. 1. Dodder (*Cuscuta* sp.) on alfalfa, Cache Junction, Cache County, Utah, July 7, 1927.
- Fig. 2. Bacterial canker (*Aplanobacter michiganense*) in Earliana tomatoes, Provo, Utah County, Utah, August 3, 1927. Only 5.5 per cent of the original plants remained free from the disease at this date.
- Fig. 3. Yellows (cause undetermined) of celery, Hewitt Farm, Ogden, Weber County, Utah, Sept. 14, 1927.
- Fig. 4. Mistletoe (*Phoradendron juniperinum*) on the Utah juniper (*Juniperus utahensis*) near Mt. Carmel, Kane County. August 22, 1927.

IV.

- Figs. 1 & 2. Stolon and tuber irregularities associated with potato psyllid-yellows (cause undetermined). Russet Burbank variety. Ephraim, Sanpete County. August 20, 1927.
- Fig. 3. Sprouting of new, immature potatoes, associated with potato psyllid-yellows (cause undetermined). Russet Burbank variety. Ephraim, Sanpete County. Sept. 1, 1927.
- Fig. 4. New growth of potatoes following the harvest of a crop affected with psyllid-yellows. The young, healthy plants in this photograph arose from the small tubers left in the soil when the first, badly diseased crop was harvested. This early crop of Bliss Triumph yielded approximately 15 per cent of a normal crop of small tubers. Note the dried remains of the vines of this first crop. The new plants, when photographed Sept. 13, 1927, appeared free from psyllid-yellows. Dibble Farm, west of Layton, Davis County.

V.

- Fig. 1. Bacterial blight (cause undetermined) of strawberry. Lower surface of leaflet, showing numerous angular, dark green, water-soaked spots, and glistening drops of milky bacterial slime, X 2. Logan, June 14, 1927.
- Fig. 2. Bacterial blight (cause undetermined) of strawberry. Lower side of leaf, X 1. Logan, June 14, 1927.

PLATE III

PLATE IV

PLATE V