

## DISEASES OF VEGETABLE AND GARDEN CROPS.

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In making inquiries among the agriculturists of the Island as to why the growing of the common northern vegetables was not taken up for at least a home supply, the reply has universally been that all such attempts ended in failure. At times with the weather favoring one crop would be secured, but a second was apparently impossible. While it was realized that tropical weather conditions would not be conducive to the best growth of northern vegetables, still it was difficult to see why such complete failures resulted. Consequently a close watch was kept on the various trial plots at the Station and in so far as possible upon gardens in other parts of the Island; in particular the public gardens and those maintained in connection with the normal school at Río Piedras.

As a result observations have been made upon a very large number of fungi causing diseases of the various garden crops. In some cases these have attacked with such virulence as to readily explain the numerous failures reported, especially those with cucumbers and tomatoes. Practically all of the troubles so far observed are those of common occurrence in continental America and have all doubtless been introduced with the seed or other plant parts. Many interesting questions have arisen in the work with these diseases especially as regards their dependence upon weather conditions (temperature and humidity), their relation to insects as spore carriers, and above all their modes of attack. Soil and cultural conditions have likewise played an important part. Some of these points will be touched upon in the separate account of the diseases to follow, but others must be deferred until more detailed investigations can be carried out.

Some previous work has been done on the diseases of vegetables in Porto Rico, but with the exception of short notes of occurrence in reports of the Mayagüez Experiment Station, there are no published records. In Bulletin 7 of that Station, issued in 1906, reference is made, in connection with cultural directions for the various vegetables, to certain of the more common diseases and some suggestions for control are made. Certain ones are definitely reported as found in Porto Rico, but for the most part it is impossible to tell whether a given disease is so reported or whether the note is merely

a warning against a trouble that may appear. In the following account such data as the records of this office afford are reported, including for the purpose of completeness other published notes.

Very little has been attempted as yet in the way of control of the fungus diseases here given. Such experiments as time has permitted will be touched upon in the individual discussions which follow. It may be noted, however, that these have been rather uniformly unsuccessful and that methods other than those commonly advised for northern conditions must be tried.

Notes and observations on the various diseases found or reported follow, arranged topically under the various host plants.

#### ASPARAGUS (*Asparagus officinalis*).

In so far as noted this crop has not been grown successfully, although there have been reports of fair yields. The few plants seen had produced a fair growth of top but no edible shoots. An undetermined imperfect fungus, causing black lesions on the stems, has been found on old or dying plants. The rust (*Puccinia asparagi*) does not occur.

#### BEANS (*Phaseolus* spp.).

Two plantings of this crop were made at the Insular Station, one in February and the other in May on separate pieces of land. It is of interest to note that the diseases occurring on the first planting were lacking or of minor importance on the second; a state of affairs doubtless to be attributed in part to weather conditions and in part to the use of seed from various sources infected with different diseases.

As will be noted below there was a marked varietal resistance to the different diseases and a solution of the problem seems most probable through the use of resistant varieties. Native types already exist which thrive very well, and doubtless others will be found in the course of the experimental work which will be even more thrifty and disease resistant.

ANTHRACOSE, SPOTTING OF PODS (*Colletotrichum lindemuthianum* [Sacc. & Magn] Scribner).—This well-known disease has been very prevalent and forms one of the greatest obstacles to successful bean culture in Porto Rico. It has been commonly observed on green beans of local varieties offered for sale in the native shops, as well as on the northern types tried experimentally.

The pods, leaves, and stems were subject to attack. On the leaves the disease was noted as irregular, red-brown spots or more com-

monly as lesions along the midrib and principal veins. Susceptible varieties lost a large percentage of their leaves. Similar lesions also occurred on the stems and petioles, several such often uniting so as to involve practically their entire length. Young plants were in some cases completely girdled, resulting in speedy death, and in other instances they were so seriously weakened that little growth was made. On the pods very characteristic spots occurred. These appeared first as circular dark-brown areas, soon becoming sunken, and often coalescing to form irregular cankers. In each of these spots there was an abundant production of conidia (reproductive bodies) occurring in the form of numerous pink masses, so that at this stage the spots had a decided pink color. The fungus grows from these spots into the seeds, where it remains dormant until germination occurs, when it attacks the young plant. The necessity of selecting seed from disease-free pods will be apparent, since there is no method of destroying the fungus present without destroying at the same time the vitality of the seed.

As soon as the presence of anthracnose was noted spraying tests with Bordeaux mixture were initiated. Two applications were made. While it is impossible to draw definite conclusions from the results of one year's tests on a small plot, it seems apparent that spraying, with Bordeaux at least, is not effective, a conclusion which workers in other regions have also reached. Here as elsewhere the solution of the problem lies in the production of resistant varieties, a matter which has already been taken up by the plant breeder with excellent prospects of success. A black Venezuelan bean has so far given excellent results, and if it maintains its freedom from disease will be very satisfactory.

The first trials included the following varieties arranged here in their order of susceptibility as indicated by one season's tests in short parallel rows:

	Per cent of pods spotted.
Saddle black wax.....	42
Burpees round yellow, six weeks bush.....	34
Improved black wax.....	32
Hendesons bountiful bush.....	21
Extra early refuge.....	10
Early bountiful bush.....	8
Early red valentine bush.....	7
Curry's golden wax rust proof.....	5

This arrangement is based upon observations of the severity of infection on leaves and stems and upon counts of the pods, classifying them as free of spots, spotted and rejected. This count seemed

to show some benefit from the spraying, but the plantings were not large enough to give conclusive evidence. It is doubtful whether spraying will prove effective enough to pay for the additional expense. It must be noted with regard to varietal resistance that seed infection, a most important point, was not considered.

Later in the season a second crop of beans was grown on a neighboring plot of ground. The varieties were refugee, 1000-1 (both northern types), a black Venezuelan bean, and the native red bean. Only the slightest trace of anthracnose appeared, and this on the "refugee." Whether this freedom from disease was attributable to weather conditions, to clean seed or to varietal resistance was not apparent. Further tests are necessary.

**DOWNY MILDEW.**—A virulent disease, caused by a fungus of the *Phycomycetes* or alga-like fungi, attacked the refugee and 1000-1 beans of the second planting. The Venezuelan black wax and native red types in adjacent parallel rows were unaffected. The trouble appeared over night practically, and within a week had destroyed large portions of the plantings.

A plant once attacked rapidly succumbed, the leaves wilting and drooping in such a way as to suggest root troubles, but examination of early stages revealed healthy stems and roots, the tops being attacked first. The withering and consequent death of an infected plant, however, occurred very speedily. At times single plants only were attacked, but more commonly entire sections of a row up to eight or ten feet in length were killed, the disease spreading rapidly from the original point of infection. The most striking feature of this disease was the fungus growth on the pods occurring as flocculent (fluffy) white masses of mycelium obscuring the upper half of, or even at times the entire length of, the pod. Attacked pods were destroyed by soft rot.

The damage that this disease would be capable of, if bean growing were attempted on a commercial scale, was well illustrated by the fate of a peck of the refugee variety which was left for several days in the picking basket. When examined the entire lot had been matted together by the mycelial masses of the fungus and completely soft-rotted. Shipping this variety at least would have been a decided failure.

Time has not permitted any further studies of this disease. Hence the systematic position of the fungus involved has not been determined. It is not *Phytophthora phaseoli* Thaxter, which fungus, however, has been reported (5)<sup>1</sup> on lima beans in Porto Rico.

<sup>1</sup> Reference is made by number to "Literature cited," p. 117.

GRAY LEAF-SPOT (*Isariopsis griseola* Sacc.)—On the first planting spots due to this fungus were rare, but on the second were fairly abundant on the northern varieties. The black Venezuelan remained free. A native variety of the red kidney type was noted, in which the entire planting was spotted to such an extent as to cause a heavy dropping of leaves and consequent weakening of the plants. It is a common disease in native plantings. It can doubtless be controlled by Bordeaux mixture.

This disease was characterized by irregular, brownish gray to gray spots on the leaves up to half an inch in diameter. The spots differed from those due to *Cercospora* in that they were duller in color and lacked the definite red-brown angular margin. The fungus fruited freely in the center of the spots and appeared under a hand lens as numerous erect, rather compact, black clusters of conidiphores or conidia-bearing threads.

LEAF SPOTS (*Cercospora* spp.)—At least one other type of leaf spot occurred. The one commonly found and due to *Cercospora canescens* Ell. & Martin was collected on varieties of *Phaseolus vulgaris* (common bean), *Dolichos lablab*, and *Phaseolus lunatus* (lima bean). The spots due to this fungus were more or less angular, up to one-fourth inch in diameter, gray with a reddish brown definite margin, and their appearance was the same on both sides of the leaf. A specimen of *Cercospora cruenta* Sacc. collected on bean in Porto Rico is in the herbarium of the New York Botanical Garden. *Dimerium grammodes* (Kuntze) Gar. is reported on *Phaseolus lunatus* by Garman (9).

POWDERY MILDEW (*Erysiphe polygoni* DC?).—A powdery mildew appeared on the leaves of several of the varieties after the crop had been gathered and the plants were past maturity. Only unsprayed portions of the rows were attacked. It is of very minor importance since only old, unsprayed plants were found subject to it. The determination can be only provisional since the imperfect or *Oidium* stage only was found.

CROWN ROT (*Fusarium* sp.)—A crown rot or damping-off was noted to a very limited extent attacking the native red variety. Sunken lesions occurred on young plants at the ground level and extended for an inch or two along the stem, accompanied by a scanty production of white mycelium of a *Fusarium* sp. This was later noted on northern varieties, attacking young plants at various stages up to six inches in height, in some cases isolated plants only, in others accounting for several plants in a group or even a dozen or

more. The *Fusarium* found is apparently the same as causes a "damping-off" of tomato and eggplant seedlings.

BLIGHT (*Bacterium phaseoli* Sm.).—While this disease has not been definitely identified by exact methods, there can be but little doubt of its presence on northern varieties, but fortunately to a very limited extent only.

RUST (*Uromyces appendiculatus* [P.] Lk.).—The bean rust is known to occur on the Island, but has not been collected on the cultivated bean at this Station, although of common occurrence on several of the wild legumes (*Phaseolus adenanthus*, *Vigna repens*), etc. It forms very small, but numerous brown powdery eruptions on leaves and pods. It is not of sufficient importance to warrant control measures.

ROOT ROT OR WILT.—As many as four types of root rot or wilt are reported (5, 1). *Cercosporium* (?) *beticola* is given as the possible cause of one form. No further notes are given. This type of disease has not been observed during the present investigations.

#### BEET (*Beta vulgaris*).

The leaf spot (*Cercospora beticola* Sacc.) has been the only disease so far observed on this host. The death of mature leaves was somewhat hastened, but no further damage resulted. The spots were numerous, of the same appearance on both sides of the leaf, circular, brown at first, but later dull gray to dirty white, with definite red-brown margins. The Swiss chard (*Beta vulgaris* var.) was also attacked, whenever the leaves were allowed to come to maturity.

#### CABBAGE (*Brassica oleracea*).

Cabbage remained comparatively free of disease, although not making a very satisfactory growth. A soft, putrid, bacterial rot destroyed individual plants which had been injured in cultivating. Diseases due to *Pseudomonas campestris*, *Plasmodiophora brassicae*, *Peronospora parasitica*, and *Macrosporium brassicae* are mentioned by Henricksen (5), but are not definitely reported as found in Porto Rico.

#### CELERY (*Apium graveolens*).

Celery was slightly attacked by rootknot (*Heterodera radicumicola*), which is described in detail later. Leaf spot due to *Septoria petroselinii* Desm. was not found.

CASSAVA (*Manihot utilissima*).

WILTHERTIP (*Gloeosporium manihot* Earle).—In one locality a sweet (non-poisonous) variety of cassava was suffering severely from die back induced apparently by poor soil, and prolonged drouth, aided by the fungus in question. There was a characteristic withering and dying of the leaves which remained hanging at the tips of the twigs. The twigs and even the branches died back for a considerable distance, at times nearly to the ground level. Examination of the underground portions of the plants revealed no indications of disease. On the dead twigs the fungus formed small black fruiting pustules. Under favorable conditions this disease probably will give no trouble, though removal of diseased portions and cultivation should suffice to check it if it should by any chance get a start.

LEAF SPOT (*Cercospora henningsii* Allesch.)—The characteristic leaf spots due to this fungus are common but of no great importance. They are angular, small (seldom over one-eighth inch in diameter), and dull white or gray in color, with a definite reddish-brown margin.

RUST (*Uromyces janiphæ* [Wint.] Arthur.)—Not common, producing brown, powdery pustules on the under sides of the leaves. A root rot has also been reported (8) on this host.

CHAYOTE (*Sechium edule*).

The chayote is very subject to one or more leaf diseases which very often completely destroy the plant, frequently before any fruit has been produced. Spraying with Bordeaux mixture has not given satisfactory results in so far as observations have been made, nor do published records report any success along this line (5).

Miss Young (7) describes one type of leaf spot due to *Phyllosticta Sechii*. The spots caused by this fungus are said to be amphigenous, more or less irregular, often confluent, varying in size from two to twelve millimeters and dull white in color. Minute dark brown or black pycnidia are produced in the center of the spots on the upper surface of the leaves.

A second and much more virulent type of leaf spot occurs. This is due to an apparently undescribed species of *Cercospora* or preferably *Helminthosporium*. The spots are angular, up to ten millimeters in diameter, dull brown above, lighter below, sometimes becoming a dull white at the center in old spots, margins definite, fruiting on both surfaces. The leaf area between the numerous spots speedily dies and the leaf withers and drops. This disease presents

a very serious obstacle to the successful culture of the chayote. All of our collections of leaf spot on this host have been of this latter type, pyrenidia of *Phyllosticta* being found in only one very old spot, making it appear probable that the *Phyllosticta* is but secondary when present at all.

A root rot has been reported by some growers, but no data has been secured.

#### CORN (*Zea mays*).

Both the rust and smut were observed, the latter less commonly. The rust *Uredo pallida* (Diet and Holw.) attacked the older and lower leaves, generally at a time when the ears were nearly mature so that little damage could be attributed to it. It appeared as numerous small brown pustules on the under side of the leaves.

The smut (*Ustilago zea* [Beck] Ung.) attacked all parts of the plant, distorting or destroying them, and forming irregular masses covered by a white membrane, which broke away, liberating the black, powdery, spore mass. It is of no importance in Porto Rico as yet.

A third disease occurred quite commonly, but is of no economic importance as yet. This is manifested as numerous black, carbonous slightly raised spots on the leaves (both surfaces) and leaf sheaths in which the spore-bearing bodies are produced. Each spot is surrounded by a yellow or brown circle of dead tissue. The death of old or basal leaves is hastened, especially when the rust is also present as is usually the case. The fungus is *Phyllachora graminis* (Pers.) Fuckel.

#### COWPEA (*Vigna unguiculata*).

This legume has been used in some gardens between crops to improve the soil. Certain varieties thrive very well and their increased use is recommended. The iron variety is especially good for growing in this connection since it is not subject to nematodes, and in so far as observed does well under Porto Rican conditions. Other varieties are cultivated to some extent under the name of "frijoles" as food plants. Most of these latter types are, however, very subject to root-knot and proper precautions must be taken to avoid this trouble.

LEAF SPOT (*Cercospora vignae* Racib.)—This leaf spot as mentioned in a previous report (10) caused defoliation of an unknown variety of cowpea (not the iron) grown at the Station. The spots were numerous, circular, up to one centimeter in diameter, reddish brown in color, with distinct margins, and soon confluent, causing the death of the leaf.

GRAY LEAF SPOT (*Cercospora cruenta* Sacc.)—This leaf spot was found on one of the native edible seeded varieties, causing a serious weakening of the plants and partial defoliation. The diseased areas were angular to indefinite, three to eight millimeters in diameter at first, but rapidly coalescing, a dirty gray in color below, due to the copious production of conidia and conidiophores and yellowish or chlorotic above, becoming dull rust red. Would doubtless be controlled by Bordeaux or other fungicide.

On the iron cowpea a powdery mildew (*Erysiphe polygoni* DC?) was noted in several instances, but causing little harm. The *Oidium* stage only of the fungus was present.

#### CUCUMBER (*Cucumis sativus*).

Attempts to grow cucumbers in Porto Rico have been particularly disastrous. In some instances a splendid first crop has been obtained, but the second almost invariably fell prey to disease. A similar state of affairs occurred in the Station trials. The cause was largely the disease known as downy mildew and described below. Successful cucumber culture will depend upon its control.

DOWNY MILDEW (*Pseudoperonospora cubensis* [B & C] Clinton.)—This disease was characterized by indefinite yellow spots on the leaves, which under the humid conditions existing here were so numerous or so rapidly coalesced that the death of the leaves quickly resulted. The superficial growth of the fungus itself could be seen as a delicate grayish purple layer on the under side of the leaves. The older leaves were attacked first and the disease progressed with the growth of the vines, usually three to four leaves behind the growing point. In wet weather, however, the leaves were attacked before they were completely unfolded, and in the second planting the cotyledons (seed-leaves) were attacked and destroyed before the second leaf had completely unfolded.

The mildew appeared on the first planting when the vines were about a foot long and had developed from four to seven leaves. Bordeaux mixture at a strength of 3-3-50 was immediately applied and additional applications made at weekly intervals until March 2, or eleven sprayings in all. As far as it was possible to observe spraying was without practicable results, except that aphids developed unchecked by fungus (*Acrostalagmus albus* ?). The disease progressed in the same degree upon sprayed plants and checks. Marketable cucumbers were secured for a time, but the disease finally gained the upper hand and the few fruit set after that time were small and misshapen.

Even worse results were obtained with the second crop planted in the same beds as the first. As noted the disease attacked the plants almost as soon as the first leaf was formed, although the first spraying had already been given. In all nine sprayings of Bordeaux (3-3-50) were made at three to four-day intervals. Practically no salable fruits were produced, the vines making little growth after the first few weeks.

One peculiar circumstance was noted after the beds were abandoned. Certain of the plants which had not been killed outright made considerable new growth, free of disease, and even produced normal fruit after the weeds had grown up around them, in spite of rather heavy rains. This circumstance suggests that infection occurs from the soil. Another year it is proposed to experiment with mulching and the training of the vines off the ground, since it is apparent that spraying is ineffective under Porto Rican conditions.

This disease has been reported as occurring upon various other wild and cultivated members of the cucumber family, but except for the melon no other hosts have as yet been found. Species examined have been:

<i>Luffa cylindrica</i> .....	Esponja.
<i>Momordica charantia</i> .....	Cundeamor.
<i>Sesquium edule</i> .....	Chayote.
<i>Lagenaria leucantha</i> .....	Pipe gourd.
<i>Cucurbita pepo</i> .....	Calabazo, squash.

ANTHRACNOSE.—Ripe cucumber fruits and particularly the nubbins exposed to the sun on the nearly leafless, mildew-infected vines were attacked by anthracnose (*Colletotrichum lagenarium* [Pers.] E & H). The black fruiting spots of the fungus occurred in more or less circular sunken spots on the exposed surface and also on the indefinite dull white corky areas due primarily to sunburn. Various other saprophytic fungi were also present in such cases.

A fungus apparently referable to *Phyllosticta cucurbitacearum* Sacc. was found under the same conditions as the anthracnose fungus. In this case the grayish or dirty white irregular areas were dotted with the minute black pycnidia (fruiting bodies).

Neither the fungus nor bacterial wilt nor any form of damping off were observed.

#### EGGPLANT (*Solanum melongena*).

As was the case with the beans, one serious disease attacked the first planting and another quite distinct, the second. It was not possible to determine from the data of one season whether this was

due to weather, varietal differences, infected seed, or to a combination of various causes.

**ANTHRACNOSE** (*Gloeosporium melongenae* E & H).—The first planting was of the long purple variety and for some time was quite free of disease. When in full bearing the fruit on certain plants was attacked by anthracnose, which from that time on increased until at the time the bed was abandoned and the plants pulled, practically all of the fruit on all plants was affected. It seems probable that the fruit on naturally weak plants was attacked first, and then as the other plants were weakened through nematode attacks and other agencies, the disease spread to all. The fact that, owing to lack of a market, the fruit was not picked more than a few times doubtless assisted.

The disease was characterized by sunken, more or less circular, pits of varying size up to half an inch, often coalescing. Many fruits were so severely attacked that from a half to three-quarters of the surface was cankered. Fruit of all sizes was attacked, and when seriously infected dropped to the ground, leaving the pedicel still attached to the plant. The conidia occurred in salmon-pink masses (*sporodochia*) clustered in the bottoms of the pits.

It is not likely that spraying will avail against this disease. Resistant or non-susceptible varieties properly cultivated and kept free of nematodes or other weakening agencies will prevent serious loss.

**WILT OR CROWN ROT** (*Sclerotium rolfsii* Sacc.)—Several plants were killed by this fungus early in the season. The cases observed were all very characteristic. There was a rotting of the roots and of the bark at the crown, accompanied by production of white mycelium both on the roots and at the base of the stem. Later brown sclerotia appeared around the crown and on the surface of the soil adjoining. When occurring together with root-knot, death of the plant was especially rapid. *Scleria pterota* and *Alternanthera sessilis*, weeds growing adjacent to the eggplant, were found attacked in one instance.

**LEAF SPOT, FRUIT ROT** (*Phomopsis vexans* [Sacc. & Syd.] Harter.<sup>1</sup>)—This fungus caused a leaf spot, fruit rot and stem blight or canker of the New York spineless variety grown in the second planting. As a leaf-spot fungus it has been commonly known as *Phyllosticta hortorum* Speg. Neither the anthracnose nor other diseases were observed on this variety. Commercially the crop was a total failure as a result of the combined attacks of this fungus and insects.

<sup>1</sup> Identification verified by Mr. L. L. Harter, Pathologist, Bureau of Plant Industry, U. S. Department of Agriculture.

Bordeaux and lead arsenate applied at intervals of a week sufficed to check the disease to some extent and to stop the insect attacks, but were of no practical value. No salable fruit was obtained.

On the leaves this disease occurred as brown spots, varying considerably in size and shape. On seedlings in flats they were small, hardly over one-eighth inch in diameter, more or less circular, and attacked the older, lower leaves. At this stage it appeared to be merely a disease of old over-mature leaves, or of plants held too long in the flats and so weakened. However, the disease appeared on plants in the field, causing large irregular, dull-brown spots on the leaves and brown, sometimes sunken, lesions on petioles and young stems. Branches or twigs were often girdled, and in some plants this was so common that nothing remained alive beyond a short length of the main stem. The fungus produced nearly circular, raised areas on the fruit, hardly different in color at first from the normal skin of the fruit, but soon coalescing to form black areas covering large portions of the surface area. The calyx lobes and pedicels were also often attacked, resulting in irregular, sunken brown cankers. In all diseased areas the fruiting bodies appeared as minute black points, but were especially prominent in the fruit and stem cankers. There was at first a soft rot with some leaking, and the fruit very soon fell to the ground, leaving the infected pedicel and calyx on the plant. Within a short time it became a black, wrinkled mummy.

FRUIT ROT (*Diplodia* sp.)—Fruit of the long purple variety was rotted by a species of *Diplodia* not at present distinguishable from *Diplodia natalensis*, the cause of stem-end rot of Citrus. Inoculations have not yet been carried out. The fungus apparently attacked through the stem end, causing the fruit to drop to the ground, where it was soon mummified by a dry rot. The pedicel and calyx remaining on the plant had much the same appearance as when attacked by *Phomopsis*. There were first brown lesions followed by death and complete withering and drying. The rot of the fruit progressed very rapidly to the blossom end, appearing, externally medium brown in color, internally light brown, with no juice exudate. Only young fruit were observed attacked. The pycnidia produced in a damp chamber resembled those of *D. natalensis* on Citrus.

ROOT KNOT (*Heterodera radicum* [Greef.] Mül.)—Some few plants were attacked by root knot. Except where *Sclerotium Rolfsii* was also present no perceptible damage resulted, although the plants were undoubtedly weakened by the presence of these parasites.

A *Nectria* sp. was found at the base of a plant that had been killed by *Sclerotium*, so that it can be considered only as a sapro-

phyte. There were no other disease symptoms than those due to the *Sclerotium*.

Damping-off of seedlings in flats was due to *Fusarium* sp. Care in watering and in the use of sterile or new soil should obviate this trouble.

Henricksen (5) reports bacterial wilt (*Bacillus solanacearum* Sm.) as very common. Such cases of wilt as have been found in the present investigation were, however, in all cases easily attributable to *Sclerotium* and root knot.

#### GANDUL, PIGEON PEA (*Cajanus indicus*).

The gandul or pigeon pea is subject to a number of fungus diseases which tend to shorten the life of the plants.

One of the commonest is *Cercospora Cajani* P. Henn., causing a leaf spot. The spots are numerous, subcircular to irregular, medium brown in color, margin indistinct, appearance much the same on both surfaces. Affected leaves are shed sooner than normal ones.

RUST (*Uromyces Dolicholi* Arthur).—The rust, while quite common, causes very little damage. It is characterized by small, deep-brown, powdery pustules on the lower leaf surfaces.

A very serious stem canker, apparently due to a fungus not yet determined, has been observed in several localities, but studies have not been carried out. Numerous other fungi aid in the death and rotting of stems of mature plants, notably *Megalonectria pseudotrichia*<sup>1</sup> and others of the same group.

#### LETTUCE (*Lactuca sativa*).

LEAF SPOT (*Cercospora lactucae* n. sp.)—But one disease was found on lettuce and that of minor importance. This was a leaf spot due to an apparently new species of *Cercospora*, which is described below. The fungus attacked principally the older and lower leaves and caused slight injury as long as the leaves were gathered regularly. At the time of production of the flowering stalk, however, it rapidly spread to all leaves and, the numerous spots becoming confluent, practically the entire leaf surface of the plant was destroyed.

*Cercospora lactucae* sp. nov.—Spots amphigenous, drab (Ridgeway, Plate XLVI), subcircular to angular, slightly sunken, with definite margin (not raised), one to eight millimeters in diameter, often confluent especially along margin and tip; conidiophores amphigenous, fascicled, few (four to ten to each fascicle), simple, four

<sup>1</sup> Determined by Dr. F. J. Seaver, of the New York Botanical Garden.

to eight septate, 15-50 by 5-7 mu., medium brown, tips paler; conidia clavate to long clavate, often curved, hyaline to smoky, six to twelve septate, tips often non-septate, 3.5-5 by 50-100 mu.

On leaves of *Lactuca sativa* L. in Porto Rico: Río Piedras, 6244 (type), 5071, 5613.

#### MARIMBO, GOURD (*Lagenaria leucantha*).

A leaf spot (*Cercospora cucurbitae* E & E) occurred on this host. The spots were numerous, nearly circular, up to eight millimeters in diameter, brown at first, becoming dull white or tan at the center, with a slightly raised, definite margin, and red brown in color, causing the death of the older leaves.

#### MUSKMELON (*Cucumis melo*).

The growing of melons has been as little successful as that of cucumbers. Several diseases are in large measure responsible for this condition, although unsuitable varieties and poor cultural practices must be blamed in part.

On the early (December) plantings the downy mildew (*Pseudoperonospora cubensis*) was especially virulent and accounted for the death of the plants. Spraying with Bordeaux mixture (3-3-50) was without apparent effect. The symptoms were the same as on cucumbers.

ANTHRACNOSE (*Colletotrichum lagenarium* [Pass.] Ell. & Hals).—Plantings made later in the season were subject to other leaf diseases, and while not so quickly destructive as the mildew they were quite effective in cutting down the yield to practically nothing. The most important of these was the anthracnose which appeared as irregular brown spots or patches on the leaves. These soon coalesced causing the death of the entire leaf. Often the centers of the diseased areas dropped out leaving large ragged holes. Lesions on petioles and stems were also produced. This disease has been reported as serious on the fruit and would doubtless have proved so in this case if there had been fruit present in any amount.

Occurring sometimes in the anthracnose spots and at other times alone, another fungus was found, *Phyllosticta citrullina*. Spots caused by this fungus were light brown, nearly circular, and with the minute black fruiting bodies (pycnidia) clustered at the center. Of minor importance.

CHLOROSIS.—One case of chlorosis was found in which an entire plant had taken on a yellow color, portions of the stem only re-

maintaining green. The leaves were small, wrinkled and thicker than normal. Inoculations with material from this plant on other non-chlorotic plants were without result because of the death of the plants from other diseases.

#### MUSTARD (*Brassica* spp.).

The common mustard grown chiefly for the leaves, which are used as greens, is subject to several leaf diseases. The white rust (*Albugo candida* [P.] Rouss.) is common, producing numerous white pustules on the lower leaf surfaces.

A leaf spot (*Cercospora bloxami* Berk. & Br.) causes the death of the leaves in many cases. The spots are at first nearly circular (hardly spherical as given in one description), white or dull yellow in color and up to half a centimeter in diameter. They very soon run together, however, destroying the leaf.

#### OKRA (*Hibiscus esculentus*).

Okra was commonly subject to a leaf disease due to *Cercospora hibisci* T. & Earle). This fungus did not occur in definite spots, but rather in indefinite sooty patches often confluent on the lower surfaces of the leaves. The leaves were sapped of their vitality, turned yellow and dropped. The result was a tall stem, bare of leaves except at the tip and bearing very little fruit. No experiments for control have been tried.

#### ONION (*Allium cepa*).

Onions are raised to a considerable extent in the western part of the Island. Opportunity, however, has not been had to examine any of the plantings. Reference is made by Henricksen (5) to smut (*Urocystis cepulae* Frost) and to downy mildew (*Peronospora Schlegeliana* De Bary) but without definitely reporting them as present in Porto Rico.

#### PEA (*Pisum sativum*).

Wherever observed the garden pea has been subject to powdery mildew (*Erysiphe polygoni* De?). This fungus formed a thin gray or white coating over leaves and pods, and while it did not actually kill the parts attacked, it checked the growth and so lessened the yield. In common with all other powdery mildews collected on various plants, wild and cultivated, the conidial stage only was found. This disease could be readily controlled if necessary by Bordeaux, or other fungicide.

In one instance a leaf spot due apparently to *Cercospora* sp. has been collected. The spots were small (two to three millimeters in diameter) amphigenous, circular to angular, without a definite margin, dull brown to gray, often coalescing and causing a yellowing and subsequent death of the leaf. Fruiting on both surfaces. Conidia hyaline, long clavate, strongly septate. If, as appears certain now, this species is undescribed, a complete description and name will be published later, together with more complete notes on the nature and amount of injury caused by it.

#### PEANUT (*Arachis hypogea*).

The peanut was subject to two leaf diseases, both quite effective at times in reducing the yield. Other diseases due to *Sclerotium Rolfsii*, or to other root-rot or wilt inducing fungi, have not been observed, but doubtless occur, or will with any extension of planting.

LEAF SPOT (*Cercospora personata*).—The leaf spots caused by this fungus were nearly circular, brown to black with an indefinite margin, and generally numerous enough to practically cover the leaf surface. The lower leaves were attacked first, but the others soon succumbed in turn. It was difficult to estimate the damage, some growers declaring that the disease appeared after the crop was practically mature and that hence no damage was done.

RUST (*Uromyces arachidis*).—This fungus attacked all varieties, causing innumerable small golden brown to dark-brown pustules on both sides of the leaves, in many cases practically covering them and undoubtedly doing some harm since the effective leaf surface was reduced. In fact, experiments in the British West Indies have shown that decreased yields do result from attacks of this disease. Spraying with Bordeaux at intervals of a week was reported to have been without effect in checking or controlling either of these diseases.

#### PEPPER (*Capsicum annuum*).

FRUIT ROT.—The peppers of the first planting (Neapolitan) remained comparatively free of this trouble, but those of the second were seriously attacked. These varieties were Sweet Mountain, Large-bell, Chinese Giant and Ruby King, all of which were attacked to about the same degree, in so far as preliminary observations of one year show. At the time the first picking was made a large percentage of the fruit was found to have on one side or at the blossom end rotted areas. These were in general medium to light brown in color or at times nearly white, with definite margins and often sunken.

The affected tissues were softer than the normal, but still quite firm, and there was no juice exudate. In many cases the spots had all the appearance of sunburn or other non-parasitic causes. Fruit so affected soon dropped, unaffected portions turning a deep red and the whole fruit ultimately mummifying. It was noted that the fruit of certain plants remained comparatively free of the disease, while all of the fruit on other plants was affected, the weaker plants apparently. Certain fungi were commonly found associated with the spots, in particular *Cladosporium herbarum*, *Fusarium* sp., *Pestalozzia guepinia*, and *Macrosporium* sp. *Macrosporium* sp. is ordinarily considered the cause of a serious rot of peppers, but in the present instance it was found in so few cases that it is grouped temporarily at least with the other forms. Further work is necessary to ascertain the exact relations of these fungi to the disease. This may result in the division of the disease into both parasitic and non-parasitic as is suggested by observations to date.

**DIAGNOSIS.**—In the early stages it was not always possible to distinguish this disease from the above. In general, however, it was marked by more nearly circular areas, often several on one fruit, and more definitely sunken. The spots showed first as water-soaked areas turning brown. The fruit ripened prematurely, became shriveled, but quite often remained hanging to the plant. Two fungi were found in connection with this disease, *Gloeosporium piperatum* E. & E. and *Colletotrichum nigrum* Ells. & Hals., which after further work may prove to be the same, the presence or absence of setae in the fruiting bodies being the only point of difference, which is a doubtful character at best. At the first report of trouble with fruit rot spraying with 3-3-50 Bordeaux was commenced and continued at intervals of a week until eight applications had been made. Counts were made of the diseased and sound fruit at each picking. At no time was it possible to find any constant difference in amount of disease between sprayed and unsprayed areas. The percentage of spotting at first very heavy, gradually declined through the season, due apparently to cultural and climatic reasons; certainly independent of the spraying.

**WILT** (*Sclerotium Rolfsii* Sacc).—This common disease of sugar cane (red rot of the leaf-sheath) attacked several of the vegetables and was especially serious on the peppers. Plants attacked by this fungus exhibited first a slight drooping of the leaves exactly as occurs when there is a shortage of water. The wilting increased each day with partial recovery at night until at the end of four or

five days the plant was practically dead. Examination of wilting plants showed healthy tops, but further search revealed brown sunken lesions at the crown, which grew rapidly until the stem was girdled and death resulted. A scanty white mycelium was generally present in these areas spreading down along the roots for some distance, rotting and killing them, as well as out over the surface of the ground, attacking weeds or other plants with which it came in contact. At the base of the diseased plant, there was in most cases an abundant production of the so-called sclerotia or fruiting bodies, yellow to dark brown, nearly spherical bodies, of about the size of mustard seed. Sclerotia from peppers produced typical cases of red rot of the leaf-sheath when transferred to cane.

All four varieties of the second planting were attacked and to about the same degree. The loss was greatest in the lower ends of the rows where there was possibly more moisture, although plants in all parts of the field were lost. About three per cent were killed.

**LEAF SPOT** (*Cercospora capsici* H. & W.)—This leaf spot was most abundant and was collected or observed in numerous localities. The determination is provisional. The spots were circular, varying in size from a sixteenth to half an inch in diameter and were often very numerous. Their appearance was the same on both sides of the leaf, not raised, but rather slightly sunken with definite margins. The color was a dark dull brown with dirty white center and a surrounding faint halo of yellow. Centers of old spots often broke out irregularly. All varieties were very subject to attack. Older and lower leaves were first infected, turned yellow, and dropped. At times no further damage occurred, but quite often nearly complete defoliation resulted.

This disease was readily controlled by Bordeaux mixture. No spotting occurred on sprayed rows.

**ROOT KNOT** (*Heterodera radicolica* [Greef] Müll.)—Peppers are very much subject to root-knot and serious damage often results. The trouble is prevalent in many parts of the Island. See under tomato.

#### POTATO (*Solanum tuberosum*).

Potatoes do not thrive, at least in the lowlands, and it is extremely doubtful whether any results can be hoped for in any part of the Island. A root rot has been reported (1), and the opinion is there given that the disease will prevent the growing of potatoes in Porto-Rico. The fungus concerned was not determined.

ROSELLE (*Hibiscus sabdariffa*).

Barrett reported (3) a root rot of this plant, possibly due to bacteria. Not observed in the present investigations.

SESAME (*Sesamum orientale*).

This plant, locally known as "ajonjolí," is commonly subject to a leaf spot attacking particularly the lower leaves, although instances have been observed of mature plants which had been practically defoliated. The spots, due to *Cercospora Sesami* Zimm, are very numerous, small (not over two millimeters in diameter) sub-circular to angular, dull white to gray, with a definite, slightly raised deep brown margin. Sporulating on the upper surface.

SQUASH (*Cucurbita moschata*).

In so far as observed this crop was free of disease, even when in proximity to other cucurbitaceous plantings, such as cucumbers or melons. Henricksen (5) reports downy mildew as an enemy of the squash.

SWEET POTATO (*Ipomoea batatas*).

The sweet potato is one of the most common of the native crops, and while no large plantings are made the total of the innumerable small patches is considerable. As is usual with a crop which is not planted in large or continuous areas, serious diseases seem to be lacking. There have been reports received of losses, but in so far as it has been possible to discover from specimens submitted, insects have been to blame. However, it is known that some at least of the dry rots reported for other countries do exist here, and an effort will be made to find them.

WHITE RUST (*Albugo ipomoeae-panduranae* [S.]<sup>4</sup> Swing.)—Only three fungi have been encountered on this host, all leaf parasites. The most common of these was the white rust, which caused indefinite spots varying from the size of a pinhead to half an inch or more in diameter. At times whole leaves were deformed and swellings produced on stems and petioles. The spots were yellow to brown above, and below showed the white pustules formed by myriads of spores. All of the various types or varieties of sweet potato, both cultivated and wild, have been found subject to attack.

LEAF SPOT (*Phyllosticta batatas* E. & M.)—In one instance leaf spots due to this fungus were found. The spots were circular to angular, up to one-quarter inch in diameter and light gray in color

with a definite brown margin. The minute black pycnidia were clustered at the center.

RUST (*Coleosporium Ipomoeae* [Schw.] Burr).—The rust was of common occurrence but cannot be considered of any economic importance. Small yellow pustules broke out on the under side of the leaf.

Two species of sooty mold (*Meliola clavulata* Wint. and *Meliola Ipomoeae* Earle) occur on this host, but without causing apparent injury.

#### TOMATO (*Lycopersicon esculentum*).

The tomatoes in the test plots as well as those observed in gardens about the Island have suffered most severely from a number of diseases, which can be held responsible in large measure for poor yields obtained in some cases and the failures in others. There is again to be noted the occurrence of different diseases at different seasons of the year.

LEAF MOLD (*Cladosporium fulvum* Cke.)—This fungus also occurs commonly on the wild berengena (*Solanum torvum*), a very common weed in all parts of the Island. All varieties of tomatoes (Trophy, Livingstone globe, and Ponderosa) in the first planting (December-February), as well as those in other gardens growing at this time of the year were attacked. The disease commenced in the shelter of the windbreak and spread very rapidly over the entire garden. The lower leaves were attacked first, but with little delay the balance of the plant was infected, only the very tips remaining free. Diseased leaves soon withered and dropped with the result that the plant consisted of but a few long spindling stalks devoid of mature leaves or fruit. Removal of diseased leaves was without effect in checking the spread of the fungus.

Spraying with Bordeaux was commenced before the *Cladosporium* appeared, and although various strengths, combinations with lead arsenate, and different kinds such as paste, powder, and home-made solutions were tried, no differences were at any time observed between sprayed and unsprayed rows. The number of sprayings varied from three to eight on the different plots and were at intervals of a week except in one instance, twice a week.

The fungus was virulently parasitic, occurring on the lower surface of the leaves in irregular velvety patches, which were white at first, then brown, and finally nearly black. The various patches soon coalesced by which time the leaf was yellow and curling.

This disease was not found on any of the varieties grown in the

second planting (April-June). *Solanum torvum* was also present in abundance at this time, but was free of disease.

LEAF SPOT (*Septoria lycopersici*) Speg.—This fungus caused very definite spots in contrast to the effuse irregular areas of the *Cladosporium*. The spots were more or less circular, appeared the same on both sides of the leaf and were quite small, hardly ever more than one-eighth inch in diameter with a definite dark brown margin. They were brown to nearly black with the minute black fruiting bodies (pycnidia) at the center. When the spots became numerous, as was the case with all the varieties of the first planting, the leaves turned yellow, curled, and dropped. Lower leaves succumbed first. In combination with leaf-mold this disease was the cause of much damage through defoliation and consequent reduction of yield. Some few fruit only were found bearing the characteristic spots. It was especially a disease of young plants in flats or pots, tending to produce weak spindling plants, which if not entirely ruined by this cause remained weak or fell easy prey to other destructive agencies. As noted in the leaf-mold discussion, spraying and other measures were of no avail.

In the second planting *Septoria* appeared only after the plants were well advanced in contrast to its attack of the plants of the earlier crop in the seedling stage. It did not prove serious. Lower leaves were killed, and together with the *Phoma* spot some dying of the upper leaves occurred, but in no way to be considered serious. Spraying was again without effect.

BLOSSOM-END ROT.—Considerable trouble was experienced with a blossom or point-end rot, which was apparently due to cultural conditions rather than to any parasitic organism. A *Fusarium* sp. quite commonly occurred in the rotted areas, but it is not likely that it was other than saprophytic since it was generally present in advanced cases only and sometimes not at all. It formed pink and white masses of mycelium and conidia over rotted areas.

The rotted areas were medium brown in color, nearly circular, at first limited to a small area around the blossom end, but soon enlarging until one to two inches in diameter, at about which time the fruit dropped. The spots were only slightly sunken if at all and but little softer than normal tissues until secondary decay set in due to bacteria or saprophytic fungi. All varieties of the first planting were subject, the loss running around ten per cent. The trouble was not experienced in the second planting, possibly due to more satisfactory moisture or cultural conditions.

SOFT BROWN ROT.—In the second crop there was some loss from

a soft brown rot apparently due to an undetermined fungus of the *Phycomycetes* or alga-like fungi. This occurred more commonly on fruit hanging close to the ground or actually in contact with it. In the latter case there was a surface growth of white flocculent mycelium. The rot commenced as a discolored or water-soaked area, soon becoming dull brown and spreading irregularly over the balance of the fruit, accompanied by a heavy exudation of juice.

ANTHRACNOSE (*Colletotrichum phomoides* [Sacc.] Chester).—Some few cases of this disease on ripe fruits were collected. It caused sunken, circular areas on the side or end of the fruit, often of considerable size, in which appeared the pink (or in advanced cases black) conidial masses. Of slight importance.

Following cracks, insect and mechanical injuries or other wounds bacterial soft rot was common.

ROOT-KNOT, NEMATODES (*Heterodera radicum* [Greef] Müll.)—The losses due to the attack of this minute worm have been heavy and much more in fact than is generally realized because of the fact that it works below ground. Attacks by this parasite will explain to some extent, it is thought, the weakness of not only the tomatoes but of other crops permitting leaf and fruit parasites to make headway in spite of spraying or other preventative measures. In the Station plots tomatoes suffered most severely, but eggplant and peppers were also attacked. At the end of the season examination showed a hundred per cent infestation of all varieties, certain ones, however, maintaining growth in spite of the nematodes and even giving a crop of fruit.

Where death occurred, the first symptoms were a slight wilting of the upper leaves, which increased until within a few days the entire plant was involved and death ensued. Upon pulling a wilted plant, the roots were found malformed or to consist of a series of enlargements or galls. Within these swellings the presence of the parasitic worms or nematodes in various stages was easily demonstrable with the microscope. Various fungi contributed to the death of attacked plants and speedily rotted away roots and crown, liberating a new brood of worms into the soil, so that in old cases nothing remained but the woody tap root and fragments of secondary roots and galls. The nematodes liberated in this manner remain in the soil for a number of years and are capable of reinfesting any new plants that may be set out.

Certain varieties in particular of the second planting, namely, Stone, Duke of York, Matchless, and Beauty were practically destroyed, the potting soil having been infested apparently. It was

noted that those supplied with manure survived, which suggests a means of control by supplying improved cultural conditions together with care in avoiding infested soil. Where possible infested soil should be sterilized by steam or by fire before using in flats or pots. This will insure healthy plants.

BLACK SPOT (*Phoma destructiva* Plowr.)—The Livingston Globe variety and to a less extent other varieties in the second planting were attacked by this recently described disease (6). The spots, similar on both sides of the leaf, were brown with a definite dark brown margin, circular at first, then irregular, and finally confluent, causing the death of the leaf. Very few spots were found on the fruit, and these apparently following injuries from other causes, sucking insects, etc. The fungus agreed with the description given of *Phoma destructiva*.

WILT (*Bacillus solanacearum* Erw. Sm.)—This serious disease has on several occasions been reported from Porto Rico (1) and doubtless does occur on tomato as well as on other related plants, but it has not been found in the present investigations. In the brown-stained vascular tissues of the lower portion of the stalks of plants killed by nematodes, bacteria were present, but were not capable of independently causing wilt of otherwise healthy plants. Nematodes were the causes of all cases of wilting which it has been possible to examine.

MINOR TROUBLES.—Splits and cracks were very common. They can doubtless be attributed to extremes in the water supply, a drouth followed by excessive rains, excessive fertilization, and the like.

One case of rosette was observed. No cause was discerned nor was the juice of the plant infectious.

“Damping-off” of seedlings occurred as with eggplant and due apparently to the same cause.

*Phytophthora infestans* Mont (De Bary) (Downy Mildew) has been reported from near Maricao by Prof. Whetzel and Dr. Olive, but has not been with certainty seen here. It is also reported by Henriksen (5).

#### TURNIP (*Brassica campestris* and *B. Rapa*).

A leaf spot (*Cercospora Bloxami* Berk. & Br.) is reported (11) on this host. This is the same fungus as given under mustard. Not serious.

Black rot (*Bacterium campestris* Er. Sm.) is also reported (5) but has not been encountered by us.

## WATERMELON (*Citrullus vulgaris*).

The leaf spot (*Cercospora citrullina*) mentioned in the last report (10) continues to be present and through the killing of the leaves is most effective in reducing yields. Also reported from Mayagüez (5).

**BLOSSOM-END ROT.**—This year a blossom-end rot of the fruit was observed. The blossom end of a fruit attacked by this disease dried up and turned brown, although the remainder of the fruit sometimes continued to enlarge for some time. Fruit of all sizes were attacked. Various fungi gained entrance and set up a soft rot with juice exudate. *Diplodia* sp. was found in several instances associated with this rot and also as the apparent cause of a stem-end rot in one case. No studies have been made of this fungus.

It was observed that this trouble was most prevalent during a drouth, but that later when the plants were growing vigorously under the stimulus of an abundant water supply, it practically disappeared. Irrigation or frequent cultivation will doubtless check the disease fairly well.

## YAUTÍA (*Colocasia* sp., *Xanthosoma* sp.)

The yautías were quite subject to a disease known as "El mal" and probably due to a vascular parasite, although there was no opportunity to investigate it. Plants attacked by this disease failed to thrive, the leaves remained small, and were generally yellow. The yield was greatly reduced. The disease was favored by poor soil and dry weather. It can be avoided by care in planting only healthy "heads" or offsets in uninfected soil.

*Phyllosticta colocasicola* Höh. has been reported (7) on *Colocasia* sp. Other fungi (*Periconia* sp. and *Gloeosporium* sp.) are mentioned as occurring in spots on yautía. Of minor importance.

## CONCLUSION.

Studies to date have been merely preliminary, a survey of the field as it were. However, certain points have become clear as regards the presence of diseases. It can be taken for granted that they will appear, and consequently all steps possible should be taken to control or minimize their attack. Most of the problems must be met by producing or introducing resistant varieties, a proposition for the plant breeder and one that requires time. Much can be done, however, and fair crops of most vegetables realized by following such corrective measures as are now known, such as proper preparation

of seed beds, thorough cultivation, irrigation and drainage, and the destruction of weeds.

After each crop all old plants and debris should be burned and a proper rotation maintained. Spraying with the various fungicides will be found of value for many of the diseases.

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