New York Agricultural Experiment Station.

Geneva, N. Y.

TROUBLES OF ALFALFA IN NEW YORK.


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BULLETIN No. 305.

TROUBLES OF ALFALFA IN NEW YORK

F. C. STEWART, G. T. FRENCH AND J. K. WILSON.

SUMMARY.

New York farmers are becoming much interested in alfalfa culture and the acreage of this crop in the State (5582 acres in 1899) is rapidly increasing. This bulletin gives an account of the various hindrances to successful alfalfa culture in New York.

Undoubtedly, the chief difficulty is to get the crop established. Several factors may be concerned in this: Poor seed, poor fitting of the seed-bed, sour soil, wet soil, sowing with a nurse crop, lack of nodule bacteria, lack of humus, weeds, leaf spot disease, close cutting and winter injury. Dodder is often a serious pest and leaf spot (Pseudopeziza medicagoe) is an important fungus disease.

No alfalfa seed is produced in New York. Much of the seed used here is imported and the remainder comes from the Western States. Farmers experience much difficulty in obtaining good alfalfa seed. It is often impure, containing dodder, English plantain, wild carrot and divers other troublesome weeds. Sometimes it is adulterated with seed of yellow trefoil, bur clover and sweet clover. To avoid trouble from this source farmers should submit samples of their alfalfa seed to the Experiment Station for examination. In 548 samples of alfalfa seed examined by the Station during the past two years 126 contained dodder. If dodder-infested seed is used it should first be sifted in a 20 x 20 mesh sieve made of No. 34 steel or iron wire. Dodder is a dangerous weed and no chances should be taken with it. Fields badly infested with dodder should be plowed up and reseeded. If there are only a few dodder spots they may be dug out or, better yet, burned out, using kerosene and hay for fuel. Dodder does not commonly produce seed in New York alfalfa fields. It is carried over from one year to the next chiefly by means of hibernating threads on the crowns of the plants; that is to say, dodder is perennial not annual as generally believed. The number of kinds of dodder occurring on alfalfa in New York is not known. Cuscuta epithymum is the most common
species. Usually, the reseeding of dodder-infested fields may be accomplished without the reappearance of dodder in the new seeding provided dodder-free seed is used.

Yellow trefoil closely resembles alfalfa, but it has a yellow blossom whereas alfalfa has a purple one. Another striking difference is found in the root-systems of the two plants. Alfalfa has a strong tap-root with few side roots, while the tap-root of yellow trefoil is smaller and has numerous side roots. Yellow trefoil is not a troublesome weed; it is merely a worthless plant. In New York, yellow trefoil is regularly a biennial in alfalfa fields and lawns. It becomes conspicuous in the first cutting of the second season, then disappears. The adulteration of alfalfa seed with yellow trefoil is much less frequent than it was a few years ago.

In newly-seeded alfalfa fields weeds are a serious menace. Before seeding with alfalfa the land should be cleaned thoroughly. It is folly to sow alfalfa on foul land. Practically all of the trouble with weeds comes during the first season. In established alfalfa fields few weeds are able to maintain themselves. When weeds threaten to smother young alfalfa the field should be promptly clipped, but not mown closely. Close mowing may ruin young alfalfa.

The only really important fungus disease of alfalfa in New York is the leaf spot caused by Pseudopeziza medicaginis. Other diseases sometimes found are wilt (Sclerotinia libertiana), anthracnose (Colletotrichum trifolii), downy mildew (Peronospora trifoliorum), Ascochyta leaf spot (Ascochyta sp.), Stagonospora leaf spot (Stagonospora carpatica (?)), and Cercospora leaf spot (Cercospora medicaginis). In germination tests, dead, brown seeds commonly become overgrown with a species of Alternaria, but whether the fungus is parasitic or saprophytic is not clear.

Frost blisters occur on the under surface of alfalfa leaves after every frost. A root-knot disease caused by nematodes is common but probably not important. There appear to be no very important insect enemies of alfalfa in New York.

There were found four diseases the cause of which could not be determined, viz.: White spot, an unimportant disease of alfalfa leaves; yellow top, which causes the plants to stop growing and turn yellow; pitting of the tap-root, due to the gnawing of some unknown animal, and a blackening of the fibro-vascular bundles in the tap-root. There was found, also, a freak alfalfa plant having unifoliate leaves throughout.
INTRODUCTION.

PURPOSE AND SCOPE OF THIS BULLETIN.

The purpose of this bulletin is to give an account of the hindrances, both great and small, to the successful culture of alfalfa in New York; to state their relative importance, their nature and distinguishing characters and the best means of overcoming them. Special attention is given to dodder, fungus diseases and the impurities and adulteration of seed. Along several lines there is a regrettable lack of data. Some of the topics are treated only briefly because they do not properly belong in the province of the Botanical Department. In order to facilitate the labors of those who wish to pursue the subject further, an attempt has been made to make the list of alfalfa diseases complete. Following the discussion of the diseases of alfalfa in New York there is given a list of other alfalfa diseases not known to occur in the State.

ALFALFA AS A FARM CROP IN NEW YORK.

According to Dawley\(^1\) the successful culture of alfalfa in New York dates from 1867. On the Station farm it has been grown continuously and successfully since 1882. The Federal Census for 1900 gives the total acreage of alfalfa in the State as 5,582 acres which yielded 13,002 tons of hay. Over four-fifths of the entire acreage was then in three counties in the central portion of the State; viz.: Onondaga (3,767 a.), Madison (588 a.) and Oneida (212 a.). The remaining acreage was divided among 36 counties with from 1 to 87 acres each. At the present time, the acreage must be considerably larger and somewhat more uniformly distributed. During the past few years interest in alfalfa has been growing rapidly. With a better knowledge of the requirements of the plant it is now grown successfully in every agricultural county in the State.

\(^1\)Dawley (22). The number in parenthesis refers to the bibliography at the end of this bulletin.
However, there are many localities in which alfalfa culture is still in the experimental stage.

It is grown chiefly for hay, being cut two to four times each season according to weather conditions and fertility of the land. It is used to a considerable extent, also, as a soiling crop. Sometimes it is put into the silo either alone or mixed with corn. It is seldom pastured and no seed is produced. While fed more or less to all farm animals it is regarded as especially valuable for milch cows.

VARIETIES GROWN.

The botanical name of alfalfa is usually given as *Medicago sativa* L.² There are but a few named varieties. Very little is known as to the value of the different varieties of alfalfa for New York conditions. New York farmers, when buying alfalfa seed, seldom inquire about the variety or where the seed was grown. Much of the seed used is imported from Europe, Asia and South America and the remainder comes from various parts of the western United States. There is no home-grown seed available.

THE CHIEF DIFFICULTIES.

The greatest difficulty with alfalfa culture in New York is to get the crop established. Several factors may be concerned in this: Poor seed, poor fitting of the seed bed, sour soil, wet soil, sowing with a nurse crop, lack of nodule bacteria, lack of humus, weeds, leaf spot disease, close cutting and winter injury. If the first winter is passed safely the chances of ultimate success are excellent. Dodder (*Cuscuta* spp.) is often a serious pest, being sometimes so destructive as to necessitate plowing up the crop. Leaf spot (*Pseudopeziza medicago-ginis*) is a common disease causing enormous loss in the aggregate, although seldom ruining the crop completely. Heavy losses also result from the frequent rains in June which often prevent proper curing of the first cutting.

²For the botany of alfalfa see Brand (6, p. 18) and Scofield (92). According to the latter the correct name of alfalfa is *Medica sativa* (L.) Mill,
UNCONGENIAL SOIL CONDITIONS.

Some common causes of failure with alfalfa fall under this head. However, the discussion of them here will be brief for two reasons: First, because the writers have been unable to give much attention to this phase of the subject, and; second, because the Bacteriological Department of the Station has under way special investigations covering parts of the field.

POOR FITTING.

All writers on alfalfa agree that the land should be very thoroughly fitted. It should be disked, rolled and harrowed until it is in fine garden condition. In New York, as elsewhere, this important matter is frequently neglected.

ACID SOIL.

In other states and other countries it has been found that frequently a dressing of lime is an important aid in securing a stand of alfalfa. Some experiments made by the Cornell Experiment Station and the experience of farmers show that the same is true in New York. It is believed that the success of alfalfa in Onondaga County is due, in large part, to the large amount of lime in the soil there. What proportion of the soils of the State require liming before alfalfa may be grown upon them successfully is not known. The Bacteriological Department of the Station has in progress some experiments which are expected to throw light on this point, but the results are not yet available. It is the popular opinion that the soil on many of our farms is too acid for alfalfa.

WET SOIL.

An excess of water in the soil is another serious trouble of alfalfa. It should be understood that alfalfa will not thrive on wet land. Just what degree of wetness is prohibitive to al-

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3Miller (66); Williams and Kyle (109); Hopkins (47); Duggar (24).
talfa culture can not be stated. Coburn, of Kansas, says that alfalfa does not do well where water is nearer to the surface than six feet or where in winter water will stand on the ground for over forty-eight hours. In New York, a fair degree of success has been attained, frequently, with the water table considerably nearer the surface than six feet. Where water stands within three feet of the surface it is unwise to attempt to grow alfalfa. The usual symptoms of "wet feet" are stunted growth and yellowish or reddish discoloration of the foliage.

Although it was in New York that tile drains were first used, there are still large areas of agricultural land in the State needing underdrainage badly. It appears that the benefits of underdrainage are not yet fully realized by many of our farmers.

HEAVING.

Considerable damage is done by the so-called "heaving" of the plants which is quite as common with alfalfa as with red clover and due to the same cause, alternate freezing and thawing when the surface layer of the soil is filled with water. Newly seeded fields suffer most, but fields of any age may be affected. This trouble was unusually common and severe in New York in the spring of 1904. Prof. Stone says: "About the first of May [1904] the writer saw fields of alfalfa of the previous spring's seeding where three-fourths of the plants were thrown out upon the surface of the soil so completely that they could be gathered up by handfuls like so much straw."

The effects of heaving are best observed during the latter part of April. It is most severe in the wetter portions of the field. Sometimes nearly all the plants are killed out over large areas the boundaries of which are fairly well defined, but the trouble is more likely to take the form of thin spots of irregular shape and indefinite outline. In mild cases, when

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5Coburn (15, p. 44).
6A discussion of heaving is given by Sorauer (97, 1: 65).
7Stone (99, p. 6).
only a few affected plants are scattered here and there each spring, the trouble may pass unnoticed until in the course of a few years the alfalfa becomes "run out." The plants may be lifted completely out of the ground and left lying on the surface or they may remain standing with one to four inches of the tap-root exposed. If the plants are lifted as much as four inches death usually results; in less severe cases recovery is frequent although the plants never regain their normal position and their productivity is probably lessened.

Thorough drainage is the approved remedy for heaving. However, there are instances in which the drainage is apparently good yet the land heaves. Such a case is mentioned by Watson.  

HARDPAN.

Most writers on alfalfa regard the character of the subsoil as very important. Miller says that "the subsoil seems to be the controlling factor in the successful growing of alfalfa in Missouri." Where the subsoil is of the hard, impervious kind known as hardpan, alfalfa is not likely to succeed unless the land is very thoroughly underdrained and other conditions are favorable. Doubtless, some of the failures with alfalfa in New York are to be attributed to hardpan. Stone, after reviewing the experiences of the spring of 1904 when alfalfa in New York was found badly winterkilled says: "This indicates that while alfalfa may succeed on lands with somewhat impervious subsoils, yet on such subsoils the crop is much more liable to damage than upon those of a more porous nature."

There has come to our attention one quite remarkable case of success with alfalfa over hardpan. A farmer at East Bloomfield, N. Y., entered into an agreement with the Bacteriological Department of the Station to conduct a coöperative experiment on soil inoculation for alfalfa. The plat of land used contained one acre and was so situated on the brow of a hill that the surface drainage was excellent, but it was not

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8Watson (106).
9Miller (66, p. 13).
10Stone (99, p. 7).
underdrained. The soil was clay loam, underlaid with hard
pan at a depth of only five inches! The seed was sown June 12, 1905. The young plants prospered and passed the first winter safely. During 1906 three cuttings were made and a total yield of about six tons of cured hay obtained. The field was not seen by a Station representative during 1907, but the owner reports that it was again mown three times, the yield being about four tons of cured hay.

SOIL DEFICIENT IN HUMUS.

Many New York soils are greatly deficient in humus. This is a condition which militates against success in starting alfalfa. It may be remedied by plowing in clover or by the application of stable manure. Stable manure is exceedingly useful. As a rule, it should be plowed in the fall before seeding. If used as a top dressing immediately before sowing it must be thoroughly rotted to avoid the introduction of weeds which will surely make serious trouble.

SOIL DEFICIENT IN NODULE-FORMING BACTERIA.

It is a well known fact that alfalfa will not thrive unless the roots bear the so-called nodules.¹¹

These are caused by bacteria, *Pseudomonas radicicola* (Beyer.) Moore.¹¹ᵃ Some soils will not produce alfalfa because they are deficient in the nodule-forming bacteria. For several years it has been known that some of the alfalfa failures in New York are due to this cause and recent investigations by the Bacteriological Department of the Station enable us to make an estimate of the extent of such deficiency.¹² In 65 experimental fields a portion of each was artificially inoculated by spreading over it a small quantity of soil from an

¹¹The literature of this subject prior to 1903 has been collected by MacDougall (61) and Schneider (90), (91). See also Atkinson (2) and Jacobitz (49).

¹¹ᵃRecent investigations by de' Rossi (83a) indicate that the so-called bacteroids, and not *Pseudomonas radicicola*, are the cause of the nodules. Heretofore, the bacteroids have been regarded as an involution form of *Ps. radicicola*, but de' Rossi holds that they belong to a distinct species.

¹²Harding and Wilson (39).
old alfalfa field. Satisfactory crops of alfalfa were obtained on the inoculated portion of 46 of these fields; whereas, on the uninoculated portion only 13 gave satisfactory crops. In other words, artificial inoculation increased the percentage of successes from 20 to 70. Since the experiments were distributed over 33 counties it would appear that they represent fairly well the conditions prevailing over the State as a whole. If so, at least 50 per cent. and perhaps as much as 75 per cent. of our soils are deficient in nodule bacteria.

One of the above-mentioned experiments showing beneficial effects from artificial inoculation was conducted by R. C. Colyer, Hicksville, Long Island. The experimental field contained about two acres. It was about twice as long as wide and nearly level. After plowing in the spring of 1906 the field was limed all over, shell lime being used at the rate of 75 bu. per acre. It was then planted with early potatoes. After the potato crop was harvested, during the last week in July, the land was plowed and harrowed. Three weeks later an application of commercial fertilizer, 500 lbs. per acre, was made and the land harrowed a second time. During the last week in August, 1906, the seed was sown at the rate of 30 lbs. per acre and harrowed in lightly. In order to test the effect of inoculation a strip along the west side of the field (about one-half acre) was treated with 140 lbs. of soil from the Station alfalfa field. It was sown broadcast after the alfalfa was up. The alfalfa came up well and went into the winter in good condition with no apparent difference between the inoculated and uninoculated portions of the field.

In the spring of 1907 there was nothing unusual at first but by the latter part of May there was considerable difference in color between the inoculated and uninoculated portions. During the early part of June the contrast in color steadily increased and became very marked. Up to this point the observations here reported were made by Mr. Colyer. On June 11 the senior author examined the experiment and observed the following: The difference in color and size of the plants was so striking that the boundary of the inoculated strip could
be followed by the eye the whole length of the field. (See diagram on page 343.) On the inoculated strip there was a rank growth of dark green color. The plants were 17 to 24 inches high, most of them were robust and much branched, and they covered the ground completely. On the adjacent uninoculated portion of the field there was a light growth of golden yellow color. The plants were 12 to 17 inches high, slender, mostly unbranched and the ground among them was plainly visible. The yellow plants did not show any dead or spotted leaves—they were simply golden yellow throughout. However, this condition did not prevail over all of the uninoculated portion. On a strip about 50 ft. in width and extending from the south end about one-third of the distance across the field near the east side, the alfalfa was nearly as large and as good color as on the inoculated strip. A satisfactory explanation of this could not be found. This part of the field was a little lower than the rest. Scattered over the remainder of the uninoculated portion were occasional small clumps of thrifty, dark green plants which contrasted strongly with the yellow plants about them. Such clumps were especially numerous in a line extending from the low area above-mentioned to the north end of the field. This is shown in the diagram.

Upon making an examination of the roots it was learned that the dark green plants, wherever found, were well supplied with nodules which often occurred in conspicuous whitish clusters one-half inch or more in diameter; while the yellow plants, even when standing close beside green ones, appeared to be wholly devoid of nodules.

Mr. Colyer states that the first cutting was made July 1, when the alfalfa was commencing to bloom. On the inoculated strip (A) and the low area (C) there was a heavy yield of hay, but no weights were taken. The second cutting was made on August 9 and 13. On the latter date we made a second examination of the experiment. This time there was a fairly good crop of hay on the inoculated strip and the low area, while over the remainder of the field the plants were short and there were many bare spots. The contrast in color had now
Diagram of the Hicksville Alfalfa Soil Inoculation Experiment.

Dark shading indicates good growth, as shown by large, dark green plants.

A—Half-acre strip artificially inoculated with soil.

B—Uninoculated.

C—Low area where alfalfa grew well without artificial inoculation.

...entirely disappeared. The whole field was of the normal green color. However, it was evident that many of the yellow plants had died. The nodules, also, had mostly disappeared. A few live, plump nodules were found and some of the clusters were still in evidence, but most of them were shriveled and dead. A severe drought prevailed at this time and the ground was exceedingly dry. It should be stated, also, that over the whole field the plants were severely attacked by leaf spot (*Pseudopeziza medicaginis*) which caused a majority of the leaves to fall.

Mr. Colyer reports that the third cutting in 1907 was made October 1 and that in the spring of 1908 the inoculated portion made a splendid growth, the plants standing 12 inches high by May 12.

In several other experiments the beneficial effects of inoculation were quite as marked as in this one and manifested themselves in a similar manner.
As the best method of supplying nodule bacteria, the Station advises the use of soil from a successful alfalfa field. It should be sown broadcast at the rate of 150 to 200 lbs. per acre. This is the method now most used in the State. The principal objection to it is the danger of introducing troublesome weeds and plant diseases. However, if proper precautions are taken the risk is slight. In New York no case of serious trouble from this source has come to our attention. Nevertheless, because of such danger, Moore\(^{13}\) and others of the United States Department of Agriculture discourage the use of soil and recommend pure cultures instead. Concerning this disagreement in recommendations we can only say that we doubt that the pure-culture method is yet sufficiently perfected so that it can be safely relied upon to produce the desired results.\(^{14}\)

**WINTER INJURY.**

In New York, as elsewhere,\(^{15}\) it is not uncommon for alfalfa to winterkill. Yet, where other conditions are favorable as, for example, in Onondaga County, fields last for many years. Spillman\(^{16}\) cites a New York alfalfa field 45 years old. Coburn\(^{17}\) says, "there is a field in New York which has been mown successively for over sixty years."

More or less injury occurs every winter. The winter of 1903-1904 in New York was the coldest since temperature records of the State Weather Bureau began in 1888 and alfalfa winter-

\(^{13}\)Moore (67); Moore and Robinson (69); Woods (114), (115); Kellerman and Robinson (51), (52).

\(^{14}\)Some recent papers bearing on this point are the following: Harding and Prucha (38); Kellerman and Beckwith (50); Harding (37); Moore (68); Stone (100); Prucha and Harding (81). See also those cited in Footnote 13 and the following Experiment Station bulletins and reports: Cornell (N. Y.) Bul. 237; Ga. Bul. 71; Ky. Bul. 125; Mass. Rpt. 18:77; Me. Bul. 126; N. C. Rpt. 30; Ohio Bul. 181; Okla. Bul. 68; Ontario (Can.) Agr. Coll. Buls. 148 and 164; Pa. Bul. 78; Tex. Bul. 83; Va. Bul. 159; W. Va. Bul. 105; Wis. Rpts. 22:242 and 23:281. See, also, Circ. 16, Office of the Secretary, U. S. Dept. Agr., Mar. 1906.

\(^{15}\)Brand (6); Buffum (11); Moore and Stone (70); Wiancko (108); Watson (106); Wilson (111); Williams and Kyle (109).

\(^{16}\)Spillman, W. J. Quoted by Coburn (15, p. 9).

\(^{17}\)Coburn (15, p. 5).
killed to an unusual extent. The ground froze deeply, there was much freezing and thawing during March and probably what was most disastrous of all, a thaw in February was followed by a sudden, hard freeze which left the ground covered with a thick coat of ice. On the Station farm an alfalfa field which had produced good crops for several years was completely killed out.

Winterkilling is brought about in different ways—by freezing of the roots, by heaving, and by smothering of the plants under ice and standing water. It is prevented chiefly by providing good surface and underdrainage, and by avoiding late cutting in order that the alfalfa may go into the winter with several inches growth to hold the snow. Top-dressing with stable manure in December is also useful. Winterkilling is most likely to occur during the first winter after seeding especially if the soil conditions are in any way unfavorable. It is possible that a part of the winterkilling of newly-seeded fields in New York is due to the use of southern-grown seed. Although there appear to be very few data on which to base an opinion, it is claimed by some that Arizona-grown seed will not succeed here. Wing says, "Arizona seed if brought as far north as Buffalo will surely die out." Considerable Arizona seed has been used in the State. Alfalfa certainly varies much in hardiness. Brand states that Peruvian alfalfa is completely lacking in hardiness in all northern localities. Until comparative tests have been made in New York it can not be stated from what region it is best to secure seed for use here. Coburn, on theoretical grounds, advises Utah seed grown without irrigation.

FAILURE OF THE SEED CROP.

It is of little use to attempt to produce alfalfa seed in New York. A few years ago F. H. Stillwell, Manlius, N. Y., grew

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18Stone (99) gives the mean temperature at Ithaca for each of the three winter months (December, January and February) from 1888 to 1904. He also discusses the winter killing of alfalfa in New York in 1904.
19Wing (113).
20Brand (6).
21Coburn (15, pp. 28–29).
about eight bushels of alfalfa seed, four bushels of which came from a single acre. This is the only success known to us. On the Station grounds several unsuccessful attempts have been made to obtain seed from Turkestan alfalfa and the common sorts, sown broadcast and also in drills. However, plants missed by the mower on the margins of fields sometimes seed sparingly. Probably, climatic conditions are in some way responsible for the failure of alfalfa to seed in New York, but the exact manner in which the trouble is brought about is not clear.

VIABILITY OF THE SEED.

Concerning the viability of alfalfa seed in New York, definite statements can not be made. The writers have made few germination tests. However, judging from the appearance of samples sent in by farmers and seedsmen we are of the opinion that the alfalfa seed sold in New York is frequently rather low in viability.\(^{22}\) The Station can not undertake to make germination tests, but farmers should make such tests for themselves. With some experience one may determine, approximately, the viability of alfalfa seed by its color and plumpness, but it is generally advisable to make germination tests.\(^{23}\) Usually, plump, bright, greenish-yellow seed may be depended upon to germinate well. Brown seed should be avoided. Brownness is an indication of age. It is hastened by exposure to light. Shriveled, dark-brown seeds are usually dead. Plump brown seeds, on the contrary, may germinate fairly well, for plump seeds retain their viability for several years. Of 100 plump brown seeds selected by the writers from a sample of unknown age, 90 germinated. In tests made by Headden\(^{24}\) a sample of prime seed 12 years old showed a germination of 93.66 per ct. while another sample 16 years old gave 63 per ct.

In this connection it is interesting to note that while, according to Headden,\(^{25}\) 70,000 to 650,000 plants per acre constitute

\(^{22}\)The standard germination for alfalfa seed is 85 to 90 per ct. (U. S. Dept. Agr. Yearbook for 1896:624.)
\(^{23}\)On this point see Roberts and Freeman (83, p. 61).
\(^{24}\)Headden (41).
\(^{25}\)Headden (40, p. 40).
a good stand of alfalfa it is considered necessary to sow from 10 to 100 times that many seeds per acre. From 20 to 30 lbs. of seed per acre is the quantity recommended in New York, the majority of experts favoring the larger amount. The number of seeds contained in a pound of alfalfa is variously stated by different investigators. Probably, the figures given by Nobbe\(^2\) are as reliable as any. He tested 47 samples of commercial seed in Germany and found the average number of seeds per pound to be 225,014. Our own work on this subject consists of an examination of six samples of prime seed offered for sale at different places in New York. Preparation of the samples for counting consisted in shaking them well in the 20 x 20 mesh sieve recommended for removing dodder (see page 357) and afterward removing by hand such impurities as would not pass through the sieve. The results of the counts were as follows:

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>5 gms. pure seed contained</th>
<th>2272 seeds = 206115 per lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;</td>
<td>2 5</td>
<td>2281 = 206932 &quot; &quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>3 5</td>
<td>2316 = 210106 &quot; &quot;</td>
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<td>&quot;</td>
<td>4 10</td>
<td>4935 = 223851 &quot; &quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>5 10</td>
<td>4938 = 223987 &quot; &quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>6 10</td>
<td>5166 = 234329 &quot; &quot;</td>
</tr>
</tbody>
</table>

Average of six samples, 217,545 seeds per pound.

From these figures it will be seen that in 30 lbs. of prime alfalfa seed there are over 6,000,000 individual seeds. Either the seed sown is low in viability or else the mortality of the seedlings is extremely high.

**IMPURE AND ADULTERATED SEED.**

New York farmers experience considerable difficulty in obtaining pure alfalfa seed. It being next to impossible to produce alfalfa seed in New York, all of the seed used must be purchased from seed dealers. Frequently, the Station is asked to recommend some seedsmen who may be relied upon to furnish good seed. Such requests are refused because it is the established policy of the Station to avoid advertising anyone’s business. Farmers are advised to buy by sample and not to sow alfalfa seed until an expert has examined it for dodder and

\(^2\)Nobbe (73, p. 501).
other troublesome weeds and for evidence of adulteration. For residents of New York, the Station makes such examinations free of charge.

**Impurities.**

Between November 20, 1906, and August 15, 1908, the Station analyzed 548 samples of alfalfa seed sent in by farmers and seedsmen from various parts of the State. Since these samples were grown in many different parts of the world it is to be expected that they would contain many different kinds of weed seeds and such was found to be the case. Several of the weed seeds we were unable to identify. One of these unknowns, found in 37 samples, was sent to the Seed Laboratory of the United States Department of Agriculture for identification. Mr. Edgar Brown, Botanist in Charge, informs us that the seeds of a species of Centaurea, which is common in Asia Minor, and that they probably come to us only in the seed of Turkestan alfalfa. Thus it is sometimes possible to determine where seed was grown by the weed seeds it contains.

Usually, it is the character of the impurities rather than their quantity which makes them objectionable. The most objectionable impurity of all is dodder seed. So little as one dodder seed per pound renders alfalfa seed unsafe for use. Dodder often makes serious trouble in alfalfa fields and no chances should be taken with it. Of the 548 samples analyzed, 126, or 23 per cent., contained more or less dodder. In 122 of the infested samples the number of dodder seeds per pound was determined. The numbers, given in the order of their size, are as follows:

<p>| | | | | | | | | | | |</p>
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<tr>
<td>2</td>
<td>8</td>
<td>16</td>
<td>25</td>
<td>38</td>
<td>58</td>
<td>99</td>
<td>162</td>
<td>270</td>
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<tr>
<td>2</td>
<td>11</td>
<td>16</td>
<td>26</td>
<td>39</td>
<td>60</td>
<td>100</td>
<td>174</td>
<td>273</td>
<td>972</td>
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<td>3</td>
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<td>28</td>
<td>44</td>
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<td>102</td>
<td>182</td>
<td>309</td>
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<td>4</td>
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<td>46</td>
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<td>192</td>
<td>378</td>
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<td>14</td>
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<td>67</td>
<td>127</td>
<td>194</td>
<td>489</td>
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<td>6</td>
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<td>34</td>
<td>52</td>
<td>68</td>
<td>129</td>
<td>197</td>
<td>645</td>
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<td>7</td>
<td>15</td>
<td>22</td>
<td>35</td>
<td>53</td>
<td>73</td>
<td>138</td>
<td>198</td>
<td>672</td>
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<td>7</td>
<td>15</td>
<td>22</td>
<td>36</td>
<td>56</td>
<td>76</td>
<td>141</td>
<td>227</td>
<td>735</td>
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<tr>
<td>8</td>
<td>16</td>
<td>23</td>
<td>37</td>
<td>57</td>
<td>77</td>
<td>143</td>
<td>232</td>
<td>744</td>
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<td>8</td>
<td>16</td>
<td>23</td>
<td>37</td>
<td>57</td>
<td>82</td>
<td>156</td>
<td>234</td>
<td>870</td>
<td></td>
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</tr>
</tbody>
</table>
Several different species of dodder infest alfalfa, but how many of them are represented in the above-mentioned samples is not known. The identification of the different species by their seed characters being somewhat difficult, the writers have not attempted it. It appears that for all practical purposes it makes little difference to what species the dodder belongs except that the seed of some species, being larger than that of others, is more difficult to remove by sifting. (See page 359.) Accordingly, the writers place them all in two classes, small-seeded dodders and large-seeded dodders.27. (See Plate II, figs. 3 and 4.) In the samples analyzed, the small-seeded kinds of dodder greatly predominated.

Most of the dodder-infested samples belonged to the poorer grades of seed, but some of them were decidedly high grade in all respects except that they contained dodder. Seed may be of good color, high purity and high-priced yet contain enough dodder to make it unfit for use. Even the so-called reclaned seed is not entirely reliable as regards freedom from dodder.

However, the use of dodder-infested seed does not necessarily result in a dodder-infested crop. Probably, the great majority of dodder seeds fail to make plants. In the spring of 1906 the writers sowed three twentieth-acre plats with dodder-infested alfalfa seed from three different sources. The exact number of dodder seeds applied to Plats I and II is not known, but the seed used was taken from lots analyzing, respectively, 105 and 360 dodder seeds per pound. Since one and one-half pounds of seed were sown on each plat, it is likely that Plat I received about 157 and Plat II 540 dodder seeds. In both cases the dodder was one of the small-seeded kinds, Cuscuta epitymum Murr. Plat III received seed containing (by actual

27Hillman (46) distinguishes five principal species of dodder occurring in alfalfa seed; viz., Cuscuta epitymum Murr. (clover dodder), C. planiflora Ten. (small-seeded alfalfa dodder), C. arvensis Beyrich (field dodder), C. indecora Choisy (large-seeded alfalfa dodder) and C. racemosa chileana Engelm. (Chilean dodder). The first two have small seeds, the last three, large ones. Hence, the term "small-seeded dodders" as used by the writers includes Hillman's first two species while the other three are classed as "large-seeded dodders."
count) 120 seeds of one of the large-seeded dodders. A fourth plat of the same size was sown, at the same time, with red clover seed containing 100 dodder seeds from the same source as those used on Plat III.

A good stand of alfalfa and clover was obtained on all four plats, but there was never any evidence of dodder. Each of the plats was carefully examined several times during 1906 and 1907 without the discovery of a single dodder plant. Concerning the viability of the dodder seed at time of sowing nothing is known except that a part, at least, of the seed used on Plat II must have been viable since some dodder from the same lot of seed germinated in March, 1907.

Narrow-leaved plantain (*Plantago lanceolata* L.) also called English plantain and buckhorn and generally regarded as a troublesome weed, was found to be a very common impurity. Thirty-six and one-half per ct. of the samples contained more or less of it. The actual amount was determined in only fifteen of the worst-infested samples in which the numbers of seeds per pound of alfalfa seed were as follows: 154, 224, 246, 332, 348, 453, 477, 513, 586, 605, 627, 756, 944, 1451 and 1457.

Yellow foxtail (*Setaria glauca* (L.) Beauv.) and green foxtail (*Setaria viridis* (L.) Beauv.) were found in a large percentage of the samples. Although these are troublesome weeds they are so universally distributed that their presence in alfalfa seed is not considered to be of any particular importance. Wild carrot (*Daucus carota* L.) also occurred in a considerable number of the samples, and Russian thistle (*Salsola kali* L. var *tenuifolia* G. F. W. Mey), was found in 78 of the 548 samples examined.

Besides a large number of unimportant weeds some kinds of which occurred in many samples, the following troublesome weeds were found occasionally: Curled dock (*Rumex crispus* L.), crab grass (*Digitaria sanguinalis* (L.) Scop.), Canada thistle (*Cirsium arvense* (L.) Scop.), chicory (*Cichorium intybus* L.), charlock (*Brassica arvensis* (L.) Ktze.), black mustard (*Brassica nigra* (L.) Koch.) and quack grass (*Agropyron repens* (L.) Beauv.).
The question naturally arises, how great is the risk incurred in sowing impure alfalfa seed and what are the most dangerous impurities? As stated above, the risk on dodder is certainly large. The damage done by this pest is discussed more fully on page 362. Narrow-leaved plantain and wild carrot are troublesome weeds, but the great majority of New York farms are already infested with them so that the sowing of a few additional seeds with alfalfa seed can do no great harm. However, there are some careful farmers who are making strenuous efforts to keep their farms free from these weeds. To such persons, even a small amount of narrow-leaved plantain or wild carrot in alfalfa seed would be objectionable. Canada thistle, curled dock, mustard and charlock are all very bad weeds and few persons would care to use any seed containing them. Fortunately, they do not occur in alfalfa seed very frequently; besides, it is probable that all of them find much difficulty in establishing themselves in alfalfa fields. Further discussion of this subject will be found on page 381.

The danger from weeds is often greatly overestimated. The Russian thistle is a conspicuous example. About fifteen years ago much ado was made over the Russian thistle and several of the experiment stations published sensational bulletins on the subject. Subsequent events have shown the weed to be quite unimportant.\textsuperscript{28} Certainly, New York farmers have nothing to fear from it. Although seeds of Russian thistle must have been sown with alfalfa seed many times the plant is almost unknown here. There have come to our attention only two instances in which Russian thistle has appeared in alfalfa fields in New York. Both of these occurred in 1908—one near Geneva and the other at Halls Corners. We have not seen it growing elsewhere in the State. However, Peck\textsuperscript{29} records its occurrence near Rochester and Prof. W. W. Rowlee of Cornell University informs us that it is quite abundant around the salt sheds and on the waste of the Solvay Process Co., at Syracuse.

\textsuperscript{28} Bessey (5).
\textsuperscript{29} Peck (75).
ADULTERATION.

Alfalfa seed is sometimes adulterated. Each year, during June, the Station receives almost every day one or more specimens of a clover-like plant with small yellow blossoms. Usually, the specimens are accompanied by a statement to the effect that plants of this kind constitute one-half or more of the herbage in fields sown the summer before with what was supposed to be alfalfa seed. The sender of the specimens is informed that the strange plant is yellow trefoil (Medicago lupulina L.) the seed of which closely resembles alfalfa seed and being much cheaper than alfalfa is used to adulterate it. (See Plate II, figs. 2 and 5.) He has sown adulterated seed.

Between 1901 and 1905 trouble of this kind became so common as to attract general attention. Farmers became more cautious in purchasing alfalfa seed and began sending samples to the Experiment Station for analysis. Then Congress helped out by directing the Secretary of Agriculture to obtain in the open market samples of alfalfa and certain other seeds and if any are found to be adulterated or misbranded to publish the results of the tests together with the names of the persons by whom the seeds were offered for sale. Moreover, in a few cases the matter was taken into the courts and farmers collected damages from seed dealers who had sold them adulterated seed.

It appears that these things have had a tendency to discourage the sale of adulterated alfalfa seed in New York. During the past two or three years the situation has improved considerably. Of the 548 samples of alfalfa seed analyzed by the Station between November 20, 1906, and August 15, 1908, only ten showed evidence of adulteration and none of these were heavily adulterated. One of the adulterated samples contained 9 per cent. of sweet clover (Melilotus alba Desr.) while in the

30 The nature and habits of yellow trefoil are described more fully on page 379.
31 Brown (9); Roberts and Freeman (83); Galloway (35), (36).
32 Two circulars dealing with alfalfa seed have been published under this act. See Galloway (35), (36).
other nine the adulterant was yellow trefoil which was used to the extent of 6 per ct. in two samples, about 7 per ct. in four samples, 8.4 per ct. in one, 9 per ct. in one, and 10 per ct. in the remaining one.

Besides yellow trefoil and sweet clover, two species of bur clover (*Medicago hispida* Gaertn. and *Medicago arabica* Huds.) are used to adulterate alfalfa seed. Adulterated samples frequently contain both yellow trefoil and bur clover. In New York, there have come to our attention only four cases of adulteration with bur clover. One of these was a quantity of alfalfa seed purchased by the Station in Geneva in 1904. It was heavily adulterated with yellow trefoil and also contained a considerable amount of the two species of bur clover. Some of the seed was sown and the resulting plants of bur clover identified as *Medicago hispida* and *M. arabica*. In 1908 a sample from Oswego contained nine per ct. of yellow trefoil and two per ct. of bur clover. A sample of alfalfa seed sent to the Station from Canandaigua in 1904 showed 30 per ct. yellow trefoil and 4 per ct. bur clover. Another sample from Canandaigua in 1905 contained 44.4 per ct. yellow trefoil and 3.9 per ct. bur clover. This last sample has a court history which it may be well to relate since it has a bearing on the responsibility of seed dealers for damages resulting from the use of adulterated seed.

In June, 1904, G. M. Depew of Canandaigua, N. Y., sowed a 15-acre field with alfalfa using 30 pounds of seed per acre. Two-thirds of the field was sown with seed purchased from the Peck Hardware Co., Canandaigua, N. Y., and the remaining five acres with seed from another seed dealer. In the fall of 1904 the stand of alfalfa appeared good, but in the latter part of May, 1905, a part of the plants supposed to be alfalfa produced yellow blossoms. Specimens were sent to the Experiment Station where they were identified as yellow trefoil, *Medicago lupulina*. In a letter accompanying the specimens Mr. Depew stated that the yellow-flowered plant constituted

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33Galloway (35), (36).
one-half the crop. We advised him to plow up the field and reseed it. This he did about the middle of July, 1905. He then sent to the Station a sample of the seed left over from sowing the last five acres. An analysis of this seed showed it to contain 44.4 per ct. yellow trefoil and 3.9 per ct. bur clover besides some minor impurities and dodder at the rate of 114 seeds per pound. Upon being threatened with a suit for damages the dealer who sold this seed settled. The Peck Hardware Co., however, refused to settle and was sued for damages as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of one year's crop of alfalfa on ten acres.</td>
<td>$700.00</td>
</tr>
<tr>
<td>Plowing and fitting ten acres for reseeding</td>
<td>$80.00</td>
</tr>
<tr>
<td>Alfalfa seed to sow ten acres.</td>
<td>$42.00</td>
</tr>
<tr>
<td><strong>Total.</strong></td>
<td><strong>$822.00</strong></td>
</tr>
</tbody>
</table>

The case was tried in the Ontario County Court at Canandaigua in June, 1906. As to whether the seed had been bought upon an express guaranty, the evidence was conflicting; but there was positive evidence that it had been represented to be "good alfalfa seed." In charging the jury the Judge stated that there is such a thing as an implied guaranty; also, if seed is sold as alfalfa seed there is an implied guaranty that it is alfalfa seed and in case it proves to be wholly or in large proportion some other kind of seed the seller may be held liable for damages. No mention was made of the so-called "non-warranty clause" and it appears not to have figured in the case. None of the seed bought from the Peck Hardware Co. was in evidence as all of it had been sown. Proof of the existence of yellow trefoil in the Peck seed rested chiefly upon the testimony of several witnesses that the portion of the field sown with the Peck seed showed yellow blossoms the same as the five acres which was sown with the other seed shown by analysis to contain 44.4 per ct. yellow trefoil. As to the percentage of trefoil plants in the field, the testimony of different witnesses varied greatly. One said it was only 9 per ct. while others placed it at 50 to 90 per ct. Several witnesses testified to
the frequent occurrence of trefoil along the highways in the vicinity of the Depew farm and the defense endeavored to show that the trefoil in the Depew field may have come from seed already in the soil or from wild plants in the vicinity. Two witnesses testified to instances in which alfalfa fields showing much trefoil in the second season after seeding were practically free from trefoil in the third season. The defense claimed that the plowing of the field was unwarranted by the circumstances. The presence of growing dodder in the field was proven and counsel for the plaintiff pointed out that this was an additional reason for plowing up the field.

The jury rendered a verdict for the plaintiff in the sum of $377.42 with costs. The case was then carried up to the Appellate Court where the plaintiff won again. Finally, it was taken to the Court of Appeals where it has not yet been passed upon at this writing (November 14, 1908).

**ANALYSES.**

For residents of New York, the Station makes purity tests of alfalfa and other seeds free of charge. Seed dealers should learn to recognize dodder and the other principal impurities and adulterants of alfalfa seed, but for farmers this is scarcely worth while. Most farmers will find it safer and more satisfactory to rely on tests made by experts at the Experiment Station or in the United States Department of Agriculture. An analysis made by an expert is the farmer's chief safeguard against impure and adulterated seed. Samples of alfalfa seed for analysis should contain at least two ounces and should be taken in such manner as to represent fairly the lot of seed to be tested. If the seed is in bags the sample should contain some seed from each bag and in all cases a portion of it should

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34This is unlikely since the land grew oats in 1902 and corn in 1903 and no manure was applied in 1904 the season in which the alfalfa was sown.

35Some bulletins especially useful for this purpose are the following: Hillman (44), (45), (46); Brown (9); Roberts and Freeman (83).

be taken from the bottoms of the bags. When alfalfa seed containing dodder seeds is shipped in bags in an upright position the dodder seeds, being smaller than the alfalfa seeds, tend to settle to the bottoms of the bags. Samples should bear the name and address of the sender. The postal rate on seeds is one cent an ounce.

Many of the samples received at the Station are entirely too small for a dependable analysis as regards dodder. The samples sent out by seedsmen are usually too small. A majority of the 548 samples reported upon in this bulletin contained less than one ounce. Had all the samples been of proper size it is likely that the number found to be infested with dodder would have been larger.

A sample from Moira, N. Y., containing only 2 grams was free from dodder. Upon being informed that the sample was too small, the sender forwarded another 20-gram sample of the same seed. This contained 22 dodder seeds which is at the rate of 499 per pound.

A Canandaigua farmer brought to the Station a good-sized sample taken from the top of a bag of seed. It was entirely free from dodder. A few days later he brought another sample from the same bag but obtained by thrusting his hand deeply into the bag. This sample contained dodder at the rate of 20 seeds per pound.

A farmer at Delhi, N. Y., sent a sample (5.3 grams) which was found to be free from dodder. Upon receipt of the Station report on the sample he purchased and sowed some of the lot of seed from which, supposedly, the sample had been taken. However, the seed dealer was in doubt as to which bag the sample had been taken from and a mistake may have been made. Anyway, the crop was practically ruined by dodder during the first season.

These examples show the importance of using proper samples for analysis; also, that absolute confidence should not be placed in an analysis. As an additional precaution against dodder the writers advise the sifting of alfalfa seed as described under the next heading.
SIFTING SEED TO REMOVE DODDER.

Trouble with dodder in alfalfa fields is usually due to the use of dodder-infested alfalfa seed. Since much of the alfalfa seed on the market in New York is more or less infested with dodder it is often difficult to obtain dodder-free seed. The statements of seed dealers should not be relied upon. Most of the alfalfa seed in this State is handled by hardware merchants and small seed dealers who, themselves, do not know dodder seed. As dodger seeds are much smaller than those of alfalfa they may be easily overlooked. Good-looking seed, otherwise clean, may be badly infested with dodder. Even so small an amount as one dodder seed per pound makes alfalfa seed dangerous to sow until properly cleaned. Farmers are advised to protect themselves against dodder by sowing no alfalfa seed until it has been pronounced dodder-free by a seed expert or else sifted as directed below. The safest method is to have the seed both analyzed and sifted.

The idea that alfalfa seed may be freed from dodder is not a new one. But prior to the appearance (in January, 1907) of Circular No. 8 of this Station the information on the subject available to New York farmers was too meager and indefinite to be of any practical value. It is not sufficient to state merely (as has sometimes been done) that a 20-mesh sieve should be used. It is necessary to know, also, the size of the wire, where sieves of the proper kind can be obtained and how they are to be used. To the uninitiated it may seem that the size of the wire is unimportant, but, in practice, it makes all the difference between success and failure. With a given mesh, the larger the wire the smaller will be the openings. It is desirable that the openings shall be as large as possible without permitting the passage of an unduly large amount of alfalfa. After several experiments on sifting dodder-infested seed with sieves of various kinds the writers reached the con-

37Stewart and French (98).
38Hillman (43, p. 8; 45, p. 10); Selby and Hicks (93). More explicit directions are given by Hillman (46, p. 20).
clusion that the proper sieve for the purpose is one made of 20 x 20 mesh steel- or iron-wire cloth, the wire being No. 34 on the Washburn & Moen gauge. (If a brass- or copper-wire sieve is used it should be 20 x 20 mesh No. 33 wire on the Old English gauge.) Unfortunately, ready-made sieves of this kind are not readily obtainable. Also, it is difficult to get them made, because few hardware dealers carry in stock the proper kind of wire cloth. Accordingly, the Station had a quantity of the 20 x 20 mesh No. 34 steel-wire cloth made to order and placed it in the hands of Dorchester & Rose, Geneva, N. Y., who offered it for sale during 1907. The original lot has been all sold, now, but Dorchester & Rose have had some more made on their own account and expect, hereafter, to keep it for sale at twenty cents per square foot, postpaid.

A foot-square piece of this wire cloth tacked over a light wooden frame twelve inches square by three inches deep makes a cheap, serviceable sieve for sifting alfalfa seed (see plate I).

With such a sieve a man should be able to clean from three to seven bushels of seed per day. One-fourth to one-half pound of seed should be put into the sieve at a time and vigorously shaken during one-half minute. In order that the work may be uniformly thorough the operator should use a cup holding not over one-half pound thereby making it impossible to get too large a quantity at one time. A watch should be kept constantly in sight and no more than two batches of seed should be sifted in one minute. If the seed is known to contain but little dodder, one sifting will do; but when there is much dodder and particularly if the dodder is one of the large-seeded

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39No. 34 brass wire is not of the same size as No. 34 steel wire In 1900 the Wire Cloth Manufacturers' Association adopted the Washburn and Moen gauge for all steel and iron-wire cloth and the Old English gauge for all brass and copper-wire cloth. On the Washburn and Moen gauge No. 34 wire has a diameter of .0104 inches. Hence, in 20x20 mesh No. 34 steel-wire cloth the actual size of the openings is .0396 in. each way. On the Old English gauge No. 34 wire has a diameter of .0095 in. which makes the size of the openings in 20x20 mesh No. 34 brass-wire cloth .0405 in. each way. This is too large. No. 33 brass wire, which has a diameter of .01025 in. and gives openings .03975 in. wide, more nearly meets the standard requirements.
kinds, two siftings, both made strictly in accordance with the above directions, are recommended.

Our experiments and observations indicate that by the above method most alfalfa seed on the market in this State may be made practically free from dodder and safe to sow. Of course it is advisable to begin with seed as nearly free from dodder as can be conveniently obtained. If a sample of the seed has been examined at the Experiment Station the owner has been informed as to whether the dodder in it is of the small-seeded or large-seeded kind and he should manage the sifting accordingly. Occasionally, samples are found in which some of the dodder seeds are so large that they will not pass through the sieve. Fourteen cases of this kind were found among the 126 dodder-infested samples examined at the Station. Such seed should not be used.

Since the farmer has no means of determining whether he is removing all of the dodder it is absolutely necessary for him to follow directions closely. Care should be taken to secure the right kind of sieve. In purchasing sieves or wire cloth for making sieves it should be seen to that they are actually 20 x 20 mesh. This may be determined by placing a rule on the sieve and counting the number of meshes to the inch. Also, the wire must not be coarse. The Station will furnish small samples of the proper kind of wire cloth free upon request.

The quantity of siftings varies from one to five pounds per bushel according to the original cleanliness of the seed and the thoroughness of sifting. Besides dodder, various other small weed seeds, broken seeds and dirt, as well as some of the smaller alfalfa seeds, also pass through the sieve. Probably, most of the alfalfa seeds which pass through the sieve are somewhat inferior in quality. Small, shriveled seeds are not likely to make as strong plants as are large plump seeds. However, it appears that the difference is not as great as might be supposed. Once, the writers put this to the test. Two lots of seed were thoroughly sifted according to the directions given above. Then the cleaned seed and screenings (with dodder removed) were sown side by side under parallel conditions.
The experiment was continued only two years, but during this time there was no observable difference between the plats sown with cleaned seed and those sown with screenings. Still, it is believed that little if any real loss is sustained through the rejection of the screenings. If the seed contained dodder the quantity of this pest in the screenings will probably be so great as to ruin the crop. Even when the seed has been analyzed and reported free from dodder it is generally advisable to sift it as an additional precaution. In such cases the screenings might be sown by themselves in one corner of the field so that should dodder appear it could be stamped out with a minimum amount of loss.

In experimenting with some samples of alfalfa seed infested with narrow-leaved plantain (*Plantago lanceolata*) it was observed that the sifting for dodder reduced considerably the percentage of plantain.\(^{39a}\) The results of three experiments with three different lots of seed are shown in the following table:

**Table I.—Showing Results of Sifting Alfalfa Seed to Remove Seed of Narrow-Leaved Plantain (*Plantago lanceolata*).**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>No. of <em>P. lanceolata</em> seeds per lb. before sifting</th>
<th>1st Sifting</th>
<th>2nd Sifting</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. seeds per lb. removed</td>
<td>Percentage removed</td>
<td>No. seeds per lb. removed</td>
</tr>
<tr>
<td>I.</td>
<td>416</td>
<td>128</td>
<td>30.76</td>
<td>16</td>
</tr>
<tr>
<td>II.</td>
<td>544</td>
<td>160</td>
<td>29.4</td>
<td>32</td>
</tr>
<tr>
<td>III.</td>
<td>543</td>
<td>154</td>
<td>28.36</td>
<td>85</td>
</tr>
</tbody>
</table>

It is to be hoped, that in the future, seed dealers will take more care to remove dodder from their alfalfa seed. Farmers should aid the movement for better seeds by refusing their patronage to firms offering adulterated and dodder-infested seed for sale. Some seed dealers advertise alfalfa seed sifted according to the method recommended by the Experiment Station. This is well, but we would caution farmers against placing implicit confidence in such seed. Samples should be

\(^{39a}\) For removal of plantain seed from alfalfa seed, see Shaw (Bur. Plant. Indus. Circ. No. 2).
PLATE I.—TOOLS REQUIRED FOR SIFTING ALFALFA SEED TO REMOVE DODDER SEED.
1, Home-made sieve 12 in. square by 3 in. deep; 2, 20 x 20 mesh wire-cloth made of No. 34 steel wire.

(Natural size.)
PLATE II.—DODDER, ALFALFA AND YELLOW TREFOI.

1, Alfalfa infested with dodder (Cuscuta epithymum) which is in bloom; 2, alfalfa seeds; 3, seeds of large-seeded dodder; 4, seeds of small-seeded dodder; 5, yellow trefoil seeds.

(All natural size.)
submitted to the Station for analysis just the same as in other cases. The sifting may not have been done properly. In the spring of 1907 a Geneva farmer brought to the Station 90 lbs. of alfalfa seed which he had purchased with the understanding that it had been thoroughly sifted as directed by the Station. Resifting this seed brought to light 660 seeds of one of the small-seeded kinds of dodder.

DODDER.

BRIEF GENERAL STATEMENT.

Dodder is a yellowish, thread-like, twining plant which is very troublesome in alfalfa fields. It usually appears in circular spots three to thirty or more feet in diameter. At the center of the spot the alfalfa is mostly killed out while around the margin the ground is covered with a tangled mat of yellow threads which twine closely about the stems of the alfalfa plants and slowly strangle them. The spots increase in size from year to year. Many alfalfa fields have been completely ruined by dodder, sometimes during the first season after sowing, but more commonly in the second or third season. In New York, it is not often injurious to other crops (except red clover), but once established in an alfalfa field it is very difficult to eradicate without killing the alfalfa.

Dodder produces clusters of small white flowers, also seeds (see Plate II), but is leafless and has no connection with the soil except during the seedling stage. It is a parasite, deriving all its nourishment from the host plant about which it twines. The dodder infesting alfalfa in New York is probably of two or more kinds closely similar in appearance and producing similar effects. The kind of dodder most abundant in New York (Cuscuta epithymum) does not commonly seed here. It is carried over from one season to the next by means of the yellow threads which live over winter around the crowns of the plants (see page 369). Since trouble with dodder generally originates in the use of dodder-infested alfalfa seed it may be easily prevented by sowing only pure seed (see page 355). Fre-
quent mowing will not kill dodder. It can not be combated successfully with sprays. Close pasturing is not practical. Heavy mulching with coarse manure and the application of strong chemicals such as arsenite of soda, crude carbolic acid and common salt are methods having some merit. Digging over the spots is effective, but expensive and not practicable in stony soil. In most cases the most satisfactory method is to burn over the infested spots using kerosene and dry hay to insure a hot fire which will kill the alfalfa as well as the dodder. This applies where the spots are not very numerous. Badly infested fields should be plowed up. In New York plowing generally eradicatecs dodder promptly so that, usually, infested fields may be reseeded at once with safety.

IMPORTANCE.

In New York, dodder is a really serious alfalfa pest, but it is outranked in importance by weeds and by leaf spot (*Pseudopeziza medicaginis*). Also, certain uncongenial soil conditions such as acidity, wetness and deficiency in nodule-forming bacteria, are more important. The notoriety attained by dodder is largely due to the plant's strange appearance which attracts attention to it. It is true, however, that many farmers have had more or less trouble with dodder. Some fields have been ruined by it the first season, but in the majority of cases the greater part of the damage is done during the second and third seasons after sowing. Sometimes it is quite destructive in the second season where it was not observed at all during the first season. It is most conspicuous in the second and third cuttings.

Although dodder-infested hay is not refused by cattle it appears that they do not entirely relish it. There is no evidence that dodder is in any way injurious to cattle or other animals.

APPEARANCE OF INFESTED FIELDS.

The alfalfa is killed out in spots which vary much in size and shape. Spots resulting from a single infection are gen-
erally circular and rarely attain a diameter of more than 5 or 6 feet during the first season. Usually, they increase in size from year to year, ultimately reaching a diameter of 30 feet or more. In some spots the dodder dies out and may be said to have become extinct. By the coalescence of two or more spots large bare areas of irregular shape are formed. On the interior of the spots there remain a few scattered alfalfa plants which, somehow, escaped destruction by the dodder, but the ground is occupied chiefly by weeds.

Dodder-infested spots are especially conspicuous during the first week in May, owing to the fact that the alfalfa starts into growth sooner than the weeds on the interior of the spots. The dodder, however, is but little in evidence at this time. Its presence is revealed only by careful search. Later (from about June 10 on) it becomes conspicuous as a tangled mass of yellow threads which twine closely about the alfalfa plants around the margin of the spot. Not infrequently the dodder mats are so dense that they impede the progress of the mowing machine. Little or no dodder is found in the interior of the spots,—only around the margins.

**SPECIES AND HOST PLANTS.**

According to Engler and Prantl\(^4\) there are 90 species of Cuscuta, the genus to which the dodders belong. All are parasites, but only a few of them are injurious to alfalfa. Just how many species of Cuscuta may attack alfalfa it is difficult to say. Hillman\(^4\) gives five species the seeds of which occur in alfalfa seed; viz., *Cuscuta epithymum* Murr., *C. planiflora* Ten., *C. arvensis* Beyrich, *C. indecora* Choisy and *C. racemosa chileana* Engelm. Doubtless, seeds of all these species have been sown with alfalfa seed in New York and plants of all of them may exist here. Our field observations have not been sufficiently numerous to enable us to make a positive statement on this point. The problem is somewhat difficult owing to the fact that, in this State dodder in alfalfa

\(^{40}\)Engler u. Prantl (28).

\(^{41}\)Hillman (46).
fields flowers sparingly, and without either the flowers or seeds it is impossible to determine the species with accuracy. All of the flowering specimens examined by us have proven to be *Cuscuta epithymum* Murr. It is likely that this species is by far the most common one in New York alfalfa fields. It is also of frequent occurrence in clover fields here.

The color of dodder threads varies from yellow to red. On certain alfalfa plants or on certain spots all of the dodder threads may be yellow while on other plants or other spots they are all decidedly reddish. These differences in color are so marked, sometimes, as to suggest the idea that yellow-threaded dodder and red-threaded dodder may be two different species, but the writers have been unable to convince themselves that such is the case. Specimens with only yellow threads and others with only reddish threads have all shown themselves to be *Cuscuta epithymum* when they have produced flowers.

The dodders which attack alfalfa are capable of thriving, for a time at least, on some other plants; but New York farmers need have no fear of serious trouble with dodder in any crops excepting alfalfa and clover. It is a common thing for alfalfa dodder to twine around such weeds as occur on the infested spots, particularly ox-eye daisy (*Chrysanthemum leucanthemum* L.), dandelion (*Taraxacum officinale* Weber), and fleabane (*Erigeron annuus* (L.) Pers.). By means of its haustoria the dodder fastens onto these weeds quite as firmly as on alfalfa. On dandelion and fleabane it frequently lives over winter. Yet it appears to do the weeds no serious harm and infests them only when they are mixed with alfalfa or clover.

**DODDER SEEDLINGS.**

The following statements about seedlings are based upon observations made by the writers on seedlings of *Cuscuta epithymum* grown in the Station greenhouse.

Alfalfa seeds and dodder seeds sown together in boxes of earth germinate at about the same time. Apparently, condi-
tions favorable to the germination and growth of alfalfa are also favorable to dodder. The dodder seedlings are slender, unbranched threads, yellowish toward the tip and lighter colored below. (See Plate III.) At first they stand upright, attaining a height of about an inch. Frequently, the tip is bent over to one side. If the dodder seedling comes in contact with an alfalfa seedling it twines around it and fastens onto it by means of haustoria. Then the lower portion of the seedling withers and connection with the soil is severed. (See Plate III, fig. 2.) Unless the seedling comes in contact with some congenial host plant it lives only a few days. It soon becomes decumbent then commences to wither in the lower portion. Almost invariably seedlings become brown and shriveled at the surface of the soil while their tips are yet turgid and of normal yellow color. Dodder seedlings have no roots. Ten seedlings which had reached the limit of their growth and commenced to wither gave the following measurements respectively: 16, 17, 20, 20, 20, 20.5, 20.5, 22.5, 25 and 25 millimeters. On another occasion a seedling was found which measured 31 mm. in length. The writers have observed nothing indicating that dodder seedlings are attracted by alfalfa. It seems that contact is brought about purely by accident. In the field, the beating of the rain is probably one of the most important factors in bringing the dodder seedlings into contact with the host plant. As soon as the dodder has established itself on the alfalfa plant and begins to draw nourishment from it, the dodder threads become much larger in diameter and increase in length rapidly. The plant attacked soon stops growing and then gradually dies.

PROPAGATION AND DISSEMINATION.

Where alfalfa seed is grown, dodder produces seeds which, in threshing, become mingled with the alfalfa seed. Through the use of such alfalfa seed dodder is disseminated far and wide. It is in this way, mainly, that New York alfalfa fields become infested with dodder. Impure seed is at the bottom
of nearly all of the trouble. The original dodder spots increase in size from year to year and new spots appear occasionally, but dodder does not spread rapidly like most weeds. It may exist for years in one corner of a field without showing in other parts of it and it rarely spreads to neighboring fields.

One reason why dodder does not spread more rapidly is that it does not commonly produce seed here. In many infested fields no flowers can be found at any time during the season. In others, flowers may be abundant on certain spots and absent from others. Besides, many of the flowers fail to produce seeds. Why this is so we do not know. It cannot be attributed to the frequent mowing of the alfalfa, because *Cuscuta epithymum*, at least, may produce flowers and seeds low down on the plants below the reach of the mower. On two alfalfa plants in the Station greenhouse *Cuscuta epithymum* was permitted to have its own way for over three months. It thrived, producing threads three feet in length (see Plate V, fig. 1), and finally killed the plants, yet it produced no flowers.

When dodder produces seed it seems as if it must be spread by the operations of mowing, tedding and raking; also, in manure made from animals fed on the hay. This would be most likely to happen in the third cutting. Hay from the first cutting is not likely to contain dodder seed because it is made about three weeks before the dodder commences to bloom. Usually, the first flowers of *Cuscuta epithymum* appear about July 15. The second cutting, made about August 1, may contain some dodder seed.

While it seems reasonable to suppose that dodder may be introduced into an established alfalfa field by top dressing it with manure containing dodder seed no instance of the kind has come under our observation. In considering this problem it occurred to the writers that delicate dodder seedlings may find difficulty in establishing themselves upon old alfalfa plants. Hence, the following experiment was made: Early in the spring of 1906 two spots in a two-year-old alfalfa field were carefully marked so that they might be readily located at any time. On each spot over an area about two feet in
diameter 100 dodder seeds were sown on each of three different occasions: First, on April 18 just as the alfalfa plants were commencing growth; second, on May 5 after a heavy shower; third, on July 9 when the second crop of alfalfa was about a foot high. The seed used in the first sowing was a mixed lot taken from several different samples of alfalfa seed and consisted partly of C. epithymum and partly of C. arvensis (?); that used in the second sowing was all from one lot of alfalfa seed (different from those previously used) and all C. epithymum; while that used in the third sowing was taken from ten different lots of alfalfa seed and contained both C. epithymum and C. arvensis (?). Throughout the forepart of the season there was an abundance of rain and so far as could be determined there were no unusual conditions which might interfere with the growth of dodder. Yet no dodder appeared on either of the spots although they were kept under observation for two years. Nothing is known as to the viability of the dodder seed used, but it is scarcely possible that all of the seeds were incapable of germination.

Mr. F. E. Dawley, Fayetteville, N. Y., informs us that in a similar experiment made by him strikingly different results were obtained. Mr. Dawley sowed 27 dodder seeds in an old alfalfa field where there had been no dodder previously and 27 spots of dodder resulted.

It is probable that under favorable conditions dodder may be spread by the mower even when no seeds are formed. Sometimes during a spell of rainy weather the newly-mown hay keeps fresh for several days and the dodder on it not only remains alive but continues its growth and is capable of attaching itself to living alfalfa stems with which it may come in contact. Owing to their tangled condition bunches of dodder-infested hay are often dropped short distances by the mower. Should it happen that such bunches are dropped upon plants which, in some manner, have been missed by the mower, the dodder finds its opportunity. It is also possible that the dodder may be kept alive until new growth starts. In a wet time alfalfa starts up very quickly after mowing.
That it is possible for dodder-infested hay to bring about infection in the open field is shown by the following experiment: On July 10, 1906, two handfuls of dodder-infested hay each containing about a dozen stalks were placed among alfalfa plants 12 to 14 inches high. The dodder had not commenced to bloom and there were certainly no seeds. The plants and ground were wet at the beginning of the experiment, but subsequent weather conditions were not recorded. The first observations on the experiment were made July 26, three days after the field had been mown. Although the hay had been removed the stubble showed, unmistakably, that infection had occurred in both spots. In one of the spots three plants were so much affected that the dodder was visible at a distance of 20 feet. In the other spot, dodder was firmly established on two plants. Subsequently, two other experiments of this kind were made. In one of these the dodder-infested hay was placed on the bare stubble of a newly-mown field; in the other, among a new growth of alfalfa two to four inches high. The weather being dry the dodder failed to establish itself in both cases.

The ability of dodder to continue growth as long as the alfalfa remains fresh is easily demonstrated by cutting off infested alfalfa stems and placing them in a moist chamber. In an experiment of this kind made by the writers dodder retained its color and turgidity on cut stems six days during which time the length of the threads increased about one inch. The writers have frequently infected alfalfa plants by placing dodder-infested alfalfa crowns and stems in contact with them in a moist chamber.

Dodder may be propagated also by cuttings; that is, short pieces of the dodder threads placed in contact with alfalfa plants will attach themselves after the manner of seedlings. This was demonstrated in 1880 by Koch and more recently by Peirce and others; also, by the writers who made the following experiment: Five tip-end pieces of dodder threads,

\(^{42}\)Koch (55).
\(^{43}\)Peirce (77).
PLATE III.—Seedlings of Dodder and Alfalfa.
1, left, dodder seedling; right, alfalfa seedling; 2, same seedlings, three days later; dodder attached to alfalfa, lower portion withering; 3, left, three dodder seedlings; right, dodder seedlings attaching themselves to alfalfa seedlings; 4, dodder attacking alfalfa seedling.

(All natural size.)
Plate IV.—Under Surface of Crown of Yellow Trefoil (Medicago lupulina) Infested with Dodder Which Has Survived the Winter in Thread Form.

(Cut and photographed Apr. 16, 1906. Natural size.)
four inches in length, were placed among the branches of a ten-inch high alfalfa plant in a moist chamber. In 17 days the plant was thoroughly infested with dodder several threads of which were a foot long.

Although the spread of dodder is not rapid it is by no means confined to the enlargement of the original spots. New spots are formed from time to time. Usually, the new spots appear in the near vicinity of the old ones. In a dodder-infested alfalfa field near Syracuse, examined by the writers in the spring of 1906, some of the large spots were surrounded by smaller ones which were plainly the result of secondary infection. One large spot about 15 feet in diameter was surrounded by 11 small spots two to three feet in diameter. The most distant of these was 20 feet away while four were so near that they almost touched the margin of the parent spot. Whether the small spots originated from seed or from infested hay carried by the mower could not be determined.

The method by which dodder survives the winter is so important a matter that it will be discussed under a separate heading.

PERPETUATION OF DODDER FROM ONE YEAR TO THE NEXT.

In almost all botanical writings the numerous species of Cuscuta are all classed as annuals. It seems to be the prevailing opinion that none of the dodders survive the winter in the thread form and that, in order to perpetuate themselves, they must start anew every year from seeds. Yet, so long ago as 1868, Dr. Julius Kühn⁴⁴ made the announcement, based on his own observations, that clover dodder, Cuscuta trifolii (=C. epithyum) lives over winter on clover and alfalfa plants in Germany. Also, Sorauer,⁴⁵ in the second edition of his well-known Handbuch der Pflanzenkrankheiten published in 1886, states that clover dodder is not annual but perennial and that on perennial plants it perpetuates itself more often by the further growth of the previous year’s dodder plants than by

⁴⁴Kühn (57).
the germination of new seeds. On the other hand, Frank,\textsuperscript{46} ten years later, makes an equally positive statement that the dodders are all annual plants which start anew every year from their seeds. Kerner and Oliver\textsuperscript{47} (in 1895) say that the European species of Cuscuta are all annuals, but in the tropics there are perennial species. In 1900 Kühn\textsuperscript{48} published another article on dodder in which he characterizes the supposed annual habit of clover dodder as one of those errors which, even in the realm of science, are sometimes held to with remarkable tenacity. After citing his observations made in 1868 he states that he has since confirmed them in various years, even in those having the hardest winters.

With the exception of a note\textsuperscript{48a} by the senior author, we know of no published record of any dodder living over winter in the United States. Hillman,\textsuperscript{49} in a recent bulletin which may be accepted as presenting the most advanced ideas on dodder in its relation to clover and alfalfa in this country says: "It is an unsettled question whether dodder plants in the field ever live over winter. It appears that very few, if any, survive."

Such being the present status of the knowledge of this subject it is noteworthy that, in New York, \textit{Cuscuta epithymum}, at least, is perennial, regularly living over winter on alfalfa, red clover and certain weeds. This statement is based on observations made in five alfalfa fields as follows:

\begin{quote}
Field No. 1.—This was a 4-acre field located near Geneva. It was sown in the spring of 1905 and became so badly infested with dodder during the first summer that it was deemed advisable to plow it up. The dodder was not seen to flower, but an examination of some of the left-over alfalfa seed showed the dodder in it to be \textit{Cuscuta epithymum}. The soil was sandy loam and the field sloped gently toward the east. The first examination was made April 16, 1906. Even at that time the circular bare areas marking the location of the dodder spots
\end{quote}

\textsuperscript{46}Frank (30, 2:523).  \textsuperscript{47}Kerner and Oliver (53, 1:175).
\textsuperscript{48}Kühn (58).
\textsuperscript{49}Hillman (46, p. 20).
of the previous year were easily found. Naturally, attention was first directed to the plants around the margins of the spots. The very first plant dug up showed live dodder! Further search revealed several more specimens of live dodder. In one case, a crown of yellow trefoil (Medicago lupulina L.) was covered on the under surface with a dense mat of live dodder threads. (See Plate IV.) For the most part, the hibernating dodder appeared in the form of tufts of short, stout, yellow threads, one-fourth to one-half inch long, attached to the bases of the branches close down to the ground around the crown of the plant and especially on the undersides of branches lying close to the ground. (See Plate V, figs. 2 and 3.) Yellow, haustoria-bearing threads tightly coiled around the very lowest parts of the stems were also common, but in no case has the dodder been observed on the root proper.

In a more thorough examination made April 21 live dodder was found to be plentiful in all parts of the field.

Field No. 2.—This field was located near Geneva. The soil was heavy clay. It was sown in the spring of 1904. There being only a few dodder spots the field has been allowed to stand. In the spring of 1906 live-dodder was found to occur only sparingly, the dates of observation being April 17 and May 4. It was found on alfalfa, yellow trefoil and red clover. In the spring of 1907 live dodder was more plentiful. An examination made January 4, during a thaw, showed the dodder alive and apparently in good condition. On some of the infested spots it could be plainly seen without stooping down. On March 18, two or three days after the snow had disappeared, live dodder was still abundant; also on March 28. Several other observations (dates unrecorded) were made during April and May of this year and an abundance of live dodder found every time. December 10, 1907, live dodder was found on dandelion leaves. Further observations made during

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*In searching for live dodder in early spring it is necessary to cut off the alfalfa plants below the surface of the soil so that the parts lying next the ground may be examined. To do this with a knife is slow, disagreeable work. The proper tool for the purpose is a short-handled, heavy hoe or light grub-hoe.*
the spring of 1908 showed that dodder had again wintered well. The dates of observation were February 15, March 25, and April 10. Live dodder was found each time. Some dodder-infested weeds transplanted from the field to the greenhouse on April 10 proved to be daisy fleabane (Erigeron annuus). The dodder in this field was Cuscuta epithymum as determined from flowering specimens.

Field No. 3.—This field, also near Geneva, was one year old. The soil was sandy loam and the exposure a northerly one. April 20, 1906, live dodder was found here in abundance on alfalfa, yellow trefoil and red clover.

Field No. 4.—This field was located near Syracuse on clay loam with a south exposure. It was two years old and contained numerous large dodder spots. On April 24, 1906, three specimens of live dodder were found. When another examination was made May 7 several additional specimens were found, but it was evident that most of the dodder in this field had winterkilled. Three of the most vigorous dodder specimens found here were on some weed. In order to learn the name of the weed one specimen was transplanted into the Station greenhouse. When it bloomed it was determined as Erigeron annuus (daisy fleabane). Subsequently, this determination was verified by Prof. W. W. Rowlee who states that his observations on this species lead him to believe that it is a biennial in this latitude.

Flowering specimens obtained from Field No. 4 showed the dodder to be Cuscuta epithymum.

Field No. 5.—This field was located at Bergen. It was sown in the spring of 1904. During 1905 two crops of hay were cut and then cattle were turned on to kill out the dodder, if possible, by close pasturing. Although the field was in an exposed situation and went into the winter close-cropped it was an easy matter to find live dodder in it the following spring (April 30, 1906). Flowering specimens of Cuscuta epithymum were taken from this field in August.

While in all of the above observations the appearance of the dodder was such that there seemed no reason to doubt that it
was really alive and capable of further growth it was thought best to place the matter beyond all doubt by forcing the hibernating threads into growth. This was accomplished several times by placing the dodder-infested crowns in a moist chamber for a few days. Given warmth and moisture the dodder threads began to lengthen promptly. In six such experiments the dodder-infested crowns were placed in contact with thrifty young alfalfa plants growing in pots in a moist inoculation chamber in the Station greenhouse. In every case the dodder grew out promptly, established itself on the new plants and there made a profuse growth.

Our observations cover only three springs; viz.: Those of 1906, 1907 and 1908. But Mr. F. E. Dawley of Fayetteville, N. Y., assures us that he observed live dodder early in the springs of 1903, 1904, 1905 and 1906 before there had been time for it to come from seed. For several years Mr. Dawley has been a close observer of alfalfa and dodder and knows whereof he speaks. Even before learning of our observations he expressed the opinion (in conversation) that dodder lives over winter.

Owing to their more spreading habit, the crowns of yellow trefoil and red clover form a better wintering place for dodder than do alfalfa crowns. Daisy fleabane, also, seems to be a favorite winter host for dodder.

Undoubtedly, dodder lives over winter in New York alfalfa fields on alfalfa, yellow trefoil, red clover, dandelion and daisy fleabane. This is not accidental or occasional, but of common occurrence. In the writers' opinion it is the chief method by which dodder is carried over from one year to the next in New York alfalfa fields. It is likely that the seed, also, is an important factor, sometimes, but, as has already been pointed out, dodder usually fails to produce seed in New York.

Although it may be found alive at any time during the spring, dodder does not commence to grow vigorously until the latter part of May. When dodder is in active growth free threads 12 to 16 inches in length may be found running along on the surface of the soil until they come in contact with al-
falfa or other stems about which they may twine. *Cuscuta epithymum* grown on potted alfalfa plants in the Station greenhouse has produced threads over three feet in length. (See Plate V, fig. 1.) The threads are freely branched, clusters of one to four branches (always of unequal length) appearing in the axils of the scales.

METHODS OF ERADICATION.

By giving careful attention to the purity of all alfalfa and clover seed used on the farm, trouble with dodder is avoided, almost entirely; but where such precautions are not taken the pest is liable to be introduced and cause so much damage that something must be done to get rid of it.

Badly infested fields should be plowed up. Oftentimes it is difficult to determine whether it is best to plow up the field or to kill out the dodder by some other method. In reaching a decision in such cases it should be taken into consideration: That the eradication of dodder is difficult; that the successful reseeding of infested spots is difficult; and that an alfalfa field when once established should last many years. When there are only a few dodder spots scattered through the field they may be given local treatment and the plowing up of the field avoided. A dodder-infested field which has been plowed up may be planted afterward with any of the common farm crops, excepting, perhaps, alfalfa and clover, without any danger of the reappearance of dodder. Dodder is readily subdued by plowing. How much danger there is in reseeding with alfalfa or with clover is uncertain. This subject is discussed more fully on a subsequent page. Much has been written about the eradication of dodder, particularly in Germany, and numerous methods have been recommended.51

(1) The application of various chemicals, some in the form of spray to kill the dodder without destroying the alfalfa, others to kill both the parasite and its host. In the former method, the substances most frequently used are copper sulphate and

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51 For the eradication of dodder see Sorauer (97, 2:47); Kühn (58); Kiessling (54); Hillman (46); Dawley (21).
iron sulphate; in the latter, sulphuric acid and common salt. (2) Smothering. Some advise covering the infested spots deeply with coarse manure to kill both dodder and alfalfa; others recommend light coverings of manure, finely cut straw, gypsum, etc., which are expected to smother the dodder while the alfalfa breaks through and continues its growth. (3) Close pasturing with sheep or cattle. (4) Close mowing. (5) Digging over the infested spots. (6) Burning over infested spots.

Several of the above methods have been tried in alfalfa fields in this State with varying degrees of success. As yet, New York farmers have had too little experience with dodder to have any established methods of treating it. Our observations and experiments convince us that under New York conditions, the only really practicable methods are those in which both the parasite and its host are killed. Attempts to preserve the life of infested plants invariably result in the escape of some of the dodder which necessitates repeating the treatment again and again. This is the trouble with spraying. It is impossible to reach all of the dodder with the spray. Recommendations for close pasturing and close mowing are based on the false assumption that dodder may be eradicated by preventing it from seeding. Close pasturing is not only ineffective, but it endangers the life of the alfalfa. The spread of dodder is certainly hindered by frequent mowing, but it can not be eradicated or even kept under control by mowing. Heavy mulching with coarse manure will kill out dodder, but the piles of manure are in the way of the mower and hay rake.

Digging over the infested spots is effective but laborious and, in stony soil, utterly impracticable. Alfalfa plants have large tap-roots which make them very difficult to dig up with a spade. It is necessary first to cut off the plants below the crown and to dig up the soil afterward. For cutting off the crowns a sharp spade may be used, but a light, broad-bitted grub-hoe is much better. Stones in the soil dull the tool quickly. The dodder-infested crowns must be removed from the field.
Burning over the infested spots is an excellent method if the work is done thoroughly enough to kill every infested plant. This is readily accomplished by using kerosene in combination with dry hay or straw as follows: First, mow the infested spots closely, including a strip of generous width all around the margin. When the hay has become thoroughly dry rake it into a pile in the center of the spot and sprinkle the stubble with kerosene by means of a common garden sprinkler. The application of kerosene should be especially thorough around the margin of the spot—it does not matter so much about the central portion. Next, spread the hay evenly over the whole area. On top of this spread additional dry hay or straw from another source. The quantity of hay and weeds growing on infested spots is rarely sufficient for a thorough job of burning even with the addition of a generous quantity of kerosene. Especially is this true when the work is done during the first week in May which is the proper time for it. When the hay is in position it should be fired simultaneously at three or four different points on the windward side. If possible, the burning should be done when there is little wind in order to insure more complete combustion and to avoid severe scorching of the surrounding alfalfa. The burning may be done with hay alone, but it is necessary to use a large quantity in order to insure thorough work. The kerosene draws the fire down to the ground close around the crowns of the plants where it is most needed.

Whichever method is employed (burning or digging) the best time to do the work for the first time is during the first week in May. The dodder spots are then more easily located and their boundaries more sharply defined than at any other time. The alfalfa will then stand four to eight inches high while the weeds on the interior of the spot have scarcely started. Moreover, at this time, the live dodder is closely confined to a few plants and there are no long threads so that the danger of leaving some of the dodder undestroyed is not as great as it is later in the season. Of course some unnecessary work may be done on spots already extinct since it is difficult
to distinguish active from extinct spots so early in the season; but this is probably offset by the increased size of the spots later in the season. Dodder spots escaping the first treatment should be destroyed whenever discovered. At each mowing a careful lookout should be kept for new spots. If any are discovered they should be marked so that they may be found again and destroyed after the hay is removed. To the inexperienced it may appear that the ideal time to treat dodder is just after haying. However, such is not the case. The infested spots are then very difficult to locate.

Both in burning out and in digging out dodder it is necessary to sacrifice a strip of alfalfa two to three feet wide all around the margin of the spot in order to make sure that none of the dodder escapes. If the spot is sharply outlined a strip two feet wide is likely to be sufficient; but where the margin of the spot is indefinite it is advisable to include a wider strip.

If it is desired to reseed the infested spots the digging out method is preferable to any other, provided the soil is not stony, since the spots must be dug up anyway before they can be reseeded. However, we doubt the advisability of reseeding. In experiments made by the writers the reseeding of infested spots has been only partially successful. The principal difficulty is with weeds. The soil of infested spots is sure to be full of weed seeds, particularly those of green and yellow foxtail grasses. Besides, if the dodder ripened seed there is danger that the alfalfa seedlings may become affected and thus foil the attempt at eradication.

RESEEDING INFESTED FIELDS.

When it becomes necessary to plow up dodder-infested alfalfa fields there frequently arises the question as to how soon the field may be safely reseeded with alfalfa. Before this question can be answered satisfactorily it must be known whether the dodder produced seed. If the dodder ripened seeds there may be danger of the appearance of dodder in the new seed-
ing. Exactly how long dodder seeds may retain their viability when buried in the soil is not known, but it is believed to be several years. Hence, if the dodder is known to have produced seed the land should be planted with other crops for one or two years, at least, before it is reseeded with alfalfa. On the other hand, if the dodder did not seed it is entirely safe to reseed with alfalfa at once. As a rule, dodder does not seed in New York so that the risk in reseeding infested fields is probably not great.

The writers have tested this in five different fields of one-fourth acre each. One of these fields, located at Fayetteville, was two years old when plowed up because of dodder. It was then planted with tomatoes for two seasons. In the spring of 1906 it was reseeded with alfalfa seed known to be free from dodder. No trace of dodder was found in the new seeding which was kept under observation for two years. Another field, near Geneva, ruined by dodder in 1905 during the first season after sowing, was plowed up in the spring of 1906 and reseeded in May with dodder-free seed. No dodder appeared up to the close of 1908. A one-year old dodder-infested field at Oakfield was plowed up in the spring of 1906 and at once reseeded. No dodder appeared during the time the field was under observation, viz., one year. A fourth field, located near Canandaigua, was ruined by dodder during the first season. In the spring of 1907 it was plowed up and reseeded and has remained free from dodder up to date (October, 1908). The fifth field was located at Caywood. It was first seeded in the spring of 1905. Dodder became very abundant the same season, but the field was allowed to stand until about June 20, 1906, when it was plowed up and planted to beans. The following spring it was reseeded with alfalfa. The writers did not see this field during the autumn of 1907, but the owner informs us that no dodder appeared in it. An interesting feature of this field is the appearance of one colony of dodder among the beans. Perhaps this came from seed, but there is another way in which it may have originated. Many alfalfa plants survived the plowing in 1906. They came up thickly
among the beans. It is quite possible that some of these plants harbored the dodder until after the beans were large enough to receive it.

YELLOW TREFOIL.

Owing to the occasional adulteration of alfalfa seed with the seed of yellow trefoil (see page 352) this plant has recently come into considerable prominence in New York. The name yellow trefoil properly belongs to the plant known to botanists as *Medicago lupulina* L., but sometimes it has been applied to other plants. Yellow trefoil so closely resembles alfalfa as to be easily mistaken for it. The most striking difference is in the color of the blossoms, yellow trefoil having yellow blossoms while those of alfalfa are bluish or purple. When adulterated seed has been used the fraud is not detected, usually, until the plants bloom, which is in June of the second season after sowing. Yellow trefoil blooms from a week to ten days earlier than alfalfa.

In botanical works *Medicago lupulina* is sometimes described as annual and sometimes as “annual or biennial.” Our observations convince us that in New York alfalfa fields it is regularly a biennial as announced elsewhere by one of the writers. June 4, 1906, the writers sowed a tenth-acre plat with alfalfa seed which was heavily adulterated with yellow trefoil and two kinds of bur clover (*Medicago hispida* and *M. arabica*). During September of the same year some of the trefoil plants blossomed and produced seed, but the great majority first began to bloom in the spring of 1907. Some blossoms appeared the last week in May and from June 1 on to the time of making the first cutting (June 28), the field was yellow with bloom. No trefoil appeared in the second or third cutting. Many farmers have had similar experience—the trefoil becomes conspicuous during the forepart of June in the second season after sowing and after the first cut-

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63 French (33).
ting disappears from the field almost completely. Even when infested fields are plowed up and reseeded the yellow trefoil does not reappear to any great extent. In the experiment described above the plants of *Medicago hispida* flowered and produced seed-pods in abundance during the autumn of 1906, but *Medicago arabica* did not bloom and both species were completely killed by the winter.

That plants of yellow trefoil live over winter in alfalfa fields, and also in lawns, is further proven by the following experiment: On March 29, 1907, nine plants suspected of being *Medicago lupulina* were transplanted into the Station greenhouse. Six of the plants were taken from a one-year-old alfalfa field and the other three from a well-kept lawn of several years standing. In due course of time all nine plants bloomed showing themselves to be yellow trefoil as suspected.

Up to the time of blooming, yellow trefoil and alfalfa are so much alike in appearance that they are separated with difficulty except by one who is well acquainted with them. This is especially true in the earlier stages of growth. The seedlings of the two species are strikingly alike. (Compare Plates VI and VII.) The writers have sought in vain for morphological or anatomical differences by means of which one unfamiliar with the plants might distinguish one from the other with certainty. Yellow trefoil plants vary greatly in habit according to their environment. In lawns they spread their branches close to the ground, and blossom and seed in spite of frequent close mowing. Among clover and alfalfa they grow more upright and may attain a height of over two feet. But, in general, yellow trefoil is smaller than alfalfa, more spreading in habit and the leaflets are broader in proportion to their length. The most reliable characters by which the two species may be separated in early spring are: (1) The habit of growth of the crown; and (2) the character of the root system. The stems of yellow trefoil being procumbent, the crown has a spreading habit and lies close to the ground; while the crown of alfalfa is upright in habit. The root systems offer a more striking contrast. Alfalfa has a large tap-root with very few
PLATE V.—DODDER ON ALFALFA.

1, Dodder growing on potted alfalfa plant in greenhouse; some threads over three feet long. 2, Alfalfa branch bearing dodder threads which have survived the winter; cut April 21, 1906. 3, Dodder wintering on alfalfa crown; dug in March, 1908.

(1, One-sixth natural size; others natural size.)
PLATE VI.—ALFALFA SEEDLINGS IN VARIOUS STAGES OF GROWTH.
Age from time seed was sown: 1, 9 days; 2, 16 days; 3, 23 days; 4, 31 days; 5, 42 days; 6, 72 days.
(All natural size.)
Plate VII.—Seedlings of Yellow Trefoil in Various Stages of Growth.
Age from time seed was sown: 1, 16 days; 2, 28 days; 3, 31 days; 4, 42 days; 5, 53 days; 6, 72 days.
(All natural size.)
PLATE VIII.—ROOT SYSTEMS OF ALFALFA AND YELLOW TREFOIL COMPARED.

1, Yellow trefoil root; 2, alfalfa root. Plants of same age—ten months.

(Dug and photographed March 29, 1907. Natural size.)
side roots; while yellow trefoil has a small tap-root which is nearly concealed in a mass of fibrous side roots. (See Plate VIII.)

Yellow trefoil is not a troublesome weed. No special methods are required for its eradication. It readily succumbs to tillage. Nevertheless, its substitution for alfalfa is objectionable because, as a fodder plant, it is greatly inferior to alfalfa. It makes but a small amount of hay and dies after the first cutting of the second season, whereas alfalfa is perennial.

In parts of Europe yellow trefoil is sometimes sown for sheep pasture, but in America it is not considered worthy of cultivation. Although it grows spontaneously in meadows, pastures and lawns and along roadsides throughout the greater part of New York it is rarely found in quantity except where adulterated alfalfa or clover seed has been used. The yellow trefoil seed imported into the United States from Europe is practically all used for the adulteration of alfalfa and clover seed.  

WEEDS.

All writers on alfalfa culture agree that weeds are one of the chief hindrances in starting alfalfa. This applies in New York quite as much as it does elsewhere. Many of the failures with alfalfa in this State are due to sowing on foul land. Practically all of the trouble with weeds comes during the first season. Alfalfa seedlings can not successfully compete with weeds; but after the first year the alfalfa plants are able to hold their own against even the most aggressive weeds. In established fields weeds are rarely troublesome. In New York, it is doubtful if weeds ever run out alfalfa after the first season. When old alfalfa fields become overrun with weeds and grass it is likely that the stand of alfalfa has been thinned by heaving and other forms of winter injury, not by the competition of the weeds.

The weeds which are most likely to cause trouble in newly-seeded alfalfa fields in New York are crab grass (Digitaria

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54 Brown (9).
sanguinalis), green foxtail (Setaria viridis), yellow foxtail (Setaria glauca), lamb's quarters (Chenopodium album), pigweed (Amaranthus retroflexus), ragweed (Ambrosia artemisiifolia), and barnyard grass (Echinochloa crusgalli). Charlock (Brassica arvensis) and quack grass (Agropyron repens), also, are troublesome, but occur less frequently. It is folly to sow alfalfa on land badly infested with quack grass.

In established fields, narrow-leaved plantain and dandelion are very abundant and persist indefinitely. Many alfalfa fields, even thickly seeded ones, are yellow with dandelion blossoms about May 15 and a few days later white with the seed-heads which stand above the alfalfa. Wild carrot and ox-eye daisy, so abundant and conspicuous in New York meadows, do not thrive in alfalfa fields except on bare spots, e.g., those caused by dodder. Such spots may be conspicuously white with ox-eye daisy blossoms at the time of the first cutting. Sweet clover maintains itself but two years. During the latter part of May and forepart of June, in the second season after sowing, sweet clover plants growing among alfalfa may be readily distinguished by their taller and coarser growth. At the time of the June cutting the sweet clover plants stand 12 to 18 inches above the alfalfa. Being a biennial and unable to ripen seed, owing to the frequent mowing of the alfalfa, the sweet clover disappears entirely after the second season. Sweet clover hay is not relished by cattle. On rich soil, chickweed (Stellaria media) persists in alfalfa fields. It begins to grow as soon as the snow goes off in spring and becomes conspicuous during April as a green carpet covering the ground between the alfalfa crowns. It may make sufficient growth to add materially to the bulk of hay in the first cutting.

Curled dock (Rumex crispus L.) is not troublesome in alfalfa fields. The following account of an experience with dock at the Station brings out prominently two important points in regard to this weed: (1) The danger of spreading it in manure; and (2) its inability to endure in an alfalfa field. In the autumn of 1900 a strip of corn stubble on the Station farm was spread with manure made from hay purchased of a neighbor-
ing farmer. The following spring the manure was plowed under and the land seeded with alfalfa. In June, 1902, curled dock came up thickly among the alfalfa. A count made in an average part of the field showed 209 dock plants per square rod. By June 11 the dock had thrown up its flower stalks which towered above the alfalfa causing the infested strip to stand out prominently in contrast with the adjacent non-infested fields of alfalfa on either side (See Plate IX). The first cutting was made June 12 before the dock had ripened any seeds. This was the end of the dock. At the time of the second cutting, made about August 1, not a single dock plant was to be seen. Neither did any appear the following season. The history of the land and the character of the seed being fully known there can be no doubt that the dock came from seeds in the manure.

The best method of dealing with the weed problem is to free the land of weeds as thoroughly as possible before sowing alfalfa. This is accomplished in various ways. The crop preceding the alfalfa should be one which permits of thorough cultivation as, for example, corn or cabbage, and no weeds should be allowed to ripen seed. If stable manure is used it should be well rotted and plowed under. The use of manure as a top-dressing just before sowing alfalfa is usually objectionable because of the weeds which are introduced with it. The land should be plowed in early spring and thoroughly fitted. It should then be harrowed at frequent intervals until seeding time to induce the germination of weed seeds in the surface layer of the soil. The time of seeding should be governed somewhat by the weediness of the land. If the land is reasonably clean, June 1 is a suitable time for seeding; while on weedy land, later seeding (about August 1) gives better results.

When proper cleaning of the land has been neglected so that weeds come up thickly and threaten to smother the young alfalfa it should be promptly clipped, but not mown closely. Close mowing may ruin young alfalfa. The mower cutting-bar should be run at least four inches above the ground. This
is the treatment usually recommended for weeds. It is widely practiced in New York. The treatment of charlock by spraying with a solution of copper sulphate, so successfully used in oat fields, can not be used in alfalfa fields. Alfalfa is injured by the spray.

**FUNGUS DISEASES.**

**LEAF SPOT.**

(*Pseudopeziza medicaginis* (Lib.) Sacc.)

Leaf spot, also known as rust and blight, is by far the most important fungus disease affecting alfalfa in New York. In fact, it is the only really important fungus disease. It appears in all parts of the State where alfalfa is grown, on all kinds of soil, in all situations and under almost all conditions. Probably, more or less of it may be found in almost any alfalfa field in any season, in dry weather as well as in wet. Some severe cases have been observed in the midst of an August drought. It may make its appearance at any time after about June 1. The lower leaves are the first to be attacked. They show numerous small brown spots, turn yellow and fall. (See Plate X.) In severe attacks so many of the leaves fall that the value of the hay is much impaired.

Fields of all ages and in almost any stage of growth may be attacked. Newly-seeded fields are sometimes ruined by leaf spot. Older fields may suffer very severely from it but are rarely, perhaps never, killed outright. While it may seriously affect the first cutting in June, the second and third cuttings are the ones most likely to be injured. Overripe plants are especially liable to attack. Through extensive dropping of the lower leaves, affected plants present a trimmed-up appearance. The disease may also appear on the stems

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55Although there are at least three other leaf spot diseases of alfalfa in New York it seems best to reserve this name for the common and well-known disease caused by *Pseudopeziza medicaginis*. If it becomes necessary to use common names for the unusual diseases caused by Ascochyta, Stagonospora and Cercospora they may be designated as Ascochyta leaf spot, Stagonospora leaf spot and Cercospora leaf spot respectively.
in the form of elliptical black spots 1 to 3 millimeters in length. Usually, but not invariably, leaf spot causes the leaves to turn yellow. Sometimes, even in severe attacks, the leaves show scarcely any tendency to become yellow.

The diseased spots are plainly visible on both sides of the leaf, but most conspicuous from the upper surface. In color, they are brown or black. Their general shape is circular with the boundary irregular and not sharply defined. The size of the spots varies from a mere speck to 1.5 or 2 mm. in diameter. They are irregularly distributed over the leaf. Many of the spots, even on leaves which have lain on the ground several days, show no signs of Pseudopeziza apothecia. The fungus is somewhat slow in fruiting. Under a hand lens the apothecia first appear as small shiny elevations, amber colored or nearly black. In this condition they contain asci and paraphyses, but no ascospores. Soon the shiny elevations crack at the summit, the crack gradually widening until the apothecium becomes cup-shaped, flat or even elevated at the center, while the edges of the ruptured epidermis stand up all around the margin. Ascospores may be found at any time after the rupturing of the epidermis, but usually not before. They are hyaline, non-septate, elliptical, 8–11 x 4–6 μ and there are eight in each ascus arranged in sub-biseriate fashion.\(^{56}\) In 1907, mature ascospores were found at Geneva on June 7, but they were not yet plentiful. However, the spring of 1907 was a backward one—about ten days later than usual. It seems probable that, at Geneva, the first ascospores mature about June 1. After this date they may be found at any time until frost.

Leaf spot often appears in alfalfa fields on soil which has not previously grown alfalfa. When this happens in fields which have been strewn with soil from another alfalfa field for the purpose of securing inoculation with nodule bacteria the leaf spot infection is satisfactorily accounted

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\(^{56}\) Illustrations of *Pseudopeziza medicaginis* on alfalfa are given by Chester (14, p. 82); Combs (17); Briosi and Cavara (8, No. 262); and Saccardo (Fungi Italici, No. 1390).
for, since without doubt spores of the leaf spot fungus may be disseminated with soil. But it is noteworthy that the writers have observed severe attacks of leaf spot in fields on which no alfalfa soil had been used and where there were no other alfalfa fields in the vicinity. In such cases, the infection must come either from spores sown with the seed or from host plants of other species. Both methods are possible. It is highly probable that the disease may be transmitted with the seed. Red clover is attacked by _Pseudopeziza trifolii_ (Bernh.) Eckl. which is considered by some botanists to be identical with _P. medicaginis_ while others regard it as a distinct species. Yellow trefoil (_Medicago lupulina_) is known to serve as a host for _P. medicaginis_ although, according to our observations, it is a much less congenial host than alfalfa. The writers have observed repeatedly that in fields containing both yellow trefoil and alfalfa the trefoil plants are but slightly affected with leaf spot even when the alfalfa plants mingled with them are badly diseased.

Notwithstanding the probability that the seed used may be a source of infection it is unlikely that leaf spot can be avoided by any method of seed disinfection. Neither is the liability of disseminating leaf spot a serious objection to the use of alfalfa soil for inoculation. Chester's experiments,\(^57\) and also those made by Combs,\(^58\) indicate that infection through the air is common. Apparently, alfalfa leaf spot is one of those widespread, easily disseminated diseases which it is useless to try to prevent completely. The only practicable method of control known is the widely-recommended one of mowing the plants whenever they turn yellow and become so badly diseased that their growth is stopped or severely checked. Mowing causes the plants to throw up new shoots which may outgrow the disease. Newly-seeded fields should not be mown closely—only the tops of the plants clipped off as in the control of weeds. Close mowing, if followed by a period of dry weather, may kill the alfalfa. When the disease makes its

\(^{57}\) Chester (14, p. 83)
\(^{58}\) Combs (17).
Plate IX.—Alfalfa Field on Station Farm.

Left, badly infested with curled dock introduced with manure at time of seeding in spring of 1901; right, free from dock. After the first cutting the dock disappeared.

(Photographed June 12, 1902.)
Plate X.—Alfalfa Affected with Leaf Spot (*Pseudopeziza medicaginis*)
Affected leaves fall prematurely leaving the stems bare.
(Natural size.)
appearance shortly before the hay crop is ready to harvest and begins to trim up the plants it is advisable to mow the field a few days early in order to avoid the loss of leaves which may be considerable if cutting is delayed. Once well started, the disease progresses very rapidly after the alfalfa begins to bloom.

WILT.

(Sclerotinia libertiana Fckl.)

June 12, 1899, it was observed that in an alfalfa field on the Station farm some of the stalks were wilted and others quite dead and dry. The affected stalks were scattered here and there through the field. It was plain that death had come to them rather suddenly when they were nearly ready to bloom. Upon tracing the wilted shoots back to the root (the plants were large and badly lodged) there was invariably found somewhere on the stem a dead, brown section 3 or 4 inches long which was plainly the seat of the trouble. Here, the stem was infested by a fungus having whitish mycelium and compact, black sclerotia. (See Plate XI, fig. 5.) In one portion of the field, lower and wetter than the rest, there were small areas on which nearly all of the plants were diseased. On some of the stems the white mycelium was abundant. No spores of any kind were found, but sclerotia were plentiful. The sclerotia were but loosely attached to the stems so that in extricating the diseased stalks many of the sclerotia would be knocked off. Usually, the diseased section of the stem was a foot or more from the root and not in contact with the ground.

The fungus causing the disease was supposed to be the Sclerotinia trifoliorum Eriks, given in all the text books on plant diseases as the cause of a stem rot of clover and which is said to attack also alfalfa. However, Prof. R. E. Smith, to whom specimens of the fungus were sent for identification,

59 The occurrence of such a disease of crimson clover in America has been recorded by Chester (14, p. 84) and Halsted (N. J. Sta. Rpt. for the year 1897:314). The writers observed a Sclerotinia crown-rot of red clover at Phelps, N. Y., in 1901.

60 Prillieux (80, 2:419).
reported that the sclerotia are entirely similar to those of *Sclerotinia libertiana* and that they produce a Peziza form which leaves no doubt that the fungus really is *S. libertiana.*

In 1902 further observations were made on the alfalfa wilt disease in the same field. On June 9 of that year only an occasional affected stalk could be found; but by June 18, just before the first cutting, there were large areas on which over 50 per ct. of the stalks were killed by the disease. Where the plants were lodged the stems were mostly brown and many of them were brittle. The lower leaves were all dead, being frequently fastened together and to the diseased stems by the Sclerotinia hyphae. Often the hollow stems were filled with mycelium and sometimes they contained also sclerotia about the size and shape of a wheat kernel. (See Plate XI, fig. 5.) At the time of the second cutting (August 1) the field was entirely free from disease. The alfalfa was of the Turkestan variety. This field was completely killed out by the hard winter of 1903-4, but it was immediately reseeded. No diseased stalks were found in 1905 and only a few in 1906 and 1907.

Another small field on the Station farm seeded in the spring of 1906 showed traces of the wilt disease in 1907. Six stalks badly wilted but not quite dead were found on June 6 when the alfalfa was 10 to 12 inches high. Upon seeking the cause, it was found that the wilted shoots were attacked near the surface of the soil by a fungus producing a luxuriant cottony white mycelium. Underneath the cottony growth of fungus the bark was soft rotten, but the interior of the stem was not yet discolored. Probably this was an early stage of the disease observed in 1899 and 1902. The only important difference is in the point of attack being near the root. The greater luxuriance of the mycelium and the absence of black sclerotia are to be accounted for by the wet weather and the immature condition of the fungus. The hyphae resembled those of *Sclerotinia*, and there were a few light-colored immature sclerotia.

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61Smith (96, p. 404).
On June 18, four other stalks similarly affected were found in this field and one of them showed a typical black sclerotium.

At Hicksville, Long Island, June 11, 1907, there were observed two dead alfalfa stalks apparently killed by some fungus which had attacked the stems just above the surface of the soil, but the only fungus in evidence was a species of Botrytis which was fruiting profusely. This is the only instance in which we have observed Botrytis in association with a wilt disease of alfalfa.

During 1907 occasional specimens of the wilt disease were observed in several alfalfa fields in different parts of the State.

Although apparently capable of causing considerable damage when the conditions are favorable, it is unlikely that this disease will become a troublesome one.

**ANTHRACNOSE.**

*Colletotrichum trifolii* Bain.;

Colletotrichum trifolii is a recently-described fungus which, according to Bain and Essary, is one of the chief causes of failure with clover in Tennessee. All at present known of its relation to alfalfa is contained in the writings of the above-mentioned investigators who state that it occurred rather abundantly on alfalfa in Tennessee in 1906 and that J. M. Westgate has observed it doing considerable damage to alfalfa in Virginia. 62

We have found this fungus in several alfalfa fields in New York, but our study of it has been confined to a four-year-old alfalfa field on the Station farm where it first came to our attention August 22, 1907. The alfalfa was then 8 to 10 inches high after the second cutting. Owing to dry weather it had been making a very slow growth. Here and there through the field occasional stalks were dead or wilting. Sometimes, whole plants were dead. In other cases living and dead stalks were found in the same stool.

62Bain and Essary (3), (4).
In seeking the cause of the trouble our attention was first attracted by elliptical, sunken spots appearing on some, but not all, of the dead stems. In two instances, the top of the stalk was killed by a single large spot about two inches below the tip. While some of the dead stalks bore several spots there were usually only one to three on each stalk and they appeared too small to be responsible for the death of the stalks. Besides, similar spots were sometimes found on healthy stalks. It was plain that, in the majority of cases, the death of the stalks was due to something else than the spots.

The spots were elliptical, sunken, five to six millimeters long, with sharply-defined outline; their color was usually gray sprinkled with specks of darker color. Under the microscope the dark-colored specks proved to be the acervuli of some Melanconiaceous fungus, apparently a species of Glæosporium. The spores were hyaline, non-septate, about 12 x 4.5 μ, rounded at both ends and frequently somewhat narrowed at the middle. However, it was found that on the older spots some of the acervuli were supplied with setæ, also that dead stubs in the crowns of affected plants were thickly covered with a dark-colored fungus having similar spores and setæ. Specimens of the fungus were sent to Prof. Bain who identified it as his Colletotrichum trifolii.

Further study of the affected plants revealed the fact that the death of the stalks was usually due to a diseased condition of the crown which might be very properly designated black crown. Upon peeling the bark from the large branches of the crown the woody part was found conspicuously blackened below the point of attachment of the dead stalks. When there were living and dead stalks springing from the same crown the wood blackening occurred only in the portion bearing the diseased stalks. When all the stalks were dead the blackening extended all through the crown and even into the upper portion of the tap-root. Microscopic examination showed the blackening to be due to the presence of a compact black fungus mycelium closely interwoven with the wood fibers.
Besides *Colletotrichum trifolii*, the diseased crowns commonly bore two other species of fungi; viz., a Dendrodochium producing multitudes of hyaline, non-septate, elliptical, straight or slightly curved spores measuring 5–7 x 3.5–4 μ; and a Fusarium with hyaline, curved spores usually 3-septate and measuring 35–53 x 5–7 μ. Both species were whitish, but the Dendrodochium was in little heaps which often showed a tinge of pink, whereas the Fusarium was more diffuse in habit and with a tendency to become bluish green.⁶³ Although no inoculation experiments have been made we are of the opinion that the Dendrodochium and Fusarium are only saprophytes and that *Colletotrichum trifolii* is the cause of black crown. One reason for this opinion is the following observation: On September 26, 1907, 14 pieces of blackened woody tissue from as many different alfalfa crowns were placed in a moist chamber. From each piece the bark had been completely removed exposing a clean, smooth surface of blackened wood. At the end of 48 hours a microscopic examination was made. Twelve of the pieces were thickly covered with acervuli of *Colletotrichum trifolii*. Both spores and setæ were produced in abundance. There was little or no superficial mycelium—the Colletotrichum acervuli were seated directly on the cut surface of blackened wood covering it almost completely. On some of the pieces Dendrodochium and Fusarium also developed.

From our limited observations on this Colletotrichium we should say that the greater part of the damage done to alfalfa results from its attack on the crown of the plant and that the stem spots are relatively unimportant. We have never seen the leaves affected. The bad reputation of this fungus in Tennessee makes it of considerable interest to New York farmers. To what extent it occurs in New York clover fields we are unable to say, no investigation of clover fields having been made.

⁶³Grown in pure culture on plugs of sugar beet this Fusarium is bluish green very much like *Penicillium glaucum*. On unneutralized alfalfa agar it is cream colored
ROOT-ROT AND DAMPING OFF.

(Rhizoctonia sp. and Pythium de baryanum Hesse.)

In various parts of Europe there is a destructive root-rot of alfalfa caused by *Rhizoctonia medicaginis* DC. The disease manifests itself in the form of circular dead spots in the field. The roots of affected plants are thickly covered with a violet-colored mycelium. Fortunately, this fungus is rare in America. No record of its occurrence in New York is known to us and we have never seen it here although we have been on the lookout for it since 1900. There have come to our attention a few cases of mysterious dying of alfalfa in circular spots, but we have been unable to definitely connect any Rhizoctonia with such trouble. Yet there are indications that Rhizoctonia may sometimes be harmful to alfalfa.64

In the spring of 1907 Mr. C. H. Kingsbury, Barnard, N. Y., sent to the Station 25 alfalfa crowns taken from a dead spot in his alfalfa field. One of these crowns bore several typical Rhizoctonia sclerotia, but the other 24 showed no sign of Rhizoctonia. Pure cultures of the Rhizoctonia were obtained and some inoculation experiments made on alfalfa seedlings, also on five-months-old alfalfa plants in pots. There were no indications that either the seedlings or the older plants were in any way injured although the conditions must have been favorable to the growth of the Rhizoctonia. One of the writers made an examination of the Kingsbury field, but the cause of the trouble could not be determined.

In April, 1907, a box of alfalfa seedlings in the Station greenhouse “damped off” quite badly. Microscopic examina-

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64 It would be strange indeed if alfalfa is not sometimes attacked by *Rhizoctonia* which is more or less parasitic on a great variety of plants and is very common in New York soils. (See N. Y. Sta. Bul. 186). In 1900, some five-months-old alfalfa plants growing in the greenhouse were inoculated with three kinds of *Rhizoctonia*—from phlox, cabbage and carnation. Although the conditions were made highly favorable for the growth and attack of the *Rhizoctonia* no injury resulted to the plants treated with phlox *Rhizoctonia* and cabbage *Rhizoctonia*, but on one of the three plants treated with carnation *Rhizoctonia* four shoots died within a month after inoculation. Three of the dead shoots appeared to have been killed by the *Rhizoctonia* while the fourth probably died from another cause.
tion of the affected seedlings showed them to be infested with Rhizoctonia to so great an extent and in such manner as to leave little doubt that this fungus was responsible for their death. Later it was proven by inoculation experiments with pure cultures that the Rhizoctonia actually is capable of causing damping off of alfalfa seedlings provided there is present an abundance of moisture. Older plants, also, were killed by artificial inoculation, but only when their crowns were kept constantly moist by placing wet moss around them. We have never seen alfalfa seedlings in the field damped off by Rhizoctonia, but our observations have been too few to warrant the conclusion that it does not occur. In a newly-seeded alfalfa field at Halcottville, N. Y., the seedling plants over large areas were destroyed by something not visible to the unaided eye. Unfortunately, there was not an opportunity to make a thorough investigation into the cause of the trouble. A few of the dead seedlings which were examined microscopically showed traces of Rhizoctonia.

In a field at Ensenore, N. Y., some alfalfa plants nine inches high wilted and died after the manner of plants attacked by Sclerotinia libertiana or Colletotrichum trifolii although neither of these fungi was in evidence. There is reason to believe that they were killed by Rhizoctonia, with which the roots were thoroughly infested.

To what species the above-mentioned Rhizoctoniae belong is not known. It can only be stated that the one causing damping off of seedlings in the Station greenhouse is different from the one found in the Kingsbury field. When grown on potato agar (slightly acid, neutral or slightly alkaline) the former produces a conspicuous dark-brown discoloration of the medium, whereas the latter discolors it only slightly. This character may be useful in the identification of the damping-off Rhizoctonia. Such discoloration of the medium is not common among the species of Rhizoctonia.

In one instance a box of alfalfa seedlings in the Station greenhouse developed a bad case of damping off due to Pythium de baryanum Hesse.
DOWNY MILDEW.

(Peronospora trifoliorum De By.)

A few specimens of this fungus were collected on the Station farm October 3, 1907. In the forepart of June, 1908, it again occurred sparingly in two of the Station alfalfa fields; also, in fields at Canandaigua, Potsdam, Earlville and Fayetteville. In Europe, Peronospora trifoliorum is a well-known parasite on various species of Trifolium, Medicago, Melilotus and some other Papilionaceae. In America, it appears to be uncommon on alfalfa although specimens on this host, collected in Colorado, have been distributed in Fungi Columbiani, No. 2246, and quite recently it has been reported from Kansas. No previous record of its occurrence on alfalfa in New York is known to us. It is unlikely to become of economic importance.

The fungus appeared on leaves situated in the upper part of the plant, particularly on young leaves at the tips of shoots. Some of the leaflets were affected only at the tip, some only on the proximal portion and others all over, the affected portion being yellowish, gray or, occasionally, purple. Frequently, the margins of affected leaflets were curled downward. The dichotomously branched conidiophores occurred on both surfaces of the leaflet, but most abundantly on the lower surface. Violet, elliptical or ovate conidia were abundant. Round, brown oöspores, formed within the tissues of the affected leaves, were common in specimens collected in October and some, also, were found in specimens collected June 5 to 10. The dimensions of the conidia and oöspores, as determined by the writers, are somewhat greater than are usually given for this species. The most common size of the conidia was $21 \times 28 \mu$ and of the oöspores 35 $\mu$ in diameter.

On some of the leaves collected in October, there was associated with the Peronospora a Hyphomycetous fungus which may have been the Ovularia medicaginis described and illustrated by Briosi and Cavara in their Funghi Parassiti, No. 303.

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65Freeman (32).
This is an undescribed disease discovered in alfalfa fields in the vicinity of Geneva. It attacks the lower leaves almost exclusively. While it may occur on normal green leaves it is most common on those which have begun to turn yellow and are about ready to fall. In the great majority of cases it appears in the form of V-shaped, dead, brown areas, 5 to 12 mm. long, at the tips of the leaflets. Frequently, the spots are on the margin and semi-circular in shape, while in some cases circular, dead, brown spots occur on the interior of the leaflet entirely surrounded by healthy tissue. The boundaries of the spots are rather indefinite. (See Plate XI, fig. 1.)

Between May 28 and June 12, the period during which most of the observations were made, pycnidia well filled with spores were to be found on nearly all of the spots. The pycnidia, as seen under a hand lens, are light brown, depressed and visible on both surfaces of the leaf. They are delicate in structure, 100–150 μ in diameter, and ostiolate with a ring of darker brown surrounding the ostiolum. When the pycnidia are placed in water the spores escape in gelatinous rope-like or wedge-shaped masses. The spores are hyaline, mostly non-septate, 2.5–3.5 × 6–12 μ, straight or slightly curved and rounded at the ends. Mingled with the non-septate spores, particularly in the more mature pycnidia, are one-septate spores which are often narrowed at the middle or slightly constricted at the septum. These septate spores are larger than the others—commonly 3.5 × 12–14 μ. Frequently, the non-septate spores predominate to such an extent that the fungus might readily pass for a species of Phyllosticta, but undoubtedly it is properly referable to the genus Ascocytha. It may be an undescribed species. *Ascochyta medicaginis* Bres. on *Medicago lupulina* has larger spores and pycnidia; so has *Ascochyta pisi* Lib. which is reported as occurring on

*Bresadola (7).*
alfalfa in Denmark.\textsuperscript{67} \textit{Ascochyta medicaginis} Fuckel,\textsuperscript{68} found on living leaves of \textit{Medicago sativa} and \textit{M. falcata} in Germany, is a synonym of \textit{Phyllosticta medicaginis} (Fckl.) Sacc.\textsuperscript{69} the spores of which are described as very small and the pycnidia black. It is unlikely to be \textit{Ascochyta caunicola} Laub,\textsuperscript{70} which attacks the stems and petioles of \textit{Melilotus alba}.

When the Ascochyta was first discovered (October, 1907) it was thought to be identical with the \textit{Diplodina medicaginis} Oud. previously found on dead alfalfa stems in early spring (see page 409); but after careful comparison of the two fungi we have reached the conclusion that they are distinct. The spores of the two species are strikingly alike except in one respect, viz., the spores of \textit{D. medicaginis} are commonly bi-guttulate while those of the Ascochyta are rarely so. The pycnidia of \textit{D. medicaginis} are somewhat larger than those of the Ascochyta and black, while those of Ascochyta are light brown. So far as observed neither the Diplodina nor the Ascochyta attack living alfalfa stems.

There is no reason to believe that the Ascochyta leaf spot will become a troublesome disease.

**STAGONOSPORA LEAF SPOT.**

\textit{(Stagonospora carpathica} Bäuml. ?\textit{)}

While examining one of the Station alfalfa fields June 9, 1908, the writers found a leaf spot disease not previously observed. The following day the same disease was found in another field near Geneva. In neither case was the disease sufficiently abundant to cause appreciable damage, yet affected leaves were so common that several hundred specimens were collected in a short time.

Unlike the Ascochyta leaf spot, this disease attacks chiefly green leaves in the upper part of the plant. The spots are

\textsuperscript{67}Rostrup (84), (85).
\textsuperscript{68}Fuckel (34).
\textsuperscript{69}Saccardo (86, 3:42).
\textsuperscript{70}Saccardo (86, 18:336)
circular, one to three millimeters in diameter and usually light brown with a narrow border of dark brown. (See Plate XI, fig. 4.) Each spot bears several light brown pycnidia visible on both surfaces of the leaf. The pycnidia closely resemble those of the Ascochyta described above except that they are somewhat larger, usually 180 μ in diameter. In water the spores escape through the ostiolum in a gelatinous rope-like mass. The spores are hyaline, straight or slightly curved, rounded at the ends and measure 14–28 x 4 μ the most common size being 20–21 x 4 μ. In most cases the spores appear non-septate. However, septate spores occur abundantly in the more mature pycnidia which may be distinguished by their darker color and especially by the whitening of the leaf tissue at the center of the spot on which they are seated. The number of septa varies from one to four, being usually three. Frequently, slight constrictions occur at the septa.

We have been unable to find any account of an alfalfa disease like this one. However, there is a very similar leaf spot of sweet clover, Melilotus alba, caused by Stagonospora carpatica Baunl. the description71 of which agrees quite closely with the characters possessed by our fungus. We should not hesitate to refer the alfalfa fungus to this species but for the fact that numerous sweet clover plants growing among the affected alfalfa plants were entirely free from the disease.

This leaf spot is readily distinguished from the Ascochyta leaf spot and Cercospora leaf spot (next to be described) by the dark brown border surrounding the spots.

Cercospora Leaf Spot.

(Cercospora medicaginis E. & E.)

A Cercospora on alfalfa foliage was found but once, viz., on June 12, 1908. Only occasional leaves were affected. The Cercospora spots occurred chiefly on green leaves about half way up the plant. They were mostly circular with indefinite outline, smoke-colored or nearly black, 1.5 to 2.5 millimeters

71Saaccardo (86, 10:334).
in diameter and visible on both surfaces of the leaf. (See Plate XI, fig. 3.) The spores measured 40–135 x 4 μ and were 6- to 15-septate. Both in gross appearance and in microscopic characters our specimens agree closely with those distributed in Ellis and Everhart's Fungi Columbiani, Century 24, No. 2314, under the name Cercospora medicaginis E. & E. Probably our fungus is referable to this species. However, other names have been given to Cercosporas occurring on alfalfa. In Delaware, Chester found one which he described under the name Cercospora helvolia Sacc. var. medicaginis Chester. Voorhees mentions the occurrence of Cercospora helvolia on alfalfa in New Jersey. Frank gives Medicago sativa as one of the hosts of Cercospora helvolia. Saccardo includes C. medicaginis, but not C. helvolia, in the list of fungi occurring on alfalfa.

Apparently, there is no previous record of a Cercospora on alfalfa in New York.

**Alternaria Disease (?) of Alfalfa Seed.**

A few years ago Dr. Peglion, an Italian investigator, announced that dead, brown seeds of alfalfa and red clover are commonly infested with a certain fungus the hyphae of which penetrate the seed coat. He found that under temperature and moisture conditions favorable to germination such seeds, instead of germinating, soon become overgrown with a dark-colored mold, Alternaria tenuis. This is said to occur even when the seeds have been previously sterilized externally. The perithecial form of the fungus was found and identified as Pleospora alternariae Griff. & Gib.

Our observations indicate that the alfalfa seed offered for sale in New York is, likewise, quite generally infested with

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72 Cercospora medicaginis was originally described on Medicago denticulata. See Ellis and Everhart (25).
73 Chester (13),
74 Voorhees (104, p. 155).
75 Frank (30, 2:352)
76 Saccardo (86, 13:711).
77 Peglion (76).
Alternaria. Most of the samples of alfalfa seed received for examination at the Station have shown a greater or less number of dead, brown, shriveled seeds. In germination tests many of these brown seeds become moldy and in the great majority of cases the mold is of the same kind, viz., a species of Alternaria. 78

This happens even when the seeds have been sterilized on the outside and the germination apparatus also sterilized, as in the following experiment: From each of twenty samples of alfalfa seed sent to the Station from as many different places in the State, ten brown, shriveled seeds were selected. The 200 seeds thus obtained were divided into two lots of 100 seeds each in such manner that the two lots were exact duplicates, each of them containing five seeds from each of the twenty original samples. One lot (I) of the seeds was soaked 45 minutes in a 1-1000 corrosive sublimate solution to sterilize them externally. By means of sterile forceps the seeds were then transferred to a Geneva seed-tester 79 previously steam sterilized. 80 The other lot (II) of seeds, unsterilized, was placed in the seed-tester at the same time for a check. The temperature to which the seeds were exposed varied from about 16° to 23° C. At the end of nine days the condition of the seeds was as follows: Lot I (sterilized): 26 germinated, 30 moldy, the fungus being Alternaria in 25 cases; Lot II (check): 31 germinated, 34 moldy, the fungus being Alternaria in 28 cases. Seemingly, external sterilization of the seeds does not greatly reduce the tendency to mold.

78 Mr. L. Knudson, now of the Department of Plant Physiology in the New York State College of Agriculture, informs us that, in 1907, while an assistant in the Department of Agronomy at the Missouri Experiment Station, he made a large number of germination tests of alfalfa and red clover seed and observed that the brown seeds which fail to germinate usually become infested with a species of Alternaria.

79 For a description of the Geneva seed-tester see Rpt. of this Station, 2(1893):87; also in Bot. Gaz. 10:425.

80 The copper body of the seed-tester and the cloth pockets which hold the seeds were placed in an autoclave for twenty minutes at a temperature of about 120° C. and a pressure of fifteen pounds. After the apparatus had been put together it was placed over a gas flame for two hours to complete the sterilization.
What relation the Alternaria bears to the seed—whether that of a parasite or merely a saprophyte—can not be stated. Neither was it determined to what species the Alternaria belongs. Usually, it is quite black and produces multitudes of spores.

A molding and rotting of alfalfa seed in Colorado has been discussed by Headden, but he gives no clue to the identity of the fungi concerned in the trouble.

FROST BLISTERS ON ALFALFA LEAVES.

The usual effect of frost on alfalfa leaves is to cause them to become blistered on the lower surface through the separation of the epidermis from the parenchyma. This has been described previously by Noack. The writers have observed it in New York, frequently.

About April 1, 1907, at Geneva, there were a few days of unseasonably warm weather during which alfalfa started into growth and put out new leaves. Then there came a hard freeze. Some of the new leaves were killed outright. Many others were seemingly uninjured; but an examination of them showed that over large areas on the lower surface the epidermis was separated from the parenchyma so that it could be removed readily. Sometimes the loosened epidermis was shiny, but more often it was simply a lighter shade of green than normal.

After heavy frosts (28°F.) occurring May 11 and 12, 1907, alfalfa showed no material injury on May 13. However, many of the leaves were partially wilted, somewhat wrinkled and gray-green, with the epidermis on the lower surface plainly separated from the parenchyma. In some cases the loosened epidermis was ruptured.

By May 4, 1908, alfalfa on the Station farm had made a new growth about five inches high. Although the plants were not materially injured almost every leaf showed large frost blisters

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81 Headden (41, p. 13).
82 Noack (72).
on the lower surface. The younger leaves were gray-green and slightly wilted as a result of the light frosts of May 1 and 4 when the minimum temperature was 31° F. in both cases. The older leaves were considerably wrinkled and distorted and often showed ruptures in the loosened epidermis. Their injury was due probably to the hard freeze of April 21 when the temperature went down to 20° F.

INSECT ENEMIES.

The insect enemies of alfalfa have not been included in this investigation. All that can be said on the subject is that we have seen in New York no instance of serious injury to alfalfa caused by insects.

ROOT-KNOT.

An alfalfa root-knot disease caused by nematodes is of frequent occurrence in New York. This first came to our attention in August, 1907, when a newly-seeded field of alfalfa near Geneva was found to be thoroughly infested. Subsequently, the same trouble was observed in many fields in various parts of the State. However, the damage done by it seems to be small.

Root-knot is a very appropriate name for the trouble. It is characterized by clusters of rootlets which spring from small knots or enlargements on the lateral roots. (Plate XII, figs. 1, 3 and 4.) An examination of the surface of the knots with a hand lens reveals certain rounded elevations which are either whitish and glistening or else pale yellow and dull. These are pear-shaped, gravid female nematodes and they are so thoroughly imbedded in the root that they appear to be a part of it. However, with the aid of a dissecting needle they may be dislodged readily. Under the compound microscope they are seen to contain large numbers of eggs or of young larvae. (Plate XII, figs. 3, 5 and 6.)

The nematode in question is referable to the species Heterodera radicicola (Greeff) Müll, which is a common and often
destructive root parasite of many kinds of plants. In New York, it is injurious chiefly to plants grown under glass. We believe this to be the first published record of the occurrence of a nematode disease of alfalfa in the United States. However, Dr. Ernst Bessey of the University of Louisiana informs us that, according to his observations, alfalfa in this country is often attacked by nematodes. Its occurrence in Germany has been reported by Frank, and in Egypt, by Mosseri.

The root knots or enlargements caused by nematodes are readily distinguished from bacterial nodules by the fact that the former bear one to several short rootlets each, while the latter are entirely free from them.

DISEASES OF UNKNOWN CAUSE.

WHITE SPOT.

In this disease the leaves are thickly covered with light-colored spots or areas which give the affected plants a whitish appearance. The white spots are irregular in shape, rather definite in outline, .5 to 1.5 millimeters across and usually distributed irregularly although sometimes the distal two-thirds of the leaflet is thickly covered with spots while the proximal one-third is almost entirely free from them. The affected plants are scattered here and there through the field. It is a common thing to find plants so much affected that almost every leaf shows the spots without a trace of disease appearing on any of the surrounding plants.

This disease occurs in alfalfa fields all over the State, but we have never seen it sufficiently abundant to cause appreciable loss. It is usually seen in May and June.

The cause of white spot is entirely unknown. The affected leaves show no evidence of being attacked by fungi and it seems unlikely that the trouble is due to insects. It is considerably different from the work of the four-lined leaf-bug

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83 Atkinson (1); Stone and Smith (101).
84 Frank (29), (31), (30, 3:23).
85 Mosseri (71).
(Poecilocapsus lineatus) which occasionally attacks alfalfa leaves producing small, translucent spots. Probably it is a physiological disorder of some kind. The roots of affected plants generally appear normal.

YELLOW TOP.

During the past two years one of the Station alfalfa fields, seeded in 1904, has turned bright yellow from an unknown cause. In 1907 this occurred two to three weeks after the second cutting when the plants were seven to nine inches high. It commenced on a strip along one side of the field where the hay had been cut a few days earlier than on the remainder of the field. Ultimately, an area of about two acres became involved. In the spring of 1908 the affected field was entirely normal in color and the first cutting of hay was a heavy crop; but the second and third cuttings were both very yellow and the yield light. This year the trouble started in the same place as in 1907 and spread over the entire field of about four acres. It also appeared, in a mild form, in two other fields on the Station farm. Several fields in the vicinity of Geneva were affected and reports of the disease were received from various other places in the State. It appears to have been not uncommon in 1908.

On affected plants, the lower leaves are green while the upper ones are more or less yellow or, occasionally, purple. As a rule, the yellowing is much more pronounced on the distal than on the proximal portion of the leaflets. Although the yellow leaves do not fall the growth of the plants is severely checked.

There is no reason to believe that this disease is caused by any fungus, insect or other parasite working in the parts of the plant above ground. Plainly, the cause is to be sought underground. Our investigation of the roots of affected plants has been too superficial to warrant positive statements concerning their condition. We can only say that from casual observation they appear to be normal.
Apparently, climatic conditions have something to do with the disease. Dry weather seems to favor it. Both in 1907 and 1908 it made its appearance during very dry weather. However, alfalfa growing in soil containing an excess of moisture frequently shows a somewhat similar yellowing of the foliage. So far as our observations go, the character of the soil has no marked influence. In the affected field on the Station farm the soil is clay loam, with good surface- and under-drainage. Alfalfa has been grown successfully on this field during the greater part of the past fifteen years without any previous trouble of this kind so far as can be learned.

Yellow top is sometimes mistaken for leaf spot. Although both diseases cause the foliage to turn yellow the two should be distinguished without difficulty. Plants affected with yellow top show green leaves below and yellow leaves above; whereas those affected with leaf spot have yellow leaves below and green leaves above. Besides, in yellow top the leaves are free from spots and do not fall; while in leaf spot the leaves are thickly covered with small brown spots and fall prematurely. Of course, the two diseases may occur together.

A disease which may have been yellow top is said by Elliott to have greatly shortened the yield of alfalfa hay in Washington in 1906.

Pitting of the Tap-root.

The tap-roots of alfalfa plants in this State are quite commonly covered with brown pits and scars of various shapes and sizes. On the roots of old plants the scars are suggestive of the potato scab disease and one might easily believe that they are due to the attack of some parasitic fungus; but on the roots of plants one and two years old it is plain to be seen that the bark has been gnawed by some insect or animal. (Plate XII, fig. 2.) Although the growth of the plants does not appear to be seriously checked the effect of the pitting cannot be otherwise than harmful. In the aggregate, the damage done must be considerable, for the trouble is exceedingly common.

Elliott (27, p. 31).

(All figures natural size.)
Plate XII.—Two Root Troubles of Alfalfa.

1, Root-knot caused by nematodes; 2, pitting of the tap-root; 3, portion of tap-root and a lateral root with a root-knot; 4, a root-knot showing gravid female nematode at a; 5, nematode egg; 6, young nematode.

(1 and 2 natural size; 3 and 4, magnified 2 diameters; 5 and 6, magnified 95 diameters.)
BUNDLE BLACKENING IN THE TAP-ROOT.

Black or brown streaks within the tap-root are of frequent occurrence. The black streaks are discolored fibro-vascular bundles. The cause of the discoloration is unknown. So far as can be determined from microscopic examination neither bacteria nor fungi are to be found in the blackened bundles. Whether the bundle blackening indicates a diseased condition of the tap-root cannot be definitely stated. It often occurs in the roots of thrifty, apparently healthy plants.

DISEASES NOT KNOWN TO OCCUR IN NEW YORK.

For the convenience of those who may wish to pursue the subject further there is given here a brief account of the various other diseases said to affect alfalfa but which have not yet been observed in New York.

FUNGUS DISEASES.

Violet root-rot (*Rhizoctonia medicaginis* DC.)⁸⁷ kills the alfalfa in circular spots several feet in diameter. It is a destructive disease common in Europe.⁸⁸ In this country it seems to be rare, although Freeman reports it troublesome in Kansas.⁸⁹

Brown root-rot is a disease having symptoms similar to the preceding but caused by a different fungus, viz., *Ozonium omnivorum* Shear.⁹⁰ It occurs in Texas,⁹¹ Arizona⁹² and Kansas.⁹³

A Fusarium root-rot has been reported from Arizona.⁹⁴

*Sclerotinia trifoliorum* Eriks. which causes root-rot of clover is said to attack also alfalfa.⁹⁵ Duggar⁹⁶ has observed a

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⁸⁷DeCandolle (23).
⁸⁸Prunet (82); Wagner (105); Prillieux (80, 2:144); Frank (30, 2:515); Briosi and Cavara (8, No. 225).
⁸⁹Freeman (32).
⁹⁰Shear (94).
⁹¹Curtis (20).
⁹²Toumey (103); Thornber (102).
⁹³Freeman (32).
⁹⁴McCallum (63).
⁹⁵Prillieux (80, 2:419); Massee (65, p. 155); Coleman (16).
⁹⁶Duggar (24, p. 41).
sclerotial root disease (fungus not determined) of alfalfa in Alabama.

Urophlyctis alfalfa {Lagerh.} Magn. produces galls on the roots near the crown of the plant. It occurs in Ecuador,97 Europe98 and England,99 but has not been observed in the United States.

Rust (Uromyes striatus Schroet.) on the leaves is an unimportant disease of wide distribution.100 Another rust (Uredo medicaginicolae Speg.) is said to occur on the stems of alfalfa in South America.101

Other fungi parasitic on alfalfa leaves are the following: Gloeosporium medicaginis Ell. & Kell.,102 Gloeosporium moriannum Sacc.,103 Pleosphaerulina briosiana Pollacci,104 Macrosporium medicaginis Cugini,105 Erysiphe polygoni DC.,106 Phyllosticta medicaginis (Fckl.) Sacc.,107 Septoria medicaginis Rob. & Desm.,108 Ascochyta pisi Lib.,109 Cercospora helvola Sacc.,110 Laestadia destructiva (Berk. & Br.) Berl. & Vogl.111

BACTERIAL DISEASE.

Paddock112 has given a brief account of a supposedly bacterial root disease of alfalfa occurring in Colorado.

97 von Lagerheim (59).
98 Magnus (64).
99 Salmon (88).
100 Freeman (32); Briosi and Cavara (8, No. 4).
101 Saccardo (86, 16:351)
102 Ellis and Kellerman (26).
103 Saccardo (86, 10:454); Frank (30, 2:380). Saccardo (Syll. Fung. 18:449) gives Medicago sativa as the host of Gloeosporium caulivorum Kirch. This seems to be an error. The only host given by Kirchner (Ztschr. Pflanzenkrank. 12:10) is Trifolium pratense.
104 Pollacci (79); Briosi and Cavara (8, No. 383); Saccardo (86, 16:554).
105 Saccardo (86, 18:618)
106 Salmon (87, p. 180); Prillieux (80, 2:14).
107 Saccardo (86, 3:42).
108 Saccardo (86, 3:508); Frank (30, 2:431).
109 Rostrup (54), (85).
110 Frank (30, 2:350); Voorhees (104, p. 155).
111 McAlpine (62, p. 127).
112 Paddock (74).
PHANEROGAMIC PARASITES.

Several species of dodder (Cuscuta) have been recorded as attacking alfalfa stems. How many of them occur in New York is not known. (See page 349.) There are also a few phanerogamic root-parasites. Nobbe\textsuperscript{113} states that three species of Orobanche, viz., \textit{O. bukiana} Koch, \textit{O. rubens} Wallr. and \textit{O. minor} Sutt., are parasitic on alfalfa in Germany. Lignier\textsuperscript{114} includes \textit{Medicago sativa} in the list of host plants of \textit{Tesium divaricatum} var. \textit{humifusum} A. DC.

INSECTS, NEMATODES AND OTHER ANIMAL ENEMIES.

Having given but little attention to the insects affecting alfalfa,\textsuperscript{115} the writers are unable to enumerate the species occurring in New York.

In Europe,\textsuperscript{116} the nematode, \textit{Tylanchus devastatrix} Kühn, attacks alfalfa stems causing a disease which the Germans call "Stockkrankeht." It is not known to occur in America.

Other animals reported troublesome in alfalfa fields are the woodchuck,\textsuperscript{117} prairie dog,\textsuperscript{118} pocket gopher\textsuperscript{119} and ground squirrel.\textsuperscript{120} Only the first-mentioned of these is found in New York.

LIGHTNING.

Sitensky\textsuperscript{121} cites an instance in which a bolt of lightning killed alfalfa plants over a circular area five meters (about sixteen feet) in diameter.

SPONTANEOUS COMBUSTION.

It appears to be an established fact that alfalfa hay stored in stacks and barns may become so hot as to take fire through

\textsuperscript{113}Nobbe (73, p. 470). See also Caspary (12) and Koch (56).
\textsuperscript{114}Lignier (60).
\textsuperscript{115}For an account of the insects injurious to alfalfa see Bruner and Hunter (10); or Headlee (42).
\textsuperscript{116}Frank (30, 3:29).
\textsuperscript{117}Wing (112, p. 39).
\textsuperscript{118}Cottrell (19, p. 78); Coburn (15, p. 212).
\textsuperscript{119}Scheffer (89, p. 124); Headlee (42).
\textsuperscript{120}Elliott (27, p. 31).
\textsuperscript{121}Sitensky (95).
spontaneous combustion. Several examples are given by Cottrell who states that all of the cases coming under his observation occurred with hay from the first cutting. Doubtless spontaneous combustion of alfalfa occurs in New York, but no clear case of it has come to our attention.

**SAPROPHYTIC FUNGI ON ALFALFA.**

Our studies on the saprophytic fungi have been too fragmentary to enable us to give anything like a complete list of the species occurring on alfalfa in New York. Only a few species have been given more than passing attention. However, it is desirable to have before us a list of the fungi saprophytic on alfalfa. Upon further investigation some of the species now classed as saprophytes may prove to be parasites or, perhaps, genetically related to parasitic species. Accordingly, the following list of alfalfa saprophytes is appended. It is compiled mainly from Saccardo’s Sylloge Fungorum. The species starred have been observed in New York by the writers.

* **Alternaria** sp. On stems.
* **Coniothyrium** sp. On stems and stipules.
* **Dendrodochium** sp. On stems and roots. (See page 391).
* **Fusarium** sp. On stems and roots. (See page 391).

Bd. I., Abt. 8:696.


12Cottrell (18), (19, p. 67).
*Torula sp. On stems.

One of the species listed above, Diplodina medicaginis, was given considerable study. An alfalfa field at Geneva seeded in the spring of 1906 went into its first winter with a growth about a foot in height. The following March the dead alfalfa stems (which were still standing upright) were thickly covered with the black pycnidia of Diplodina medicaginis. A similar condition was found in several other alfalfa fields. The fungus appears to be an exceedingly abundant one.

The pycnidia are crumplent, membranous, distinctly ostiolate and 100 to 200 μ in diameter. On March 26 mature spores were abundant. When the pycnidia are placed in water the spores exude through the ostiolum in rope-like masses. The spores are hyaline, 10–17 x 3–4 μ, straight or slightly curved, rounded at the ends and usually bi-guttulate. Many of the spores are apparently non-septate. The majority of them are slightly constricted at the middle and many are certainly once-septate, but it is often difficult to make out the septum. Sometimes one of the cells is a little broader than the other.

The Diplodina grows readily on ordinary culture media such as sterilized plugs of sugar-beet and acidulated potato agar. On sugar beet the growth soon becomes black with enormous numbers of pycnidia which are filled with multitudes of spores.

This fungus closely resembles the Ascochyta occurring on alfalfa leaves but it is certainly a different species. (See page 395.)
MISCELLANEOUS.

AN ALFALFA PLANT WITH UNIFOLIATE LEAVES.

In alfalfa, the first leaf after the seed-leaves consists of a single leaflet while the succeeding ones are pinnately trifoliate. (See Plate VI.) Recently, the writers found an alfalfa plant having unifoliolate leaves throughout. There being, apparently, no published record of such a freak alfalfa plant it is thought worth while to give an account of it here.

The plant was discovered among some alfalfa seedlings grown in the Station greenhouse during the spring of 1907. It grew in a flower pot in the greenhouse until the spring of 1908 when it was transplanted into the open garden together with four other plants propagated from it by cuttings. At the present writing (October, 1908) all five plants are in fairly thrifty condition. In general appearance they are similar to normal alfalfa plants. None of them have never shown anything but the unifoliolate leaves which are of the same size, shape and appearance as the terminal leaflet in ordinary trifoliate leaves. The plants have flowered only sparingly and produced no seed. They have been affected with leaf spot (Pseudopcziza medicaginis), and Diplodina medicaginis appeared on some of the dead stems in October, 1907.

MULTIPLICATION OF LEAFLETS.

We have occasionally seen alfalfa leaves with four and five leaflets.

WHITE FLOWERS OF ALFALFA.

Westgate describes alfalfa flowers as "purple, rarely white." The writers have seen many alfalfa flowers which were nearly white, but only one plant which produced pure white flowers. Percival's statement that the flowers of Medicago sativa are sometimes yellow is probably an error.

124 The same is true of other species of Medicago, Trifolium and some other Leguminosae. (See Lubbock, Sir John. A contribution to our knowledge of seedlings. 1:388).

125 Westgate (107).

126 Percival (78).
DO ALFALFA ROOTS CLOG TILE DRAINS?

It is said that tile drains are sometimes clogged by alfalfa roots. The writers have heard of a few such cases in New York, but have never seen one. On this subject, J. E. Wing of Mechanicsburg, Ohio, says:127 "We find that where the tile runs to a spring with running water the year around the tile will become choked with alfalfa roots every four or five years, but where there is only the ordinary surface water to take care of there will be no trouble from roots choking the tile."

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