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FUNGUS DISEASES.

TREATMENT OF FUNGUS DISEASES.

L. H. PAMMEL.

Inasmuch as the subject of the treatment of fungus diseases of our cultivated plants has not received attention in previous bulletins issued by the station some practical suggestions in regard to a few diseases some of which have been experimented with on the college grounds during the season of 1890 will not be out of place. The loss to Iowa farmers and horticulturists from such diseases as rusts, smuts, mildews, apple scab, leaf-spot disease of the cherry, strawberry leaf blight, spot disease of currants and many others, caused by fungi, amounts to thousands of dollars every year; fortunately some of them are amenable to treatment with substances known as fungicides, which, when applied at the proper time, check the growth of the fungus. It is unfortunate, however, that the most serious pests of the farmer can as yet not be reached by these fungicides. Such diseases as rust of wheat and forage plants still continue to destroy the crops of the farmer, making it in some cases almost impossible to successfully grow some of the grains, or when grown there is great loss. To successfully treat such disease is a great problem, which can only be solved by carefully conducted experiments carried over a long series of years.

It will be well to briefly explain some terms in connection with fungi to make what I have to say more intelligible. Most of these enemies cannot be made out unless greatly magnified.
Fungi (singular fungus) are minute plants without chlorophyll, in which roots, stems and leaves are not developed. Fungi are either parasitic or saprophytic; in the former case they derive their nourishment from living tissues, while all saprophytic fungi derive their nourishment from decaying organic substances. Fungi are plants as much as wheat; they have a reproductive and a vegetative system. In most cases they reproduce by spores, which like the seeds of the higher plants when placed under proper conditions germinate and develop into the vegetative part of the plant. In some cases millions of spores are produced in an incredibly short time. The small red pustules of wheat rust contain thousands of spores; each under proper conditions is capable of producing rust again. Is it anything to be wondered at, when a single rusted wheat stalk containing millions of spores, nearly all capable of germination, that our cereals are rusted? If we begin with a single rust pustule it is not long before many plants in the vicinity show rust. How can these diseases be treated is engaging the attention of investigators in Europe and America. It is not alone in France that the vine industry is seriously threatened by such fungi as black rot, downy and powdery-mildew, but in our own country the loss is very great from these maladies. Experiments started a few years ago in France to prevent the ravages of these fungi has been the means of not only producing good crops, but a vigorous line of experimentation with fungus diseases. So that these diseases are partially under the control of the planter.1

Many experiments have also been made in this country, principally by the Department of Agriculture, inaugurated while Prof. Scribner was chief of the section of Vegetable Pathology, and since carried out extensively by the present chief of the division, Prof. Galloway. Some experiments have also been made by botanists of the various experiment stations, especially Profs. Chester, Goff, Arthur, Garman, Kellerman and Swingle, Taft, etc. Private individuals, notably Col. Pearson, have had very encouraging results. All

1For the investigation of these fungus diseases in France, see Viala Les Maladies de la Vigne, 1887.
of the papers and bulletins, quoted below, contain much valuable information and should be consulted.2

Spraying where it has been done has been the means of saving thousands of dollars. It has been stated that where grapes were not treated with fungicides in the east, during the season of 1889, the loss from Grape Rot amounted to thousands of dollars, and in some cases even a total failure, but where vines were sprayed the crops were uniformly good. Prof. Galloway3 says, in regard to this disease, "That it pays to treat vines for black rot." The cost of spraying an acre of vines six times was $7.35. At the rate of 3½ pounds per vine 1,750 pounds of grapes were produced on one acre which at 3 cents per pound would be $52.50, leaving a balance of $45.15. In one acre of vines not treated, the yield was only 500 pounds, which at 3 cents per pound would be $15.00. The difference in favor of the treated was $30.15. Surely it pays to treat for this disease. See Figs. 1, 2 and 3.

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Goff, E. S.—Preventing Apple Scab; Bulletin No. 23, Wisconsin Agricultural Experiment Station, 1890, Madison; Journal of Mycology, Vol. VI, p. 19; Vol. V, p. 33.

Garman, H.—Some Strawberry Pests; Bulletin No. 31, Kentucky Agricultural Experiment Station, Lexington, Kentucky.


Thaxter, Roland—Bulletin No. 103, Connecticut Agricultural Experiment Station, 1890. New Haven.

Taff—See Prof. Galloway and Miss Southworth, Bull. No. 10, Section of Vegetable Pathology.


Pearson—Bulletin No. 10; Sect. Vegetable Pathology.

Harvey—Annual Report Maine Agricultural Experiment Station for 1890.


Humphrey—Massachusetts Agricultural College Experiment Station, Bull. No. 11.

Clark—Bulletins 10 and 13; Missouri Agricultural College Experiment Station, Columbia.

Does it pay to treat for other fungus diseases?

In regard to Pear Leaf-Blight, which is such a destructive disease in the nursery, and pear orchards, Prof Gal­­loway$^4$ states that the actual cost of treating a block of 5,000 trees has been a little less than $100, this includes treating the trees seven times in 1889, before and after they were budded, and four times in 1890. Out of the 5,000 trees treated not 500 were lost; as the block now stands it is worth at least $7,000. The loss from this disease in all parts of the country is so great that more than 50 per cent of the buds do not take. On the College grounds it has been impossible to bud seedling pear trees owing to this disease.

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In most cases the treatment is only preventive, that is, the fungicide prevents the spores which fall on the leaf from germinating. Millardet and Gayon⁶ have shown however, that in some cases the copper salt may penetrate the cuticle somewhat. It appears that copper salt when once absorbed is sufficient to check the development of the parasite.

Millardet and Gayon⁶ have also shown that the conidia (spores) of the Frosty Mildew of the Grape (*Peronospora Viticola*) when placed in a drop of water which came from a leaf which had been treated with a copper salt solution two months previously did not germinate. Inoculation with spores on treated leaves were unsuccessful, but a large number of inoculations made on untreated leaves were successful, producing typical light colored spots on the upper surface of the leaf, with fruiting branches and spores of the fungus on the lower.

**Fungicides.**

Sulphur has long been used to treat certain fungus diseases, while the use of copper sulphate or blue stone, to prevent the germination of smut spores of wheat and oats, has been used still longer.

The principal fungicides now in use are Bordeaux mixture eau celeste, modified eau celeste and ammoniacal carbonate of copper. Bordeaux mixture and ammoniacal carbonate of copper have given the best results.

**Formula for Bordeaux Mixture.**

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of copper or blue stone</td>
<td>6 pounds</td>
</tr>
<tr>
<td>Quick lime</td>
<td>4 pounds</td>
</tr>
<tr>
<td>Water</td>
<td>22 gallons</td>
</tr>
</tbody>
</table>

The sulphate of copper should be pulverized and then dissolved in two gallons of water. Then slake the lime in six gallons of water. Allow the mixture to stand a short time, then pour it into the sulphate of copper solution. Constantly stir during the operation. The sediment should not be used.

In a recent circular, Prof. Galloway recommends the following proportions: Powdered sulphate of copper, 12 pounds dissolved in 15-20 gallons of water, 8 pounds unslaked or air-slaked lime in 10-12 gallons of water.

**FORMULA FOR AMMONIACAL CARBONATE OF COPPER.**

- Commercial ammonia (strength 22° Baume) ............... 1 quart
- Carbonate of copper ........................................ 3 ounces
- Water ...................................................................... 22 gallons

The carbonate of copper is dissolved in the ammonia, which forms a clear deep blue liquid. This is diluted with twenty-two gallons of water. It is then ready for use.

In the same circular, Prof. Galloway recommends 5 ounces of carbonate of copper to be dissolved in 3 pints of aqua ammonia, having a strength of 26 per cent. To this is added water sufficient making 45 gallons.

**FORMULA FOR EAU CELESTE.**

- Sulphate of copper ................................................. 1 pound
- Commercial ammonia ............................................ 1½ pints
- Water ...................................................................... 24 gallons

Dissolve the sulphate of copper in two gallons of water, cool and add the ammonia. Dilute this with twenty gallons of water.

**ANOTHER FORMULA FOR EAU CELESTE.**

- Sulphate of copper .................................................. 1 pound
- Carbonate of soda .................................................. 1 pound
- Commercial ammonia ............................................ 1½ pints
- Water ...................................................................... 24 gallons

In one vessel dissolve the sulphate of copper, using two gallons of water, and in another vessel dissolve the carbonate of soda. Then mix the two solutions, and when chemical action has ceased add the commercial ammonia.

**FORMULA FOR MODIFIED EAU CELESTE.**

- Sulphate of copper .................................................. 2 pounds
- Carbonate of soda .................................................. 2½ pounds
- Commercial ammonia ............................................ 1½ pints
- Water ...................................................................... 24 gallons

Prepare in the same way as the last.

In the experiments made on the College grounds last year the first formula for Bordeaux mixture and ammoniacal
carbonate of copper were used. On the whole experimenters have found more success with these fungicides than with the others.

Bordeaux mixture is more difficult to use, but in some cases it has given decidedly the best results. It adheres more firmly to the leaves. Ammoniacal carbonate of copper is easier to use and can conveniently follow the use of the Bordeaux mixture.

Most of the chemicals can be obtained from retail druggists, but at considerable greater cost than from wholesale dealers in any of the large cities.

**COST OF CHEMICALS.**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of copper, in 400 pound packages</td>
<td>.65</td>
</tr>
<tr>
<td>Sulphate of copper, in 100 pound packages</td>
<td>.75</td>
</tr>
<tr>
<td>Ammonia (strength 26° Baume) 80 pounds</td>
<td>.08</td>
</tr>
<tr>
<td>Ammonia diluted 3/4 its volume of water (32° Baume) in small quantities</td>
<td>.10</td>
</tr>
<tr>
<td>Carbonate of copper</td>
<td>.75</td>
</tr>
<tr>
<td>Carbonate of soda</td>
<td>.40</td>
</tr>
</tbody>
</table>

Carbonate of copper can be prepared considerably cheaper than this.

Dr. Thaxter\(^7\) recommends the following method of preparing it: "The substances needed for this purpose are sulphate of copper and carbonate of soda (sal soda) in the proportion of four parts of the copper to five parts of the soda. For instance—to make one pound of carbonate of copper it is necessary to use two pounds of sulphate of copper and two and a half pounds of sal soda. The sal soda should be dissolved in one barrel of hot water and the sulphate of copper in another. When both are cooled pour the sal soda solution into the copper solution, slowly stirring during the operation, which yields a heavy green precipitate of carbonate of copper." As the sal soda is injurious to foliage it should be washed out thoroughly. The carbonate of copper will settle to the bottom, then take off the water. After it is thoroughly drained it should be dried.

\(^7\)Report of Mycologist, Conn. Agri. Experiment Station, 1890, p. 33.
SPRAYING APARATUS.

An important matter in the use of fungicides is the method of application. The apparatus used should be made cheaply and yet durable. There are now several good spraying pumps on the market.

An apparatus devised by Dr. Thaxter, of the Connecticut agricultural experiment station, costs little more than $8.00. The following condensed account is taken from his report: It consists of a small copper tank, and adjusted to it is a hand force pump, known as the "hydronette" or "aquanette" pattern. See figure VI. The tank used by Dr. Thaxter holds about six gallons, is fitted with shoulder straps, and a small piece is cut out from the end of the tank cover at (e) so as to admit the base of the hydronette. In this a short collar is soldered having a slot on its outer side, to allow the hose to be pushed into it sideways. The suction basket of the pump rests in the lower left hand corner of the tank. The shoulder strap on this side should be made a little looser, and by tipping the tank a little towards this point all of the liquid can be drawn out.

As pumps of the hydronette pattern throw a heavy stream a piece of heavy five-eighths inch rubber tubing, six inches long, is drawn over the end of the hydronette nozzle at (x) and over the base of the vermorel nozzle at x'.

Figure VI.

Knapsack Sprayer, devised by Dr. Thaxter, Connecticut Agricultural Experiment Station.

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8Report of the Mycologist, 1890. p. 29, from Fourteenth Annual Report Connecticut Agricultural Experiment Station, 1890. Bul. 102, Conn. Agr'l Exp't Station, 1890.
The ends \((x)\) and \((x')\) are firmly wound with copper wire to make the joints firm and tight. The elastic chamber connecting the "hydronette" and "vermorel nozzle" is enclosed with tubing of a cloth cylinder made of stout cotton cloth, 6\(\frac{1}{2}\) inches each way, the edges are then sewed together, making a cylinder 5\(\frac{1}{2}\) inches in circumference. The cloth cylinder \((g)\) is slipped over the tubing and each end is securely fastened with a small copper wire wound tightly around it. The nozzles \((a)\) and \((d)\) are connected by a heavier wire \((c)\) fastened to the nozzles.

Another cheap, serviceable spraying apparatus has been devised by Prof. Galloway,\(^9\) of the Division of Vegetable Pathology, Washington, D. C. The following condensed description is taken from Journal of Mycology. A larger and smaller kind are manufactured. The reservoir is made of copper, and the smaller holds a little over four gallons; the larger six gallons. The larger one is 16 inches high, 15 inches broad, 5 inches deep. When filled with

Bordeaux mixture it weighs about 50 pounds. The bottom and top of the reservoir are soldered in. The top is provided with openings, one for the pump, which is soldered to the bottom, and the other for introducing the liquid. In using the pump the hollowed piston is drawn up, causing a vacuum, thus the liquid is enabled to run up through a small opening below. Instead of using the Vermorel nozzle Prof. Galloway has modified it somewhat so as to allow the degorger to slip back of its own accord. By this nozzle the spray can be cut off very quickly, which is often necessary. The cost of this apparatus is $14.00, and can be purchased of Albinson & Co., 2026 Fourteenth street, Washington, D. C. For spraying on a large scale a double acting pump is more convenient. One of the best is Gould’s double acting pump. It is not expensive and may be had of the Gould Manufacturing Company, Seneca Falls, N. Y.

![Figure VIII. Knapsack Sprayer in Operation.](image)

**Experiments in Preventing Apple Rust.**

Several trees of the Wild Crab (*Pyrus coronaria*) have for several years been seriously affected with Apple Rust (*Roestelia*...
pyrata) and the Red Cedars (Juniperus Virginiana) growing close to the apple trees have been affected with the Cedar Apple fungus (Gymnosporangium macropus). The investigations of botanists have shown that the two diseases are related. In other words, the Roestelia and Gymnosporangium are different stages of the same fungus. The spores found in the small cups on the Wild Crab are carried by the wind, and when falling on the Red Cedar produce small chocolate brown enlargements, which increase in size. They become mature the following May, when they produce long gelatin-

![Figure IX. Cedar Apple Fungus. After Seymour.](image)

![Figure X. Cluster Cup Fungus on Wild Crab. After Seymour.](image)

ous horns, the so-called “cedar apples,” familiar to everyone who has watched cedars (see figure ix). These horns contain two celled spores (see figure xi.), which germinate immediately (figure x.), and when coming in contact with the Wild Crab there produce the Roestelia\textsuperscript{10} or Aecidium stage. (See figures x. and xii.)

\textsuperscript{10}Thaxter—On Certain Cultures of Gymnosporangia, with Notes on the Roestelia. Am. Acad. Arts and Sci, 1886, p. 259
Three trees were experimented with; one was used as a check while the other two were sprayed with Bordeaux mixture and ammoniacal carbonate of copper. Spraying began on May 13, before the spores of Gymnosporangium had appeared. On Monday following the spraying the gelatinous horns with their germinating spores appeared. They were sprayed again in a week, followed by a third in two weeks. The last spraying was done with ammoniacal carbonate of copper. The spraying had apparently no effect on the fungus. The leaves showed an abundance of the fungus. It was about as severe on the sprayed as on the check. Col. A. W. Pearson made an experiment at Vineland, New Jersey, with the same species, but occurring on the cultivated apple. On one tree he used sulphate of iron, two pounds of the salt to one gallon of water; spraying was done before the leaves started. Additional applications were made every three weeks, with the following proportions: Sulphate of iron 6 pounds, and 4 of lime to 22 gallons of water. At the close of the experiment the trees were as badly affected as at any previous year. A second tree was sprayed before the leaves started with Bordeaux mixture, and continued every three weeks until July 22. Prof. Galloway\textsuperscript{11} says: "The foliage remained fairly healthy, yet the benefit resulting was not sufficient return for the labor expended." Observation made here at Ames seems to indicate that the disease is perennial in the tissues of the apple, especially where the fungus occurs in the branches, which are often much distorted.

Prof. Farlow\textsuperscript{12} has shown that \textit{Roestelia aurantiaca} is perennial.

Prof. Galloway\textsuperscript{13} also states that in many cases the mycelium of the Cluster Cup fungus on cultivated apple is perennial, living from year to year in the tissues of the tree.

**Experiments to Prevent Pear Leaf-Blight.**

This disease which is so troublesome in the nursery causing the leaves to fall long before their proper time, and preventing successful budding and grafting, is caused by a

\textsuperscript{11}Galloway—Apple Rust, Department of Agriculture, Report 1889, p. 413.
\textsuperscript{12}Gymnosporangia of the United States, p. 38.
\textsuperscript{13}L. C., p. 413.
parasitic fungus, (Entomosporium maculatum). It has been made the subject of several papers by Sorauer,14 Galloway,15 Dudley,16 Arthur17 and others. It hardly seems necessary to record the experiments made on the College Grounds since Prof. Galloway18 and others have shown conclusively that the disease can be treated, but it may be well enough to report on an experiment made under somewhat different conditions. The fungicides used were ammoniacal carbonate of copper and Bordeaux mixture. The first application was made on the 21st of May, using Bordeaux mixture. The fungus had made its appearance on the lower branches. The next application was made on the 16th of June, using ammoniacal carbonate of copper. The third application was made on the 30th of June, using Bordeaux mixture. At this time many of the adjoining plants in the check rows were badly diseased, many of them bare. On August 28, the leaves of the checks were nearly all off, and such as still remained on the tree were badly spotted. (See Plate II.) The leaves of the treated remained attached to the tree, though some of them had diseased leaves. The difference was very marked. The leaves of the treated green, and having made considerable more growth than the untreated. (See Plate III.) A few more sprayings would have been advisable, though the weather was

16Miscellaneous Observations during the Year, Bulletin Cornell University Experiment Station, 1889, p. 98.
17New York Agr'l Experiment Station, III. p. 371. IV p. 249.
so dry after the last spraying that few leaves were affected after the middle of July.

**Plum Rust.**

This disease is caused by a parasitic fungus known as *Puccinia Pruni-spinosæ*, the mycelium growing within the tissues of the leaf. It also occurs on wild cherries, peaches and apricots. In 1889 several trees of the Chippewa variety (*Prunus Americana*) were badly affected with this fungus. It seemed advisable, therefore, to test a fungicide on it, Successful experiments having been reported by several observers. On the 15th of May one tree was sprayed with Bordeaux mixture, and a second application was made on the 7th of June. Neither of the trees on the grounds showed the rust so that the results are negative. The first spraying was done when the flowers were out, using Bordeaux mixture. This proved bad for the plums, as the tree had only a few, most of them having fallen soon after the spraying was done, while the check had an abundance of fruit rather smaller than those of the treated.

**Spot Diseases of Currants.**

(*Septoria Ribis and Cercospora angulata.*)

Two fungicides were used, Bordeaux mixture and ammoniacal carbonate of copper. The experiments were made on Black Naples (*Ribes nigrum*) and White Dutch currant (*R. rubrum*).

**White Dutch.** The first spraying was done with Bordeaux mixture on the 22d of May. This was followed by two other sprayings, using ammoniacal carbonate of copper on June 6 and 30. Unfortunately some of the branches of treated plants of this variety suddenly died.

Yet the remaining portions were sufficient to show that the treatment had some effect on the fungus. Vigorous branches were selected of the treated and untreated and the diseased

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leaves of both were counted with the following results: Of the untreated more than ninety per cent. of the leaves were badly affected by the fungus, while only seven per cent. of the treated had the fungus. In selection of the leaves three good sized branches were chosen.

**Figure XII.**

*Septoria Ribis Spots on Black Naples.*

**Black Naples.** Four applications were made, the first on May 15, second on June 7, using Bordeaux mixture, followed with ammoniacal carbonate of copper on the 20th and 30th. On July 17 the leaves of the untreated were falling rapidly, while the treated had not only greener and better foliage, but an examination of vigorous branches of treated and untreated showed that over ninety per cent. of the untreated were diseased while only five of the treated, and when occurring on these it was found in the shady portions and lower parts of the bush where the fungicide did not reach the leaf. In spraying care was used to get the fungicide on both sides of leaf.
SPOT DISEASES OF THE CHERRY.

(Cylindrosporium Padi.)

This disease is usually most severe in the nursery. It is in fact so bad that the common varieties of the cherry can not be grown from pits. Thus a lot of seedlings of Shadow Amarelle lost nearly all their leaves early in July. The successful treatment of this disease is an important matter to Iowa nurserymen.

Two series of experiments were made, one on the variety Girotte Du Nord, budded the season before on the Mahaleb, growing in the nursery, the second on several varieties of large trees growing in the College Orchard. The first application was made on June 18, using ammoniacal carbonate of copper. On the 30th, three of these rows received a second application; on the 27th of July all six were sprayed again. The difference between those which received the single spraying was quite marked, many more of the lower leaves having fallen off from the latter. The difference between the checks was also marked, so much so that they were readily distinguished. (See Plates IV and V.)

Spraying in order to be effectual should begin as early as May 25, and continue till the middle of August or first of September, especially so if the season is wet, since the fungus spreads most rapidly during such weather. During the past season the month of July was so dry that the fungus did little damage, but several showers of rain during the latter part of the month caused the fungus again to spread.

In 1889 many of the cherry trees in the College orchard suffered from this disease. But during the past season the disease was not so severe.

The following varieties in the orchard were experimented with: Gros Gobet, Galatin, Duchess D'Angiolene.

**Gros Gobet**—Three applications were made, Bordeaux mixture, May 14; ammoniacal carbonate of copper, June 7 and 20.

The treated trees had much better foliage and scarcely any signs of the disease, while the check trees had many diseased leaves which were falling rapidly in the latter part of August.
Galatin—Three applications were made, Bordeaux mixture, May 14; ammoniacal carbonate of copper. June 7 and 20. The results were similar to those of Gros Gobet.

Duchess D'Angiolene—Two applications of Bordeaux mixture were made, on the 23d of May and 7th of June. It did not seem necessary to make a third application since abundant traces of the mixture were found on the foliage, no diseased leaves could be found on the tree, though an untreated but small tree lost most of its foliage very early.

Several other varieties were treated, using ammoniacal carbonate of copper. The first application was made on the 7th of June with a standard solution; on the 24th Mr. Sirrine made a second application, diluting with four gallons of water instead of six. No injury to the foliage was apparent. The results are negative since the untreated were not diseased.

In this connection it should be stated that experiments were made by Prof. Arthur²⁰ some years ago, using sulphide of potassium. He reports good results.

Prof. Galloway has been kind enough to favor me with the results of his experiments near Washington, which show excellent results. Spraying was done oftener, and consequently a very excellent showing.

The following diseases in Iowa can be treated:

||APPLE SCAB.||

To prevent this disease use ammoniacal carbonate of copper, spraying with Gould's Double Acting, or any other equally good pump. Begin spraying soon after the petals of the flowers have fallen. Apply four or five times, once in two weeks. This will vary according to season. If the season is a rainy one, spraying should be done oftener. There is no longer any doubt about the successful application of ammoniacal carbonate of copper, to prevent this fungus.

Profs. Goff and Taft, who have made extended experiments in Wisconsin and Michigan, have reported such excellent results, that Iowa horticulturists should not neglect to spray this year. We have appended a cut of the fungus that those

²⁰Sixth Annual Report, p 350.

See Annual Report of the Department of Agriculture for 1890.
Plate II. Treated.
PLATE III. NOT TREATED.

Published by Iowa State University Digital Repository, 1888
Plate IV. Treated.
PLATE V. NOT TREATED.
not familiar with the disease will be able to recognize it. It was kindly loaned to the Station by Prof. F. L. Harvey, Maine Agricultural Experiment Station. The name of the fungus is *Fusicladium dendriticum*. Plate v., figure 1, apple, showing scab. Figure 2, showing velvety spots on upper surface of leaf. Figure 3, cross-section through one of the scabby spots showing fungus threads. Figure 4, spores, some of which are germinating.

**STRAWBERRY LEAF-BLIGHT.**

Bordeaux mixture—Apply once in two weeks after the berries are harvested and continue as long as new leaves are put out. The mixture can also be applied before the flowers are out. Prof. Galloway has reported very excellent results from the use of ammoniacal carbonate of copper.

**SPOT DISEASE OF THE CHERRY AND PLUM.**

Bordeaux mixture or ammoniacal carbonate of copper—In the nursery where the disease is most injurious apply with any of the knapsack sprayers once in two or three weeks. Begin in the latter part of May or early in June.

**PEAR LEAF-BLIGHT.**

Bordeaux mixture—Apply four to six times, once in two weeks. Beginning the latter part of May or early in June. In the nursery the Galloway or Thaxter spraying apparatus can be used. In the orchard any of the double acting pumps are more serviceable.

**SPOT DISEASES OF CURRANTS.**

Bordeaux mixture and ammoniacal carbonate of copper—Spray five times, or about once in two weeks, beginning the latter part of May.

Powdery Mildew of Cherry, Plum and Apple. Spray with ammoniacal carbonate of copper solution; begin when the leaves are half grown, and continue every fourteen days.
POTATO ROT.

This disease, which is sometimes very troublesome, is caused by a parasitic fungus (*Phytophthora infestans*). Experiments have shown that it can be prevented by spraying with Bordeaux mixture. Spray at least three times, beginning the middle of June.

CLOVER RUST.

{*(Uromyces Trifolii.)*}

Clover is an important forage plant in many parts of the United States, and its great value in Iowa is becoming more and more apparent every year. It is an important matter to early recognize any enemies which it may have, so that methods of extermination may be employed. With the exception of certain spot diseases red clover has been unusually free from any serious fungus enemies in Iowa, but last August Miss Quint, a student in the botanical laboratory, brought in a lot of Clover Rust (*Uromyces Trifolii*) on red clover. The fungus did not occur until August and only on the "rowen" or "aftermath." Later it was found quite abundantly on the campus and College Farm. So severe did it attack some of plants, especially the stems and leaves, that in touching the plants, the hands became covered with brown spores. How long the fungus has affected clover plants in this country and Iowa is not known. It was first reported on white clover in Iowa in Prof. Arthur's\(^1\) list of Iowa Uredineæ, (rusts) collected by Mr. Holway, at Decorah.

Arthur, Bailey and Holway\(^2\) report it from northern Minnesota on the same host. I have seen it abundantly on that host at Madison and La Crosse, Wisconsin. It is more or less common on that plant and other clovers in many parts of the United States, as will be seen from the following references:

It was reported from Massachusetts by Dr. Farlow\(^3\) New

\(^{1}\)Bulletin Iowa Agricultural College, 1884, Department of Botany, pp. 152, 167.


York by Prof. Peck. From Texas it has been reported on Carolina Clover (Trifolium Carolinianum).

Mr. Webber has reported a variety of this fungus as very destructive on Wild Liquorice (Glycyrrhiza lepidota) in Nebraska. Trelease has reported it on Crimson Clover in Wisconsin. Mr. Sirrine has also found it on the same clover growing on the College Farm. At Madison, Wisconsin, it was very destructive to that clover, and from observations made there it would seem not a very desirable plant to generally recommend.

We are, however, chiefly concerned with the fungus on Red Clover. It seems to be more widely distributed than is generally supposed. In Europe it has long been known, and has the credit of doing much damage.

The first American reference to the fungus on Red Clover was made by Prof. Underwood, who found it in the vicinity of Syracuse, New York. He says concerning it: "Uromyces Trifolii appeared in the vicinity of Syracuse on Trifolium pratense (Red Clover), and is doing much damage. It is sometimes so abundant that the leaves are half or more dry and dead; and the damage is from five to twenty per cent. on the value of the crop."

Dr. Roland Thaxter next reported it on "rowen" near New Haven, Conn. In Bulletin, Number XV, Cornell Agricultural Experiment Station, Prof. Dudley reports it as common about Ithaca. It was reported as occurring commonly at Ames, in the August number, 1890, of Monthly Review of the Iowa Weather Crop Service Bulletin.

It is also common in Maine, as Prof. Harvey informs me. Miss Howell has recently made a study of this disease especially concerning the damage the fungus does about Ithaca, N. Y. Miss Howell says: "The disease has not been long

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24H. S. Jennings, Some Parasitic Fungi of Texas, Bulletin No. 9, Texas Agricultural Experiment Station, p. 29.
26Trelease parasitic fungi.
28Frank—Krankheiten der Pflanzen, p. 472.
30Annual Report Conn. Agrl Exp. Station, 1890, p. 175. See also Annual Report 1890.
31Clover Rust, Cornell University Experiment Station, Bulletin XXIV, December 1890, p. 128.
known in America, but has prevailed to such an extent during the several wet seasons preceding 1890, in many sections of the northern states, that it must be regarded as a disease likely to affect seriously, under conditions favorable to its development, an agricultural crop."

CHARACTERS OF THE FUNGUS.

The fungus causing this disease is a true rust and is a member of the Order *Uredineae*. Most farmers are sufficiently familiar with the red and black rust fungus (*Puccinia Graminis*) occurring on barley and oats, known respectively as the uredo and teleuto spore stages. In addition to these another stage occurs on the barberry, known as the cluster-cup fungus or aecidium stage. In Iowa thus far, only the uredo and teleuto-spore stages have been found on the Red Clover, though Miss Howell has also found the aecidium stage on that host in New York. In Wisconsin the aecidium stage is not uncommon on white clover, (see Plate VII, fig. 2) occurring on the petioles and leaves, causing them to be distorted as shown at Plate VII, figure 1, the cluster cups above. In these cups are produced small reproductive bodies, the aecid spores. The uredospores are produced in elongated or roundish spots known as sori. Plate VII, figures 3 and 6; in the latter figure one of the uredo sori enlarged. On the stem of Red Clover the uredo sori are so abundant as to cover it completely, and on picking the leaves or stems the spores impart a brown color to the hands. Plants so affected soon become brown. Each sorus consists of a large number of one-celled, roughened, rounded spores. Plate VII, figure 4. On Red Clover the teleuto spores did not form until late in the season, and usually from different sori. They are shown on Plate VII, figures 5 and 7. The uredo spores and teleuto spores undoubtedly come from the same mycelium. The mycelium is the vegetative part of the fungus and consists of colorless branched threads which are found in the interior of the leaf.*

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*Explanation of Plate VII, *Uromyces Trifolii*. 1. Aecidium spores, above it two cluster cups in which the aecidia spores are found. 2. White clover leaf showing distortions produced by the aecidium stage. 3. Red clover leaf showing clusters of uredo spores. 4. Uredo spores. 5. Teleuto spores. 6. A uredo cluster more magnified than in 3. 7. Cross section of stem showing mycelium between the cells of the leaf. Also teleuto spores and a uredo spore. Figs. 1, 2, 3 and 6 after Miss Howell."
The mycelium takes its nourishment from the interior of the leaf, stem or petiole, through its threads, (see Plate VII, fig 7). Miss Howell says: "Apparently not penetrating the cells." In the petiole of Red Clover leaf there is apparently a penetration into the cells as the dotted lines show. Miss Howell, who has carefully studied this rust, finds that the mycelium is not perennial, that is living over winter in the tissue of the host. Inoculations were made with the _uredo_ and _aecidia_ spores and both produced the _uredo-spores_, showing that the two are connected. Miss Howell reaches the conclusion that Clover Rust is propagated chiefly by the _uredo-spores_ during the summer.

It remains still to be shown whether the mycelium is not perennial in the White Clover. In 1890 at Ithaca, the _aecidia_, _uredo_, and _teleuto_ spores were found in the spring and early summer mainly on White Clover. My own observations at La Crosse and Madison, Wis., confirm these observations and it is not improbable that the "rowen" is mainly affected from the White Clover. In order to lessen the injury, if the clover is in a new field, plowing under the second crop will prove of value. Fields containing much of the fungus should be burned over in the fall. If certain forms of clover are more susceptible to the disease they should not be planted. Crimson Clover which would seem to be more seriously affected in the west should not be planted. Weeds, like Wild Liquorice (_Glycyrrhiza lepidola_), which harbor this fungus, should be exterminated.

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**SPOT DISEASE OF CHERRY.**

(_Cylindrosporium Padi._)

The cherry, like many other cultivated plants, is subject to the attacks of several parasitic fungi which materially check the growth of young and older trees. In many parts of the United States cultivators of the cherry suffer from diseases like the Powdery Mildew and Black Knot, but more destructive than these is the Leaf Drop of the Cherry, variously known as Leaf-Blight, Leaf Spot Disease and generally called Rust in Iowa. This latter name is, however, an unfortunate
one to use since the term "rust" is usually used in connection with such diseases as oats, corn and wheat rusts, diseases produced by fungi known as *Uredineae*. I have made some observations on this disease for two seasons. It is by no means a new disease for Iowa, as Prof. Budd informs me. He has long been acquainted with it, especially on the Early Richmond, the fungus has been so destructive on this variety that its cultivation on the College Farm had to be discontinued. Many of his correspondents report similar failures. Throughout the state Dyehouse, English Morello and Montmorency suffer, especially on black, rich drift soil, but not so extensively on the bluff or ridge soil of lighter color. The disease is most severe in the nursery, affecting every variety on the College Grounds though some are more affected than others. Such varieties as Gros Gobet and the Orels suffer quite as much in the nursery as the Richmond and Montmorency, but when the Orels are once well established in orchards they can apparently resist the disease, but the Early Richmond and Montmorency do not do so to the same extent. More resistant to the attacks in well established trees are such varieties as Double Natte, Duchess d'Angiolene and Brussel&8212;Braune. Seasons also more or less influence the severity of the disease. In 1889 the disease was unusually severe on many of the varieties, but in 1890 some of the trees which had lost much of their foliage in August the year before were scarcely affected and consequently the damage was but slight.

The disease is also more severe in new orchards, especially before the trees are well rooted. In a new cherry orchard consisting of Russian varieties, the trees being well rooted have during the past two seasons not shown much of the disease, but the younger trees of the same variety close to the older trees have suffered considerably. In 1888 Director Speer set out a trial orchard of many varieties. They were budded for the most part on Mahaleb, some on their own roots, while the remainder were root-grafted on the Mazzard. The following year (1889) nearly every tree in the orchard was more or less affected with the disease. Some of
the trees lost many of their leaves as early as July, and in August many of them were bare.

In another orchard, but on higher and better drained soil, well established trees of Brusselar Braune was almost free from the disease, but young cherry trees of the same variety along side of it were badly affected. I believe there can be little doubt from these observations that when trees are once well established and rooted the disease is materially checked. On this point Prof. Budd\(^3\) says: "In June of the succeeding year the trees on its own roots, on Mazzard, and nearly all of the varieties on Mahaleb with pale juice fruit, were in fine growing condition, while Cerise de Ostheim, Wragg, Brusselar Braune, Double Natte, Shadow Amarelle, Spate Amarelle, and other hardy varieties with colored juice showed dead tops or unhealthy foliage. Upon examination it was found that no real union of woods had taken place, and that the

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**Figure XIII.**

A—Mahaleb Cherry, showing spots on upper surface of leaf.
B—Common Cultivated Cherry. Under surface of leaf showing a collection of spores in angles of the veins.

\(^3\)Stocks for the Cherry, Plum and Apricot, Bulletin No. 10, Iowa Agricultural College Experiment Station, 1890, p. 423.
Mahaleb roots were dead, or nearly so in all cases. But close observers have not failed to note the imperfect union, and to attribute the loss to imperfect nutrition of the roots. During seasons of ordinary rainfall these facts would be less noticeable on young trees, but they could not prove durable under the most favorable circumstances unless deeply planted, enabling them to root above the point of union."

**PlantsAffected.**

Here at Ames the cultivated cherry (*Prunus Cerasus*) is most subject to the disease. The Mahaleb has unusually good foliage, but the lower leaves are frequently affected, especially so when growing with other cherries. It appears on the Mahaleb in other parts of the state, as specimens were sent to me by Prof. Beach, from Atlantic. The Morello and Mazzard too are affected. On the College grounds it affects the cultivated plum (*Prunus domestica*) but not seriously. It is frequently found on the Wild Black Cherry (*Prunus serotina*), while in Europe it frequently occurs on (*Prunus Padus*). Herbert J. Webber reports it on *Prunus Virginiana* in Nebraska. It has been found on the Apricot (*Prunus Armeniaca*), here at Ames by Mr. Morris. In California peaches and apricots suffer severely, and produce what is known as "gunshot injury." According to Dr. Halsted is caused by this fungus. It is so abundant as to be a very destructive fungus in orchards.

Mr. Lelong writes me that it is very troublesome on the apricot in California. Prof. Harkness writes me that the "shot hole" fungus is caused by *Phyllosticta circumscissa*, described by Cook from specimens collected by Mr. Crawford in Australia, where it is said to produce a similar injury. The fungus is quite destructive in California. Through the kindness of Prof. Harkness I have been enabled to examine some of the latter fungus on *Prunus demissa*, but is said also to occur on plums and cherries. It is nothing like our cherry fungus.

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32 [Bulletin from the Botanical Department of Iowa Agr'l College, 1888, p. 118.](http://lib.dr.iastate.edu/bulletin/vol2/iss13/3)
33 [Grevillea, Vol. XI, p. 150.](http://lib.dr.iastate.edu/bulletin/vol2/iss13/3)
Prof. Arthur, who has given the subject careful attention, finds the fungus on plums, cherries and peaches.

Mr. T. T. Lyon, of Michigan, states that the Chicksaw and Americana classes are nearly or quite exempt, while many of the Domesticas, such as Bradshaw, Damson and Bavay, are far less liable to such attacks than Washington, Green Gage, Jefferson and numerous others.

Karsten long ago found the fungus in Finland, naming it *Cylindrosporium Padi*, more recently it has been reported from various parts of Europe as in Germany, France and Norway.

It is only recently that American horticultural writers have had their attention called to this disease, though no doubt it has long been known but not recognized as due to a fungus. Mycologists have usually referred this disease to a fungus collected by Prof. Peck in the Adirondack mountains in 1876, described as *Septoria Cerasina*.

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25Sym. Mycologia Fennica, XV, p. 159.
29^Sym. Mycologia Fennica, XV, p. 159.
31^Sym. Mycologia Fennica, XV, p. 159.
33^Sym. Mycologia Fennica, XV, p. 159.
35^Sym. Mycologia Fennica, XV, p. 159.
37^Sym. Mycologia Fennica, XV, p. 159.
39^Sym. Mycologia Fennica, XV, p. 159.
Plate VIII.
Explanation foot of next page.
He found it on the Wild Black Cherry (*Prunus serotina*). It was supposed to be a fungus peculiar to America. Somewhat later the well known mycologist, Mr. Ellis, described a fungus collected by Prof. Kellerman, in Kentucky, on (*Prunus Americana*) as *Seporia Pruni*. Plate VIII, figure 2. Both of these so-called species if not identical are closely related.

Another fungus, *Septoria Ravenelii*, Plate VIII, fig. 4, has been described on the Wild Black Cherry, but I cannot see how this differs essentially from the *Cylindrosporium Padi*, and is indeed much closer related to it than *Septoria Pruni*.

For some of the references, as well as specimens, I am indebted to Prof. Seymour.

**EXTERNAL CHARACTERS.**

About the middle of May, especially in the nursery, reddish or somewhat paler spots make their appearance on the upper surface of the leaf. On older trees this appearance is usually not noticeable till the middle of June and later. At first these spots (see fig. 13) are small, less than one-sixteenth of an inch across, usually round and somewhat restricted in area, they gradually increase in size till in many cases they

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Ellis—North American Fungi, No. 1161. 
Pound—Bulletin No. 11, Nebraska Agricultural Experiment Station, 1889, p. 88. 
Webber—Catalogue of the Flora of Nebraska, p. 29. 
Ellis—N. Am. Fungi, 131. 

The distribution of *Cylindrosporium Padi* in the United States may be arranged as follows: Massachusetts (Trelease, Seymour), Connecticut (Thaxter), New York (Arthur, Peck), New Jersey (Halsted, Ellis), near Washington (Galloway), Wisconsin (Goff), Kentucky (Kellerman), Louisiana (Langlois), Nebraska (Webber), Kansas (Kellerman), Michigan (Lyon), California (Halsted), Iowa (Pammel, Halsted), Minnesota (Arthur, Holway).

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Explanation of plate VIII. 1. Cross-section through a pustule of *Cylindrosporium Padi*. Erect threads coming from a dense mass of shorter threads (stroma). Between the cells of the leaf are the threads of the mycelium, which take nourishment from them. 2. Spores of *Septoria Pruni*. 3. Spores of *Cylindrosporium Padi*. 4. *Septoria Ravenelii*; from Wisconsin. Figures 2, 3 and 4 drawn to the same scale. *Septoria Ravenelii* and *Cylindrosporium Padi* appear not to differ. The spores of *Septoria Pruni* are much smaller. If not the same species it is intermediate between the other two.
are one-eighth of an inch across. In severe cases a large number of small spots appear in a cluster which finally become confluent, forming one large spot. When near the veins the spots are more or less angular. In a short time the spots become brown and the whole leaf assumes a yellow color and falls. On the peach which it affects, Prof. Arthur says: "The fungus rarely produces many septoria spores, but after growing awhile, the tissues of the leaf containing the parasite become dry, separate perfectly from the surrounding healthy tissue, and drop out, leaving a round hole as cleanly cut as if made artificially." In cherries these holes are not common, though they may frequently be found in plum leaves.

An examination of the lower surface of the leaves directly opposite the spot, will show a small elevated body, yellowish in color and somewhat glistening, especially in fresh specimens. In many cases, however, these affairs are broken and surrounded by whitish pellicles, usually having spread for some distance.

This disease is quite different from the disease which frequently affects sweet cherries in Europe. In this disease the leaves frequently remain attached to the trees during the winter and often until new leaves are formed. The ascospores are produced in small perithecia found in the leaves, while the spermogonia as they are designated by Frank occur on the young cherries and leaves, about June. The spermogonial form is known as Septoria erythrostoma. He states that four different stages of the fungus can be recognized. In the last stage, when the leaves are brown, they roll up and then fall off. Nor should this cherry and plum fungus be mistaken for others which cause perforations or "gun shot injury," such a fungus is Phyllosticta Pyrina, (see Plate IX.

Explaination of Plate IX. Fig. 1. Cylindrosporium Padi, on plum. After Arthur. Fig. 2. Phyllosticta Pyrina causing perforation. After Bailey. Fig. 3. Cross section through pustule of Cylindrosporium Padi, showing epidermal cells above the mass of spores before the epidermis is ruptured. Coming from the mass of spores and between the cells of the leaf is the mycelium. The palisade cells are shown below, but it is really the upper side of the leaf. Figure 4. Some cells of the leaf and threads of the fungus more magnified.

http://lib.dr.iastate.edu/bulletin/vol2/iss13/3
fig. 2), which often causes perforations and spots similar to those of *Cylindrosporum*. Bailey\(^41\) reports the Phyllosticta disease in New York. The *Phyllosticta circumscissa* producing “gun shot injury” in California has been referred to.

**MICROSCOPIC CHARACTERS.**

A cross-section of a leaf through one of the pustules before it has broken open will show the following structure, (see Plate IX, figure 3). An upper layer of cells bulging out, due to the growth of the fungus beneath the epidermis, below this layer of cells is a mass of elongated spores which are more magnified in figure XIV. These spores are in some cases plainly several-celled, though often one-celled.\(^42\) At the lower end of this collection of spores is a dense collection of shorter *hyphae*, known as a *stroma*. Plate VIII, figure 1. Coming from this and extending between the cells of the cherry leaf is the *mycelium*. At figure 4, Plate IX, some of the vegetative threads are shown more magnified—these take up the nourishment from the cells. These, as well as the palisade cells shown below, are brown and dead. A section more magnified is shown on Plate VIII, figure 1. The compact *stroma* from which the spores arise and the mycelium extend into the leaf while the spores have grown outwardly.

\(^41\) Cornell University Agricultural Experiment Station Bulletin, XVIII, July, 1890, p. 380.

\(^42\) Micro chemical tests of the division have shown that they are of the same nature as the cell-wall.
The spores are at first small, as shown to the left. They increase in size until they are much longer than broad and slightly curved. When growing in such numbers as shown at the figure on Plate IX, it requires but little to rupture the delicate epidermis of the leaf. On Plate VIII the epidermis had broken away, allowing the spores to pass out in tendrils. I made sections of leaves of *Septoria Pruni* sent to me from Kansas and even after soaking they were unsatisfactory. The pustules were, however, deeper seated.

In addition to this stage which may be called the summer form, two others have been found. One is undoubtedly a *Phoma*, which makes its appearance on the fallen leaves in the form of black bodies or perithecia. The spores of this fungus are colorless and form on the ends of vertical threads. That this fungus is connected with the *Cylindrosporium* may be safely assumed since the spores of the latter frequently occur with it. Then, too, it occupies the place of the pustule of the *Cylindrosporium*.

Later, about May, the same perithecia which contain the *Phoma* spores produces elongated sacs or asci. Later still, about the latter part of May, the asci contain elongated spores, ascospores. Prof. Arthur, who kindly favored me with material of the *Phoma* and perfect form of the fungus figured in his report, is undoubtedly correct in assuming a genetic connection. It has been a very difficult matter to clearly make out the entire structure of the perfect fungus. It is hard to determine the number of asci in one of the sacs, or the presence of sterile threads paraphyses. See figure XIV A.
Figure XIV A—Perfect form of the Cherry and Plum Fungus. 1, 2 and 3 asci with ascospores. 3 not so highly magnified. 4 a single ascopore.
SPOT DISEASES OF CurrANTS AND GOOSEBERRIES.

The brown and dead spots so common on our currants and gooseberries in Iowa and other parts of the United States is due to several parasitic fungi. Two of these, Septoria Ribis and Cercosporia angulata, Winter, are common about Ames. In the east, especially in New York and New Jersey a third fungus, Gleosporium Ribis, known as Anthracnose of Currants has done considerable damage.45

Most of the injury to currants and gooseberries in this state has been due to Cercospora and Septoria. They have been very destructive for two seasons, and seem to have been somewhat so, earlier as the latter is recorded by Hitchcock in the botanical bulletin issued by Dr. Halsted, in 1888.

Prof. Galloway informs me he has been familiar with the Cercospora disease for a number of years. Mr. Ellis writes me that it is apparently the same as was found by Demetrio on Mock Orange (Philadelphus Coronarius), in Missouri.

The Septoria fungus was first found by Desmazier in Europe and described in 1842.

In the United States it occurs in Massachusetts, New York, Ohio, Kentucky, Wisconsin, Nebraska, Kansas, and in all probability is a destructive fungus in many parts of the United States.49

43Desmazier Mem. Soc. des Sc. Lille, 1842.
Frank—Krankheiten der Pflanzen p. 619.
Dudley—Anthracnose of Currants, Cornell University Agricultural Experiment Station Bulletin, XV, 1889, p. 196. Prof. Dudley has given the American literature on the subject.
47L. C.
As a disease, however, it has received little attention from mycologists in either Europe or America. The only account I have seen is that given by Prof. Seymour. As to host plants, it seems to affect a great variety. Here at Ames it has been unusually common on the Black Naples, though also occurring on red and white, (*Ribes rubrum*). Prof. Peck has reported it on the Fetid Currant, (*Ribes prostratum*). In Ohio it is not uncommon on the cultivated currant, and as stated by Mr. Hitchcock is common on cultivated gooseberries (*Ribes Grossularia*) here at Ames. In Kansas it occurs on the Missouri Currant (*Ribes aureum*). Mr. Ellis has sent specimens to me from Kansas on that host. Prof. Trelease reports it on *Ribes floridum* and *R. rotundifolium*, two of our native currants. From this it appears that the fungus occurs on nearly all of the North American species of *Ribes*.

**Figure XV.**

Spot Disease of Currants. After Seymour.
During the month of June small brown discolored spots make their appearance on the upper and lower side of the leaf. They are from less than one-sixteenth of an inch in diameter to more than one-eighth. (See figure XV.) At first the spots are circumscribed and more or less angular. In older specimens the spots are frequently confluent and of gray color.

This fungus causes a premature falling of the leaves. Many of the bushes of the White and Red Dutch Currant lost their foliage in August. Black Naples apparently does not lose its foliage so readily. The greater loss of foliage of the White and Red currants is probably in part due to the attacks of the *Cercospora*. Leaves affected with the *Cercospora* are readily distinguished. The spots on the upper surface of the leaf are not very pronounced, portions affected are of a paler color, while the under surface is of a smoky color. The spots are round or angular. They vary greatly in size, smaller ones being less than one-sixteenth of an inch in diameter, while some of the larger are more than one-eighth.

The spores or reproductive bodies of *Septoria* are contained in small brown perithecia occurring in the spots of the leaf.

*Figure XVI.*

*Septoria Ribis.* In A, spores appear not to be nucleolated as in B. B, after Seymour.
Two or three of the small perithecia are found together. The curved or thread-like spores (figure 16, a) are born on small threads arising from the bottom of the perithecium.

The method of reproduction in *Cercospora* differs materially from that of *Septoria*. In the *Cercospora* disease the mycelium collects in small tufts underneath the epidermis, which, in growing sends erect branches upward which causes the epidermal cells to be broken. The erect branches bear the many-celled hyaline slightly curved spores. The stroma, or cells of the fungus forming a kind of cushion, give rise to the erect branches. It increases in size so that in many cases it may be recognized with the unaided eye as a small blackish speck.

These bodies continue to bear the summer spores. Leaves allowed to remain on the ground till the following spring produce another kind of spore. Immature perithecia, found on the grounds and in a closed case in April, contain asci but no ascospores. The fungus appears to be connected with *Sphaerella Grossulariae*, specimens of which were kindly sent me by Mr. Ellis. The *Septoria* is apparently also connected with the same fungus. Additional observations will be made on the fungus during the coming year. *Sphaerella Grossulariae* is reported as occurring on Black Naples (*Ribes nigrum*) and the cultivated Gooseberry (*Ribes Grossularia*). I have not found the *Cercospora* on Black Naples, though the developing ascospores are common.

In preparing the articles on both cherry and currant diseases I am under obligations to several correspondents, who have favored me with specimens and other information.

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Explanation of Plate X. Fig. 1. An enlarged brownish mass, found in *Cercospora* spots, bearing spores. Fig. 2. Section through a young infected spot showing spores breaking through the epidermis. Fig. 3. Immature peritheicum, below are two immature asci. Figure 3 not magnified as much as the others. Figure 4. Some of the spores more magnified. Figure 5. Asci and contained ascospores with a single one of the latter more magnified, of *Sphaerella Grossulariae*.


Sydow—*Mycotica Marchica*, No. 2525.

WEED PESTS.

The question of weeds to Iowa farmers is one of some importance. It would be hard to estimate the loss to the agriculture of this State through the growth of weeds. It will be sufficient to say that it must amount to millions of dollars. The loss is not alone due to such weeds as Canada Thistle, Ox Eye Daisy, Dock, and the like, which are hard to eradicate, but the principal source of loss comes from some of the easily destroyed, like Foxtail or Pigeon Grass, Lance Leaved Thistle (Conicus lanceolatus), etc., which occur in such abundance as to consume much of the material required to build up the growing crop. There are other directions in which they are injurious to cultivated plants. They form a nidus for various fungi like smuts and molds, which may also occur in cultivated plants. They frequently harbor insects, and for this reason alone ought to be destroyed. An important question is how these weeds get into our fields and meadows, and can it be prevented. Investigators in both Europe and America have shown that many weeds are introduced with seeds of various kinds. That this is true to a considerable extent of seeds sent into Iowa may be seen from the preliminary report by Mr. Rolfs in this bulletin.

The utility and value of examining seeds to determine impurities is eminently proper if farmers can prevent the introduction of weeds or get a higher per centage of germination. A good illustration of the introduction of weeds with agricultural seed came under my notice last year. In several clover patches on the Farm both Ox Eye Daisy and Ribgrass came up in good numbers. Ribgrass, so far as I know, had not been known on the College Farm before, in such numbers. Ribgrass is also known as Ripplegrass, Ribwort, English Plantain, Buckhorn, Plantain, etc. The botanical name of the weed is Plantago lanceolata. It is a European plant, but now not uncommon in the East and some parts of the South. It is a perennial, bearing numerous long (6-10 inches) leaves close to the ground. The flower stalk is groove-angled from

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Nobbe—Handbuch der Samenkunde, Berlin, 1876.
Hartz—Landwirtschaftliche Samenkunde, Berlin, 1885.
McCarthy—Bulletins North Carolina Agr'l Exp. Station, Nos. 70 and 73.
Chester—Second Annual Report Delaware Agr'l Exp. Station, etc.
one to two feet long, which bears a cylindrical spike of
flowers, at first short but ultimately elongating. Two brown­
ish seeds are found in each vessel. Recently several botan­
ists\textsuperscript{53} have called attention to the occurrence of this weed in
considerable numbers in clover.

The second weed making its appearance in that clover patch
was the Ox Eye Daisy, also known as White Daisy, Daisy,
White Weed—botanical name is \textit{Chrysanthemum Leucanthemum}.
It has long been known as a pestiferous plant in the
Eastern States. It is a perennial, producing an erect stem
bearing a large head of white flowers on the margin and
small, yellow flowers on the interior. This head is ordinarily
called the flower, but in reality it is a collection of small
flowers. Another plant belonging to the Composite Family,
a species of \textit{Hieracium} or Hawkweed, was found several
times. It appeared to be \textit{H. aurantiacum}, a European weed,
which has occasioned some alarm in New York and New
England. Like the others, it is a perennial. The flowers
are deep orange or flame color. Some other weeds appeared
in the same field, but they are not likely to be troublesome.

A number of correspondents have sent me specimens of
Canada Thistle, Spiny Nightshade, and Horse Nettle, indic­
ating that some of them have a wider distribution in the
State than is usually supposed. In some places the Canada
Thistle (\textit{Cnicus arvensis}) has become well established. The
Iowa specimens sent me from Chickasaw and Taylor counties
had a good many flowers but no "seed." In these places, as
in many other parts of the West, it spreads almost entirely
by its underground stems, producing few "seeds." In this
way it has been able to cover considerable areas. It will not do,
however, to lay too much stress on the fact that it is not likely
to become troublesome in the West since it does not "seed." On
the shore of Lake Michigan at Milwaukee, Wisconsin, it
produces seeds freely. The seeds are perfect, and when
placed under proper conditions germinate.

\textsuperscript{53}Beal, W. J.—Ribgrass or Narrow Leaved Plantain in Fields of Clover. \textit{Bulletin 56 Michigan Agr\'l Exp. Station}, 1890.

\textsuperscript{53}McCarthy, Gerald—The Weed Pests of the Farm, \textit{North Carolina Agr\'l Exp. Sta-
tion Bulletin No. 70}, April 15, 1890.

Published by Iowa State University Digital Repository, 1888
Horse Nettle. Several correspondents, especially from the counties of Ringgold, Taylor and Greene, have sent me specimens of this weed. It is so troublesome, and apparently just getting a foot hold in Iowa, that a few words will not be out of place. The plant is more or less hairy. The leaves and stems are prickly, and the former have a pale green color. The leaves are wavy toothed. The flowers are usually of bluish color, sometimes white. The fruit resembles the "seed" of the potato. It is a most persistent weed when once established, since the root stock as well as the roots penetrate the soil deeply. It lives from year to year. It should be eradicated at once.

From time to time specimens of the Spiny Nightshade, or Buffalo Thistle (*Solanum rostratum*), have been sent to me. It is evidently on the increase in Iowa. It is an annual weed, a native of the plains of Nebraska, Kansas and Texas, but has now extended east of the Mississippi river, but fortunately is not troublesome. Where the plant has established itself, as in Texas and Kansas, it is one of the most troublesome weeds the farmer has to contend against. It has prickly, hoary, and pale green or yellowish somewhat divided leaves. The flowers are bright yellow, and the fruits, or "seeds," as they are termed by the farmer, are very prickly. This weed behaves like some of the tumble weeds. The whole plant breaking away close to the ground in the fall and rolling over the prairies. Every effort should be made to exterminate the plant.

Dodder. In view of the fact that this weed has been reported from several places in the United States, and as the seed of Clover Dodder (*Cuscuta epithymum*) largely occurs in European clover seed, Iowa farmers should be on their guard. In October, 1889, Mr. Henry Wallace sent me specimens of Clover Dodder from Hall Town, Missouri, just across the State line. It seems to occur more frequently in Missouri than in any other part of the United States, as Prof. Coville stated in Coleman's *Rural World* some months ago. A short description is given in this connection, so that farmers who find it...
should take measures at once to destroy it. It is leafless, with the exception of the small scales on the stem. The stem twines around the plant upon which it lives. It pierces the bark with the delicate suckers known as haustoria. Dodder is an annual, of a yellowish or reddish color, containing only a small amount of chlorophyll, which is so essential for the preparation of organized out of unorganized material. It is parasitic in its habits, deriving its nourishment from the clover by means of the small suckers.

Vigorous efforts should be used to exterminate it. Patches can be covered with straw and burned over. A more radical way would be to use oil of vitriol and water in the proportion of one of the oil of vitriol to three thousand of the water. Prof. McCarthy says: "In Europe, where the Dodder is often very injurious, farmers use a mixture of calcium sulphite and water, which is sprinkled on the infected plants from a common sprinkler." The calcium sulphite kills the Dodder, but it is rather beneficial to clover. Where it covers large fields, rotation of crops should be resorted to, being careful to sow with plants upon which Dodder does not grow—such as barley, wheat, oats and corn.

PRELIMINARY REPORT ON THE EXAMINATION OF SOME SEEDS.

P. H. Rolfs.

The farmer's crop depends upon the kind and quality of the seeds sown, so it is of the greatest importance that he should sow good seeds.

Seeds may be of poor quality. First, because they contain foreign matter such as gravel, pieces of straw, chaff or dirt. Second, because adulterated. This may be done in two ways, either by putting in cheaper seeds and weeds to make up the weight, or by coloring old and sterile seed to make it...
pass for fresh. Third, because they contain seeds of weeds in large proportion.

When seeds are adulterated with seed that is not good the farmer gets a crop which he does not want and often renders the whole entirely worthless for market.

But worse than this is when the farmer sows weeds and makes foul the land his hard work has prepared. Since weeds are very aggressive, the stand of the crop is lessened and often more or less crowded out.

Seeds are sent out to retail dealers in any form desired, either in packages or in bulk, to be sold in quantities called for, and those not sold are kept from one year to another. Seeds are not as good the second year, many not growing at all the third, but still are sold as fresh seeds.

Before 1870, when Dr. Nobbe began his excellent work, there were several establishments in Europe engaged in the manufacture of bogus clover seeds from quartz rock. The quartz was first crushed and, by means of sieves, graded to the size of different species of clover seeds; it was then colored to imitate the seeds which it was meant to adulterate. Prof. Nobbe has shown that in a single year certain English seed firms, and among the most "honorable" in the trade have purchased tons of this bogus seed.

We would not be surprised to find them still at work, there or in America. Certainly bogus seed is manufactured somewhere, not only of the clovers but also of the more expensive grasses.67

Seed merchants often cry that they have to sell pure and tested seeds as their reputation is at stake, but this does not seem sufficient to keep them all honest. To bring this occupation down to a strict business rule would be a great advantage to the upright men in the business and to the purchaser.

The Station has been buying seeds from Mr. Nungesser, New York City. Prof. McCarthy, of N. C. Experiment Station, after examining the seeds from many different dealers says of these seeds: "The purity is much above the average for grass and clovers seeds."

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67 McCarthy, p. 5, Bulletin 74, N. C. Experiment Station.
In a pound of Perennial Sweet Verne examined at this Station there was more than an ounce of dark brown sand, that an unsuspecting eye would not detect. In a pound of Fiorin there was much quartz sand. In the pound of Fiorin more than one-half of the bulk was chaff and over one-third the weight sand and chaff.

Although it is bad to buy a lot of sand at the rate of forty-two cents a pound, it is far worse to pay for weed seeds, or poor growing seeds or to buy seeds under a false name. For instance a quantity of Italian Rye Grass contained forty-one per cent. of English Rye Grass, a package marked Burnet Clover contained forty-seven per cent. of Sainfoin. Water Fescue contained eleven per cent. of English Rye Grass. This is certainly inexcusable. The farmer cannot afford to pay for new and expensive seeds and get something entirely different.

A pound of Sainfoin (Onobrychis sativa L.) examined was found to contain at least twenty-nine different kinds of weeds, (by weeds we mean a "plant out of place"). Some of the weeds are, Corn Flower (5), Medick (6), Hemp (7), Jumping Oats (12), Chess (13), five different species of the mustard family, a Spurge, Burnet, etc.

Burnet (Poternium Sanguisorba, L.), is a weed in Europe. The seed is somewhat difficult to collect. The pound examined contained forty-seven per cent. of Sainfoin. Sainfoin sells at six cents per pound and Burnet at sixteen cents per pound. It also contained much gravel and a good many snail shells. Some of the weeds are, Medick (6), Vetch (6), Corn Corkle (8), Chess (13), Black Oats, Buckwheat and others.

White Clover (Trifolium repens, L.) was found to be clean seed and looked new. It contained Red Clover (T. pratense) Alsike (T. hybridum), Pigeon Grass (14), and some Hard Fescue (Festuca duriuscula).

Japan Clover (Lespedeza striata). Clean, good, fresh looking seed.

Bokhara Clover (Melilotus leucantha), contained the following quantities of weed seeds: 857 Sheep Sorrel (2), (see fig. 3)

58These numbers refer to the number in the list of weeds.
seeds were found in a pound and 113 Plantain seeds (11). There were also a number of other weeds.

Rescue Grass (*Bromus uniloides*, H. and K., *Ceratochola australis*, Spreng), also called Schrader’s Brome Grass, contained the seeds of two different kinds of docks (2), a great deal of Long Stalked Cranesbill (3), also many Chess seeds (13).

Johnson Grass (*Sorghum halepense*), this seed was poorly cleaned. It contained very much Pigweed (9), Lamb’s Quarters (10), some Sandburs (15), and more than a dozen other kinds of weeds.

Orchard Grass (*Dactylis glomerata*, L.) A pound of this contained over 1,400 Sheep-sorrel (2), (*Rumex Acetocella*, L.) and considerable Ergot (16).

Fiorin, Florin, White Bent Grass (*Agrotis alba*, L.) as mentioned before, over one-half the bulk was chaff and over one-third its weight made up of chaff and sand. The principal weeds were Dock (2), Plantain (11), etc., besides this it contained Ergot.

Fancy Red Top (*Argrotis alba, var vulgaris*, Thurb), poorly cleaned, contained sand, weeds and Ergot (16).

**Figure XVII.** English Rye Grass, (a natural size.)
English Rye Grass, (fig. 1) \( (Lolium \textit{perenne} \text{ L.}) \) Clean and good in all respects; contained some Buttercup seed \((i)\), and Plantain \((ii)\).

Figs. 1, 2, 5 and 6, were taken from Bulletin 73, N. C. Experiment Station.

Italian Rye Grass, (fig 2) \( (L. \textit{Italicum} , \text{ A. Brown}) \). Forty-one per cent. of a pound was English Rye Grass. Among the weeds present were Buttercup \((i)\), and Long Stalked Cranesbill \((3)\). The English Rye Grass costs as much as the Italian Rye Grass, but no farmer cares to have his wheat half barley, no matter what the barley brings in the market.

Annual Sweet Verne \( (\textit{Anthoxanthum Puelli}, \text{ Lecoq et Lamoitte}) \) quite free from weeds and no adulteration was found.

Perennial Sweet Verne \( (\textit{Anthoxanthum odoratum}, \text{ L.}) \) More than one-twelfth of its weight was a dark brown gravel, but otherwise it was clean and pure. This seed costs forty-two cents per pound. It is difficult to harvest.

A pound of Meadow Foxtail \( (\textit{Alopecurus pratensis} \text{ L.}) \) contained less than one per cent. of impurity. This is considered a high grade of purity.
Tall Fescue (*Festuca elatior* L.) This species is also sold as Fall Fescue or as Meadow Fescue as three distinct grasses. The seed was comparatively clean; there were Dock (2), Vetch (6), Medick (6), and others with some gravel or sand.

Meadow Fescue, same species as foregoing, contained much Ergot (16), some Dock (2) and Medick (6). From the weed in the sample one would be inclined to think they had been grown in separate places.

Hard Fescue (*Festuca duriuscula*, L.) Very foul, containing much Dock seeds (*Rumex*) (2), some Buttercup (1), some Medick (6), and *Bromus*.

Mr. Wright, of Maquoketa, Ia., sent to the station a sample of timothy (*Phleum pratense*, L.) to have the seeds of weeds identified. It contained the seed of one of the Pepper-grasses (*Lepidium intermedium*, Gray), (fig. 3), not a troublesome weed. It is one of our native weeds which is easily crowded out by grass or other crops. The sample also contained a smaller amount of clover, mustard and dirt. It would pass for “clean seed,” as there was less than one per cent. of foreign matter present. The color of the Pepper-grass is brownish and is very striking in timothy seed.

Some of the Weeds Abundantly Found.

No. 1. The Buttercups (*Ranunculus*), belong to a family of plants with clear acrid juice. None of them are very troublesome weeds, but cattle do not feed on these plants generally. The flowers are yellow; occasionally white; the petals falling, soon leaving a flat “seed” with a short point straight or curved. They are also known as Crowfoots and sometimes incorrectly called “cowslips.”

No. 2. Dock, Sheep-sorrel (fig. 3), (*Rumex*), belongs to the Buckwheat Family. In the docks and sorrels the flowers are green. Some docks often grow four feet high. A single plant of Sheep-sorrel of medium height will bear 7,556 seeds.60 It is a perennial and hard to kill except by breaking sod. Even clover cannot keep it down.

No. 3. The Long Stalked Cranesbill (*Geranium Colum-

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60 Halsted—Bulletin Iowa Agricultural College, Botanical Department, 1888, p. 8.
Sheep-Sorrel. (A, natural size seed with valves. B, natural size of seed.)

Petunum, L. (?) is a weed that has a foot hold in some of the eastern states but has not reached Iowa yet, so far as I know. It received the name Cranesbill from the fancied resemblance of its seed pod to a crane's bill. The seed usually retains its husk and a portion of the long beak splits off to form a spiral around the seed. When the chaff is removed the black seed appears to be covered with shallow pits.

Fig. XX. Pepper grass. (A, natural size; B, natural size of seed and pod.)

No. 4. Peppergrass (Fig. xx) (Lepedium intermedium, Gray,) belongs to the Mustard Family, which contains many cultivated species and many annoying weeds. The seeds of Peppergrass are small light brown.

No. 5. Corn flower (Centaurea Cyanus, L.), Bluebottle, is another weed introduced from Europe. It is cultivated as a garden flower, not only in Europe, but in this country as well. The "seeds" are about the size and shape of a thistle "seed," the pappus, however, remains attached to the seed. It belongs to the Composite Family,
which contains many troublesome weeds. Well known examples of this family are Canada Thistle, Ox Eye Daisy and Wild Sunflower.

No. 6. Medick (Medicago), Vetch (Lathyrus) are cultivated plants from Europe. They belong to the Pulse Family. In the former the seeds are small, yellow, kidney shaped, a little larger than clover seed; in the latter, black and about the size and shape of small garden peas.

No. 7. Hemp (Cannabis sativa, L.) belongs to the Nettle Family. It runs wild easily, and is common as weed along roadsides and fences, making an unsightly field. In parts of Iowa it grows eight feet tall and shuts out all vision from the road. The seed is about the size of a small grain of buckwheat, and at first sight might be mistaken for it, but the hemp seed is not "three cornered."

No. 8. Corn Cockle (Lychnis Githago, Lam.) belongs to the Pink Family, and has been introduced into this State. Wheat containing cockle is hard to sell. It is a dark, black seed of irregular shape, covered with small pits. Farmers should not sow wheat or any other grain that contains it, since some of the seeds will find their way to the wheat field, if cockle is allowed to grow on the farm. It is far cheaper in the end to keep it off by not sowing any seeds that contain it. Cockle in wheat lowers its grade considerably.

No. 9. Pigweed, Green Amaranth (Amaranthus retroflexus, L.), is an ugly weed, known by almost every one. Sometimes it is called Red Root. The seeds are very small, somewhat flattened, shiny black and easily separated from ordinary grain and grass seeds.

Tumbleweed (A. albus, L.) and Creeping Amaranth (A. blitoides, Wats.) have very similar seeds. The flowers are green and inconspicuous. Tumbleweed and Creeping Amaranth are natives here, while the Pigweed has been introduced from tropical America.

No. 10. Lamb’s-Quarters, also called Pigweed (Chenopodium album, L.), is a common ugly weed. When young it is sometimes used for “greens.” Grows from one to four feet high. Belongs to the Goosefoot Family. Seeds resemble-
those of the Green Amaranth, except that they are very much larger.

**Figure XXI.** Plantain. (*f*, natural size.)

No. 11. Ribgrass, Plantain (Fig. xxi) (*Plantago lanceolata*, L.) has been introduced from Europe and has already made itself annoying. The seed is a little larger than ordinary clover seed, making it difficult to be separated. Much is introduced with clover seed. Clover seed containing it should not be sown, as it is very difficult to kill, and like the Common Plantain makes its way into sod land and lawns. In England it is sometimes used as a forage plant.

Grass Family contains a number of troublesome weeds. The ordinary eye will not detect many of the foul seeds and adulterants.

No. 12. Jumping oats is hard to separate from oats, and still harder from grass seeds.

**Figure XXII.** Cheat. (*a*, *b*, *c*, natural size.)
No. 13. Chess or cheat (Fig. xxii) (*Bromus secalinus*, L.) is so well known that it is hardly necessary to call attention to it. It is especially troublesome to grain growers. It is worthless as a forage plant, while in "wet seasons it often takes nearly entire possession of a field, and when at harvest time the farmer finds chess instead of oats, he concludes that the wheat has turned to chess. This is a very erroneous idea. Wheat or any other grain cannot, under any circumstances, turn to chess or to anything else. A wheat or oat seed will invariably, at all times and in all places, produce a plant of the same kind or nothing! The reason why chess takes possession of a field some seasons is, because either the ground is well-stocked with the seed produced by plants growing the year before, or the farmer himself sowed the seed. The season proving more favorable to the Chess than the grain, the former smothered out the latter and took possession of the field.\(^61\)"

No. 14. Fox Tail or Pigeon Grass (*Setaria glauca*, Beau.) is very common in stubble fields, especially such as were plowed late in the fall. Much of the seed is sown with the grain, but is kept crowded down, usually, until the crop is harvested, and then it makes its growth and ripens for the farmer to fight the next year. The seed resembles timothy in shape, but is very much larger and the color is usually straw yellow.

Green Foxtail, Bottle Grass (*S. viridis*, Beau.), is not quite as bad as Pigeon Grass. The two Foxtails taken together rank among Iowa's worst weeds.

No. 15. Sandbur, Hedge-Hog Grass, Bur Grass (*Cenchrus tribuloides*, L.,) is one of our native weeds. It is peculiar in producing a bur-like covering to its "seed." As it grows on sandy ground it is not annoying to many Iowa farmers and is mainly troublesome in sheep pastures, by damaging the wool.

\(^61\)Gerald McCarthy—N. C. Exp. Sta., p. 8, Bull. 70.
No. 16. Ergot, (fig. xxiii), \((Claviceps purpurea)\), is a fungus that attacks the grains of many grasses. Rye and Rye Grass \((Elymus Canadensis, \text{ L.})\) are badly attacked by it. The shape and size varies with the size of the "seed" it grows on. Since it causes a disease quite fatal to cattle, known as ergotism, the farmer should be careful not to sow it. Figure 7 represents specimens taken from red top \((Agrotis alba, \text{ var. vulgaris} \text{ Thurb})\).

The old maxim, "An ounce of prevention is better than a pound of cure," is most emphatically true in the case of sowing weed seeds. One plant of our common Dock for example, produced 7,556 seeds. One plant of black mustard seed produced 16,416 and one Burdock plant gave 36,456. The plants chosen to count the seeds were not the largest, but average sized.

We cannot be too careful in choosing clean seeds. To sow spoiled seeds or gravely seeds simply cheats the farmer out of his crop, or if he knows it to be bad seed he can put more on per acre, but in case of weedy seeds the bad effect is not apparent until the second year and from that time on indefinitely.

It is difficult to get seeds entirely free from weeds, but there should be no seed offered on the market that contains bad weed seeds. Why would not a weed law, such as many eastern states have in regard to fertilizers, work as much benefit for our Iowa farmers as the fertilizer laws have for the eastern farmers?

\[62\text{Halsted—Bulletin Iowa Agr’I College, Depart. of Botany, 1888, p. 8.}\]
Before such laws could be effective, we must have a standard of purity and a standard of vitality. There are too many conditions that determine whether a seed shall grow or not after it passes into the farmer’s hand. And it would not be just to ask the seed men to be responsible for the crop, but some disinterested persons should be selected to make the test. This work of testing could be done by the Experiment Station. They have the necessary equipments and it naturally falls into their line of work.

Prof. McCarthy says that about sixteen years ago a New York seed firm was sued for selling turnip seeds mixed with other seeds, under the name of cabbage seed. The plaintiff received indemnity for damages. This caused a meeting of New York seed men, who adopted a “disclaimer,” but a man cannot stipulate against his own fraud. There is no doubt but that a seed merchant can be held as liable for the quality of his seeds as any other merchant for his goods. No one can escape being punished for fraud by disclaiming responsibility, but a definite settlement will not be reached until suit is brought as a test case.

The following form of guarantee is given by a large English seed association, and is, in effect, similar to that given by all European seedsmen:

“1. Our seeds are sold guaranteed pure, clean and of the percentage of vitality named in our catalogue.

“2. This guarantee is subject to the analysis of the botanist of the Royal Agricultural Society.

“3. If the results of the analysis do not confirm the above guarantee, the association will take back the seeds and pay the cost of carriage both ways, but seeds must not be sown before making complaint.

“4. The seeds once sown, the responsibility of the association ceases. The result depends upon too many things besides the quality of the seeds, that the growth cannot be guaranteed.\textsuperscript{63}"

It is certain that no honest seed man can object to such a contract, as it would be of immense value to him and the honest seed buyer, by throwing all cheap and worthless seeds out of the market.

\textsuperscript{63}P. 6, Bulletin 67, N. C. Experiment Station.
NOTES ON METHODS OF CROSS-POLLINATION.

F. A. SIRRINE.

During the season of 1890 the following methods of castrating and pollinating flowers were tried at the Iowa Experiment Station. The object being to obtain the quickest and best way of doing the work. The plants operated on were such as Director Speer desired to secure crosses of.

Methods of Castration—Two methods of castrating the plum were tried. 1. Careful opening of the buds and picking out the stamens with a fine pair of tweezers. This was a very tedious way, but the petals helped to protect the tender style and stigma. 2. The cutting or tearing off of the whole calyx which bears the petals and stamens, leaving the ovary unprotected. This was done by taking the base of the bud between the prongs of the tweezers, simply holding the bud sufficiently close enough, not pinching it, then by giving the tweezers an upward jerk, the part of the calyx which bears the stamens will be removed. In the first few trials more buds will be pulled off than anything else, but if the prongs of the tweezers are sharp enough, the whole calyx cup will be removed with safety.

The same methods of castrating were tried on the cherry with the same results, namely, that the petals helped to protect the stigma from being injured by the sack. (Paper sacks were used in all cases.)

The second method was varied somewhat on the apple. The crown of the calyx was removed by making an oblique upward stroke at an angle of about seventy-five degrees with a prong of the tweezers. Two strokes being enough usually to remove the whole crown. With the apple this proved to be the best method, as there are leaves enough on the spurs to protect the exposed styles. By the first method there is danger of mutilating the styles in picking out the stamens.

The rose, like the apple, is castrated most readily by the second method, the only difference being that a knife with a curved blade should be used instead of the tweezers since the calyx of the rose is stronger and less brittle than the apple.
The second method was the only way in which the stamens could be removed with safety and not mutilate the pistils. There is also more or less danger of breaking the anthers since the filaments are turned in and down so that the anthers are wedged in among the outer styles. To avoid this cut the calyx from the hip, being careful not to let the knife go deep enough to strike the stigmas, the remaining anthers can be picked out readily with a dissecting needle. Dr. Mueller recommends thin sheets of wadding for wrapping the denuded flowers to absorb the sap which flows from the wounded parts. It would be well to follow this plan for the rose, at least, as the double varieties bleed profusely. *

Only one method was tried with grapes, that is, the removal of the cap just before it was ready to be thrown off, which was done by holding it firmly between the tweezers and giving an upward jerk. In this way usually all the stamens can be removed with the cap.

With most flowers it was best to do the castrating twenty-four hours before they open. The evening before will answer for the rose.

Application of Pollen—The application of pollen in case of the plum, cherry, rose, apple and grape is made most easily before it gets thoroughly dry, better as soon as collected. If it is necessary to collect the pollen several days before using, it should be spread on paper or plates and kept where it will not absorb moisture, or get too dry.

Prof. Bailey recommends the use of a pin, with the head cut off, flattened like a spatula and stuck in a wooden handle, for the application of pollen.

Grasses—The floral parts of grasses are so arranged that it is a difficult matter to castrate them and not break the anthers. The flowers open naturally between 5:00 and 9:00 A. M., and 5:00 and 7:00 P. M., depending on the grass. In some, however, the flowers do not open. Their opening

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64 Referred to in American Garden, Vol. XI, No. 4, p. 248.

* By the second method it is not absolutely necessary to cover flowers that have been castrated in order to keep insects off, since they will only visit them by mere accident.

depends somewhat on atmospheric conditions. The glumes are so rigid that it is impossible in most cases to force them open without injury to the parts, though it can be done a short time before it is time for them to open naturally. By drawing the panicle lightly through the hand the irritation will cause them to open, and the anthers can be removed with a quill while the pollen is still moist; in this way some of the pollen is apt to remain adhering to the glumes, or the anther will break in two, leaving a piece of the base. An attempt to remove this piece is sure to scatter the pollen. So that one of the best ways to cross-pollinate grasses is to cause the glumes to open by irritation, and remove as many of the anthers as it is possible to do without scattering the pollen, then apply the desired pollen to the stigmas before the glumes close. Operating on the flowers in this way the cross is left in doubt until the characters of the seedling can be compared with those of its parents.

Texas Blue Grass (*Poa arachnifera*), which is sometimes dioecious, was used as the female plant, i.e., the pistillate flowers, and the pollen of Kentucky Blue Grass as the male. A known cross was obtained in this way.

In crossing wheat, oats and rye the same difficulties are met as in grasses. Bliss Carmine, writing on crossing of wheat for the Rural New Yorker, recommends the use of a sharpened stick for removing the anthers. A goose quill was found more flexible and less liable to injure the ovary. In castrating wheat and rye it is well to carry a disinfecting solution to dip the instrument in, as there is danger of inoculating the castrated flowers with Ergot (*Claviceps purpurea*).

Sacks were found to be too heavy to tie over the heads of grains and grasses, the extra weight causing the culm to break. This can be avoided and the straw strengthened by winding the head and first joint of the culm with light cheese cloth.

*Clovers.*—The clovers are nearly as difficult to castrate as the grasses. The floral parts are not only minute, but in castrating the keel of the corolla must be removed to get at the anthers. The filaments of the latter are united and adhere closely to the ovary and style, so that in removing them
the ovary is apt to be injured by the instrument. From what is known of the structure of the flowers and experiments made on pollinating them, there is little danger of self-pollination. Two experiments were made to test the effect of self-pollination of Red Clover. The plants were covered by placing bows over them and stretching cheese cloth over the bows, care being taken to fasten the cloth to the ground close enough to prevent bees from forcing their way in. Bows were used to prevent the cloth resting on the plant, as it produced wilting or smothering and interfered with growth. In one case the plant was left alone to test self-pollination; in the other, which was a white sport of Red Clover, artificial pollination was effected with its own pollen. No seed was obtained in either case, but the sport may have been sterile.

On the assumption that clover is not self-pollinated the following method was used: The plants were covered with netting to avoid smothering and to keep insects off. The pollen was obtained from fresh heads, by taking one of the flowers between the thumb and finger of the left hand, so as to press on the wings while the point of the quill is held near the cleft of the keel. The mechanism of the flower is such that the stigma will be moved forward and upward and its brush will throw the pollen against the quill, to which it will adhere. Then by holding one of the flowers, on which a cross is desired, in the same manner, being careful not to press too hard on the wings, or hold the quill too far from the cleft of the carina, the stigma will be moved forward far enough to touch the pollen adhering to it. If the quill is too far from the cleft, the pollen will be thrown against it before the stigma can touch it.

Beans—The varieties of the bean are self-pollinated, so cannot be crossed with as much certainty as the clovers by the preceding method. They should be covered the same as the clover, but the flowers should be held between two fingers of the left hand while the thumb is used to press on the wings. As the stigma protrudes it can be touched with the point of a quill or a brush bearing the pollen. This work must be done before their own anthers open.

66 Darwin on Cross and Self-Fertilization, p. 381.
Corn.—The old method of covering corn with sacks is far from satisfactory, as it is next to impossible to cover the ears and get good results, at least if the season is an unfavorable one. This is especially so if a large number of crosses are carried on. From a trial made on planting corn in an isolated part of the field, removing the tassels and hand pollinating the ears without covering, better results were obtained. I would suggest planting all varieties that are to be crossed, side by side, in some remote part of the field away from the other corn, and if possible, surrounded by trees or in the center of a cane field. Remove the tassels as soon as they appear and apply the pollen to the silks every morning for three or four days. The varieties from which the pollen is wanted can be planted together in another part of the field. Kellerman and Swingle\textsuperscript{67} state that the tassels can be enclosed in sacks till the pollen falls. The tassels can be collected and placed in jars of water and the latter set on sheets of paper to catch the pollen as it falls. The tassels should be collected in the evening or very early in the morning. The pollen can be applied most thoroughly with the hand, but care should be used that the wind does not sow it broadcast; besides the hand should be washed in alcohol or dipped in hot water when changing from one kind of pollen to another. On trial it was found that pollen can be applied before sunrise, in fact this was the best time as there was usually less wind to interfere with the work.

Prof. Crozier\textsuperscript{68} adopted the following plan for crossing corn. The varieties to be crossed were planted in the same field, with the variety used for pollen, the tassels were removed before the pollen was shed. This is the most natural way, but it limits the number of crosses; as few varieties used for pollen can be planted in a field and be isolated enough to prevent intermixture of the pollen. By the first named plan a few hills of each variety can be devoted to each kind of pollen and thus a larger number of different crosses obtained. The main disadvantage being the application of pollen every morning for a few days.

\textsuperscript{67}Second Annual Report, Kansas Agricultural Experiment Station.

\textsuperscript{68}Crozier and Rolfs—Immediate influence of Cross-fertilization upon Fruits, Agricultural Science, Vol. IV. No. 4.
In either case the tassels would have to be pulled from the pistillate variety. The only gain by the second method is the time spent in collecting and applying the pollen.

SUMMARY OF BOTANICAL ARTICLES CONTAINED IN THIS BULLETIN.

1. Treatment of Fungus Diseases. Pear-Leaf Blight, Apple Scab, Strawberry-leaf Blight, Spot Disease of Cherry, Spot Disease of Currants, Powdery Mildew of Cherry, Powdery Mildew of Plum are all troublesome fungus diseases in Iowa, and can be treated very successfully with Bordeaux mixture and ammoniacal carbonate of copper. Bordeaux mixture is prepared as follows: Twelve pounds of bluestone dissolved in 15-20 gallons of water, 8 pounds of lime slacked in 10-12 gallons of water; after cooling mix the two. Ammoniacal carbonate of copper: Five ounces of the carbonate are dissolved in 3 pints of ammonia, strength 26 per cent. This is diluted with 44 gallons of water. In most cases the ammoniacal carbonate of copper is more convenient to use, though in some cases the Bordeaux mixture has given the best results. With Apple Scab a somewhat stronger solution can be used. In nurseries spraying can be done with a knapsack sprayer. Large trees can be sprayed with a double acting pump. Experiments made on the College Grounds indicate that Spot Disease of Cherry, Spot Disease of Currants and Pear-Leaf Blight can be prevented. Experiments to prevent Apple Rust were unsuccessful.

2. Fungus Diseases. One of the most important forage plants of Iowa, Red Clover, has been affected with Clover Rust (Uromyces Trifolii). The fungus occurs especially on "rowen" or second crop clover. It also occurs on White and Crimson Clover. Three stages occur. The fungus is spread chiefly by the uredospores. Fields containing much of the fungus should be burned over or plowed under. It is not advisable to plant Crimson Clover. Serious losses occur every year from Spot Disease of the Cherry (Cylindrosporium Padi). The
injury is most severe in nurseries, where it effects all cherries alike causing the leaves to become spotted, then yellow; soon falling. In orchards the varieties like the Early Richmond suffer severely. Varieties like Brusselar Braune are nearly exempt. It appears also that until trees are well established they are much more subject to the disease. Gun shot injury may be caused by different fungi. *Cylindrosporium Padi* has been found on various cultivated cherries, Mahaleb, apricots, plums, Wild Black Cherry, etc. In all cases the fungus causes a premature falling of the leaves. In June the perfect fruit is found in the old leaves. These are sources of infection.

Spot Disease of Currants in Iowa is due mainly to two parasitic fungi, *Septoria Ribis* and *Cercospora angulata*. Both cause premature falling of the leaves. In the Black Naples the leaves remain longer attached than in the White and Red Currants. The fungus also affects various wild currants and gooseberries. The fungus produces a perfect form in which the spores are contained in small black bodies—the perithecia. These do not mature till May or June. The fungus can be very much lessened by destroying old leaves.

Weeds are generally introduced with seed. A clover patch on the College Farm contained the following troublesome weeds: Ox-Eye Daisy, Rib Grass, Hawk Weed, etc. In one of the counties of Missouri bordering on Iowa Clover Dodder was reported. It is said to be quite persistent. The seed of this weed is largely found in clover seed imported from Europe. Measures should be taken to stamp it out at once. An examination of commercial seeds sent into Iowa, made by Mr. Rolfs, under my direction, revealed a large number of troublesome weeds, like Rib Grass, Corn Cockle, Hemp, Vetch, Sheep-sorrel, Dock, etc.

In Mr. Sirrine's paper will be found an account of the successful method of pollinating flowers during the season of 1890. Grasses are difficult to cross, owing to the character of the flowers. In dioecious grasses like Texas Blue Grass the latter may be used as a female plant, using the pollen of the Kentucky Blue Grass. Successful crosses were obtained in this way. Red Clover does not self-pollinate nor fertilize, and in a white sport of this species artificial pollination was
tried with its own pollen, but seed was not produced. Since the bean is self-pollinated there is much more uncertainty in securing a cross.

A REQUEST!

To make the work of the Botanical Section of the Station more useful, I desire to ask all those who are interested in botanical work to co-operate with me. We shall be pleased to look up for persons desiring so all questions pertaining to fungus diseases of plants, like smut, rust, mildew and spot diseases. Always send specimens affected and the name of the plant. I shall also be pleased to answer all inquiries in regard to the treatment of fungus diseases.

The botanical side of the station will give the matter of seeds and weeds considerable attention. If any one desires to have weeds identified, small specimens showing flowers, fruits and leaves should be sent.

Seeds. If any one desires to have seeds examined as regards impurities, a small sample should be sent. They will be looked over cheerfully.

L. H. Pammel.