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A NEW ALFALFA DISEASE

STEM BLIGHT

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BY

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STEM BLIGHT

*A New Bacterial Disease of Alfalfa**

By WALTER G. SACKETT.

HISTORY AND DISTRIBUTION.

In May of 1904, Hon. J. L. Chatfield, who resides at Gypsum, Eagle County, Colorado, observed that while the stand of alfalfa on his ranch was good, much of it was shorter than it should be at that time of the year, and that here and there plants were dying. He reported this condition to the Experiment Station at Fort Collins, and in response to his request, Professor Paddock and Professor Gillette visited his fields. They examined a number of plants, but they were unable to give any decisive answer as to the exact cause. Occasionally, worms were found in the crowns and in the roots, and by splitting the latter lengthwise, numerous dark streaks could be traced through the tissue. A few crowns were blackened, as well as some of the stems, but this discoloration was looked upon as due, possibly, to insect work, although no specific insects could be found at that time.

The following year, there was practically none of the trouble to be seen in the whole valley, which has an area of at least five thousand acres, more than one half of which is in alfalfa.

The next year, however, 1906, the conditions were worse than ever before and the universal complaint among the farmers was that there was "something wrong with the alfalfa." Professor Paddock again visited Gypsum, and at this time the blackened stems were very abundant and much more conspicuous than when he was there before. He brought back specimens of this material to the college and a microscopic examination satisfied him that, in all probability, the trouble was of bacterial origin. As a result of these findings, in November, 1906. Professor Paddock (1) called attention to a new alfalfa disease occurring in certain parts of Colorado, which was different from any previously described malady and which, from all appearances, was not related to either leaf spot or mildew.

The disease has spread with increasing severity until at the present time it is a very difficult matter to find one acre of alfalfa land in the whole valley which is entirely free from the trouble. The loss in tonnage for the first cutting is estimated at eighty per cent, or the crop is only one-fifth of what it was in former years. The disease became so serious in 1907 that it was thought advis-

* This is an abbreviated edition of Bulletin No. 158, entitled A Bacterial Disease of Alfalfa. The former includes detailed description of the causal bacterium and inoculation experiments. Bulletin No. 158 will be sent on request.

(1) Press Bulletin No. 28, Colo. Exp. Sta.

able to make the study of this malady a theme for special research. Accordingly, May 1, 1908, the writer began an intensive investigation of the trouble and during the past year has been occupied with laboratory, greenhouse and field experiments bearing upon the cause and possible remedies for the disease. The results of this work are given in the pages which follow.

DISTRIBUTION.

Within the state of Colorado, the disease occurs generally throughout the Gypsum Valley in Eagle county, to a somewhat less extent in Garfield county, and at Rocky Ford in the Arkansas Valley. Prof. W. Paddock has noted it in the Plateau Valley, Mesa county, and between Hotchkiss and Paonia in Delta county.

So far as our present knowledge goes, it has not been seen in the San Luis Valley, or in the Boulder, Longmont, Loveland, Fort Collins and Greeley districts.

In our neighboring states, what appears to be a similar bacterial disease has been observed by Professor Northrop in Utah, by Professor Wooten in New Mexico, by Professor Wilcox in Nebraska, and by Professor Roberts in Kansas. Its occurrence is reported as negative by Professor Nelson for Wyoming, by Professor Kennedy for Nevada, by Professor Lewis for Oklahoma, and by Professor Ball for Texas.

DESCRIPTION OF THE DISEASE.

When a field suffering with this bacterial trouble is viewed as a whole, about the only comment which could be made is that the growth is short and the alfalfa is a little off color. The rich, dark green color in the leaves is absent and the juicy, succulent appearance of the stem, so characteristic of a thrifty stand, is wanting. The plants tend to grow more spindling; the leaves often appear dwarfed, narrow, light green and have a tendency all along the stem and in the growing tip to remain partly closed just as they do in cold or dry weather.

The disease is primarily a stem infection and it is here that we find the most valuable characters for diagnosis. In the earliest stages, the stem has a watery, semi-transparent, yellowish to olive green appearance along one side. This extends down the stem from below the point of attachment of a leaf for one to three internodes. Again, on another side of the stem, the infection may cover two or three different internodes or parts of the same ones. Most commonly the first three to five internodes are the worst infected. Such stems are usually healthy and normal below the ground. Soon after they take on this dark, olive green, watery appearance, there oozes out from the diseased tissue a thick, clear, viscid liquid which spreads over the stem and collects here and there in little bead-like

droplets. This exudate dries in a short time with a glistening finish, and gives the stem very much the appearance of having been varnished, and where the liquid has collected in little amber colored scales and has hardened, it looks as if the varnish had run and dried. Stems in this condition have a dry, slightly rough feel to the touch. The exudate also dries uniformly over the surface or just beneath it, and there produces a dark brown, resinous surface which blackens with age. Such stems are very brittle and easily broken, which fact makes it almost impossible to handle the crop without an immense amount of shattering.

If the epidermis is scraped from an infected stem, the tissue underneath has the same yellowish, watery appearance. This pathological condition extends to the center of the stem and if it is split lengthwise, the interior cavity presents a brownish, mealy aspect. Such stems will collapse much more readily when pressed between the fingers than healthy ones. A shoot in this condition is virtually girdled; its circulation is impaired and its food supply is practically cut off as is evident from the poor growth it makes. Some stems remain in this inactive state and struggle along until the mowing machine puts an end to their existence; others turn black, shrivel and die six weeks before time for the first cutting. During the past season, the disease appeared about May 15th, and up until June 10, twenty-six days later, there were no blackened stems to be found. During this period, the trouble was manifested by the characteristic yellowish green, watery look.

The leaves attached to the diseased part of the stem usually show a watery, pale yellow color at the base, along the mid rib of the leaflets, and especially in the tiny petioles. Those on the parts of the stem which are blackened are always dried up, yellow and extremely brittle. The stipules at the base of the petioles are yellow and brittle and usually show the disease before their corresponding leaves.

Sometimes the leaves exhibit the infection independently of the stem. In this case the petioles become watery, pale yellow and droop. The malady may be confined to the petiole and base of the leaflet or it may involve the whole of the blade. Occasionally leaves are found where the inoculation has been made, apparently, in the margin of the leaflet, and the infection has proceeded toward the middle. In such instances, the tender tissue has a watery look, as if it had been bruised. These leaf infections have been observed to occur a little earlier than the stem troubles, although it may be merely a matter of being able to detect the pathological condition there first.

One year old plants may exhibit blackened areas in the crown, and black streaks which run down into the tap root. As the plant

grows older, this blackening increases until the whole crown becomes involved and either the crown buds are destroyed or the root is no longer able to perform its functions, and the plant dies.

So far as our present observations go, the disease appears to run its course with the first cutting, and those plants which have sufficient vitality, throw out a good growth for the second and third cuttings. Strange as it may seem, there is little or no trace of the blight during the remainder of the season, but in the following spring, a renewed outbreak may be looked for. The severity of the attack seems to vary from season to season. As has been noted before, the trouble was moderate in 1904; in 1905 it was practically unseen; in 1906 and 1907 it was extremely bad; in 1908 the attack was mild and during the past year there was but little to be found. This season the crop was the best that has been harvested for four years. This variation in the degree of the attack would seem to indicate that there may be some relation between the prevalence of the disease and the weather conditions, especially late frosts and late freezing, intermingled with warm, pleasant days as compared with a late, cold spring. Not many plants are killed the first year, but they begin to die after the blight has been prevalent more than one season, and after three or four years so many of them may be missing that the stand is practically worthless.

CAUSE OF THE DISEASE.

If a small piece of the yellowish green, watery tissue from a diseased plant, it matters not whether it be stem or leaf, is placed in a drop of clean water on a glass slide, there will appear on all sides of it, after half a minute, a dense, milky cloud, which can be seen readily with the naked eye, and which slowly diffuses out into the drop. When this preparation is examined under the low power of the microscope (Leitz Objective No. 3, Eye Piece IV.) this milky zone easily resolves itself into swarms of bacteria, which under the high power (Leitz Objective No. 7, Eye Piece IV.) can be distinguished as actively motile rods, relatively short and thick, with rounded ends and occurring for the most part singly and in twos.

If the surface tissue is removed and a portion of the deeper layers is examined, identically the same results will be obtained. If a fragment of the dried exudate is likewise placed in a drop of water, the whole gradually disintegrates and becomes a milky cloud, which under the microscope is a mass of motile bacteria.

Out of twenty-one infected stems examined and plated at different stages of the disease, thirteen gave pure cultures of this colony in the Petri dishes. In seventeen plates, it was the dominant colony. Platings from five different leaves gave pure cultures in three cases and in four out of five the above colony was the most

abundant. In other words, pure cultures were obtained in 62 per cent of the original isolations and in 81 per cent this white colony was dominant. In two out of twenty-six isolations or in seven per cent, it was absent. Plates made from the moist or freshly dried exudate, as a rule, gave pure cultures of the same organism.

Inoculations have been made upon alfalfa plants, grown under greenhouse conditions, with the three different cultures which have been isolated during this investigation, namely, the characteristic white one, the yellow and the orange, and the only one which has produced typical symptoms of the disease, in fact the only one which has produced any pathological condition whatever, is the dominant white colony referred to so frequently above. Cultures obtained from stem, leaf, petiole, or exudate, were equally pathogenic.

In order to establish further the fact, that this germ was the unmistakable cause of the trouble, an alfalfa plant was inoculated June 7, 1909 with our present stock culture of the causal organism, to which the name *Pseudomonas medicaginis,* n. sp. has been given, which was isolated from an infected stem May 27, 1909. By June 19, typical symptoms had developed, and plates were made from the yellowish green, watery tissue. On June 21, the Petri dishes showed a pure culture of the same white colony and the organism was reisolated on an agar slant. When compared with the original culture, the recovered organism was identical both in the hanging drop and when stained with aqueous fuchsin. The reisolated culture was again inoculated, June 25, by needle pricks into three different stems, and all of the inoculations gave positive results; the needle pricks showed a yellow, watery zone around the point of infection after nine days, and later turned black. When material from these diseased areas was examined microscopically, August 16, the same milky cloud appeared in the mount as has been described for field material, and swarms of motile rods were visible.

In all, one hundred and two inoculations have been made with this culture, introduced either by scraping the stem or by needle pricks, and positive results have been secured with one hundred per cent of the infections. Control inoculations with a sterile needle have been carried along with all of the experiments, and in no case have any of the check plants developed symptoms of the disease.

METHOD OF INFECTION.

In an effort to secure a satisfactory explanation of the method of infection, the writer spent over a month in the field where the disease is most prevalent. As a result of the daily observations and the gross and microscopic examination of more than three hundred plants, collected at all stages of the disease, before it made its appearance and until it was flourishing, he believes

the following to be the most tenable and satisfactory solution of the question.

This phase of the investigation was carried on at Gypsum, Colorado, where our first observations were taken May 4, 1909; this was early in the spring for this locality and altitude (over 6,000 feet above sea level). The season was considered cold and backward, and a moderately heavy snow had fallen one week before; traces of this were still to be seen in the valleys, and the surrounding hills and mountains were heavily covered.

The alfalfa was just beginning to grow, the average height in the diseased fields being from 1½ to 2 inches. Most of the plants had a yellowish green color due, presumably, to the cold. An examination of the young, succulent shoots showed that the epidermis of practically every one of them was wrinkled just below the point of attachment of the first four or five leaves, and often this wrinkling extended half way to the next leaf below. The epidermis was loose from the tissue beneath and appeared to be too large for the stem. When this was peeled off, the underlying tissue had a yellowish, green color much like the diseased plants, but a microscopic examination of such material failed to show any micro-organisms present. In those parts of the stem where this wrinkling was absent, the tissue beneath the epidermis was not yellow, but a whitish green. In many plants, the loosened epidermis had the appearance of partially collapsed blisters, while around and underneath these blisters the tissue seemed darker than normal and watery, with a suggestion of its having been frozen. Numerous lenticular breaks occurred in the epidermis of some stems. These might have been due to insect work although rather early in the season for this. Occasionally stems were found where the wrinkled epidermis had split open for a distance of one centimeter, exposing the moist pyrenchyma beneath.

Ten days later, May 14, the epidermis of practically every stem in the field was split wide open from node to node over the first six internodes, the third to the fifth internodes being the most common. This splitting appeared to have begun with the wrinkled epidermis mentioned above, and had extended the whole length of the internode thereby exposing the succulent, moist tissue beneath to infection. It is the concensus of opinion of those who have observed this phenomenon, that both the breaking away of the epidermis from the underlying tissue and the wrinkling and subsequent splitting are caused by freezing. A similar trouble ascribed to freezing has been observed in cherry trees and less frequently in the apple. Here the bark cracks and later splits open, exposing the green wood beneath just as in the alfalfa stems.

Anyone who has ever lived in Colorado is familiar with the


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soil carrying capacity of our winds, and with this in mind, it is easy to understand how germ laden soil might be blown into these cracks, where it would adhere to the moist, exposed surface, and bring about a fatal inoculation. As a matter of fact, soil was always found adhering to these surfaces, and, already, typical cases of the disease were developing. A microscopic examination of the tissues from the injured areas usually showed the germs to be present in great numbers, while ten days previous, that is before the splitting had occurred, there was no indication of any infection. Invariably, the disease appeared first and was worst on those parts of the stem where the epidermis had split and where soil had been caught in the open wound. A striking example of this was seen in an alfalfa field adjacent to a field which had been cultivated recently and sown to oats. The oat field was on the windward side, and with every gust, quantities of fine soil were carried over into the alfalfa. All along this side of the field, there was an aggravated attack of the disease, extending twenty to thirty feet into the alfalfa and the whole length of the field. Every plant was gray with soil and it is only reasonable to suppose that the disease was more severe here than in the more remote parts of the field because of the heavier soil inoculation.

This explanation satisfies one of the most difficult questions which has arisen in connection with the problem, namely, why does the first cutting, alone, suffer from the attack? There are never any frosts after the first crop is out of the way, and consequently there are no split stems in which to start the infection.

In a preliminary report (1), the writer has suggested that possibly the constant tramping of cattle and horses, pastured on the alfalfa fields during the winter, might have split open the crowns and bruised the young, tender shoots so that during the first irrigation, soil containing the disease germs was washed into the injured tissue and started the trouble on the first cutting. Our observations during the past season do not warrant such a conclusion in the majority of cases at least, since, in the first place, the disease was active at least two weeks before the first irrigation, and in the second place, our experimental plats, to which stock had no access, suffered just as severely as the fields which were pastured.

Not infrequently, we find the disease at work on stems where there has been no apparent previous injury to the epidermis; sometimes this assumes the form of a continuous, unbroken infection of the whole internode, and again it occurs as separate, punctiform lesions giving the stem a speckled appearance. This last condition would seem to indicate an infection through the stomata, and inasmuch as we have been able to secure successful inoculations in the

(1) Bulletin 138, Colo. Exp. Sta., Jan. 1909.

greenhouse by applying the culture to the unbroken epidermis, it is altogether possible that stomatal infections take place under field conditions. The leaflets often exhibit yellowish, watery areas along the margin and the larger veins when there is no evidence of the trouble in any other part of the plant; again, the tiny petioles succumb to the disease independently of either the stem or the attached leaflets. Water pore and stomatal infection similar to that described for the black rot of cabbage may explain these cases.

There are doubtless other ways in which infection can take place, but the methods described above, especially the inoculation through the split epidermis, seem to be the most common. It is possible that added observations of another season will give us more light upon this point and so rather than draw any final conclusion as to the *one way* in which inoculation takes place in the field, we prefer to leave the question open.

GREENHOUSE EXPERIMENTS.

The constant occurrence of characteristic white colonies, in such a large percentage of our plates, was sufficient to make us suspicious that the micro-organisms making up such colonies were the immediate cause of the disease. However, the crucial test of a pathogenic organism is its power to reproduce the given disease when introduced in pure culture into its normal host. Accordingly, we have fulfilled this requirement by making a large number of inoculations upon alfalfa plants under greenhouse conditions, and by this means we have been able to establish *Ps. medicaginis, n. sp.* beyond the remotest shade of possible doubt, as the unquestionable cause of the trouble. We have reproduced the infection in from five to seven days with practically its characteristic field symptoms, and we have been able to follow its progress through the different changes up to the blackening and complete destruction of the stem after six weeks.

In order to determine whether the infection was communicated to the plants through the roots, twelve pots were prepared with sick soil containing quantities of the diseased stems. Fifteen germinated alfalfa seeds, which had been sterilized previously in a 1-500 mercuric chloride solution, were planted in each of the above pots. A good, vigorous stand was obtained. The possibility of frozen stems was eliminated by growing the alfalfa in the greenhouse and the danger from dust infection was reduced to a minimum by keeping the surface soil in the pots moist. These plants are now sixteen months old and up to the present time not a single stem in any of the twelve pots has shown any sign of the disease. From these results, we can say with a reasonable degree of certainty, that the disease is not, primarily, a root trouble, and if the roots do become

diseased. the infection must start from the crown and work downward.

FIELD EXPERIMENTS.

Inasmuch as the disease seems to be directly tracable to soil infection, and consequently may be considered a soil trouble, the only practical method of controling it is by the introduction of resistant varieties. To this end we have planted twenty-six varieties of alfalfa on sick land with the hope of obtaining one or more blight resistant strains. The seed for this work was procured from the United States Department of Agriculture through Mr. W. J. Brand, and planted April 16 and 17, 1907. The ground upon which the plats are located is owned by Hon. J. L. Chatfield, and had been in alfalfa a number of years, was plowed in the spring of 1905 and planted to oats and potatoes; in 1906 again planted to oats and produced 100 bushels per acre. The rows of the plot are about fifteen rods long and run from east to west. Two rows of each variety were planted through the plot, then the series was repeated in the same order but only one row of a kind was used. The variety designated as Gypsum No. 1 was grown from cuttings which were taken from land that had been in alfalfa, and was plowed up because of the prevalence of the disease, and planted in oats. These plants were very vigorous at the time the cuttings were made. This part of the work was begun by Professor Paddock over two years ago.

The following is a list of the varieties which we have used in our field tests.

No. 9451, Sairam.
No. 11275, first quality commercial.
No. 12398, from Colorado.
No. 12409, Utah, non-irrigated.
No. 12671, from Kansas.
No. 12702, from Sherman, Texas.
No. 12747, from Billings, Mont.
No. 12748, from Germany.
No. 12784, Utah, irrigated.
No. 12801, from Texas Panhandle.
No. 12816, from Chinook, Mont.
No. 12820, from Nebraska.
No. 12846, from Kebilli Oasis, Tunis.
No. 13291, from New York.
No. 13259, from Nebraska.
No. 13857, from Simbirsk, Russia.
No. 17698, from Chinook, Mont.
No. 18751, from Turkestan.
No. 19508, from Kansas.
No. P. L. H. 3251, grown in South Dakota, from Baltic seed.
No. P. L. H. 3252, also grown in South Dakota.
No. 9322, from Touggourt.
No. 12694, from Provence, France.
No. 9453, from Bokhara.
No. 13437, from Arizona.
No. 1, Gypsum, Colorado, from cuttings.

A very satisfactory stand was secured with all varieties except No. 12,846 and No. 9,322. When the plants were one year old, they were examined very carefully for the presence of the disease with the result that all varieties but one, P. L. H. 3,251, were affected to a greater or less degree. While not all of the plants in each variety were suffering, some from each, with the exception of the one mentioned above, were diseased. Table No. 6, below, gives the results of these observations which were made June 20, 1908.

TABLE NO. 6

Showing Condition of the Different Varieties of Alfalfa When One Year Old. June 20, 1908.

Variety	Stand	Vigor	Prevalence of Disease	Size of Plants
9451	Fair	Fair	Present	Medium and small
11275	Good	Good	Present	Variable
12398	Fair	Fair	"	Variable
12409	Good	Good	"	Large
12671	Fair	Good	"	Variable
12702	"	Fair	"	Variable
12747	"	Good	"	Large
12748	"	Very good	"	Large
12801	"	Fair	"	Small
12816	"	Good	"	Variable
12820	"	Good	"	Variable
12846	Very poor	Very poor	"	Almost no plants
13291	Poor	Fair	"	Large
13259	Fair	Fair	"	Small
13857	Poor	Good	"	Large, varieties mixed
17698	Very good	Good	"	Low and large
18751	Good	Good	"	Variable
19508	"	Fair	"	Small
P. L. H. 3251	"	Very good	Absent	Large
P. L. H. 3252	Fair	Fair	Present	Small
12694	"	Poor	"	Frost bitten, varieties mixed
9453	"	Fair	"	Large spreading
13437	Poor	"	"	Small
12784	Fair	"	"	Variable
9322	.....	.....	.....	No plants
Gypsum 1	Very good	Very good	Present	Small

Similar observations, made June 11, 1909, when the plants were two years old, showed that all varieties were affected, including P. L. H. No. 3,251, which had promised immunity the previous season. At this time of the year, the alfalfa was from ten to twenty inches high; the majority of it had a good color, and while the blight was present in all varieties, it was not abundant enough to do any serious damage to the crop. Only a few stems of each plant were suffering and only the lower internodes of these. Such stems had the characteristic watery, yellow green color, very little blackening having occurred up to this time. Occasionally plants were found on which the attack had been so acute that they were entirely destroyed. Their location was marked only by patches of dwarfed, shriveled

stems, now dried and prostrate. Four of the twenty-six varieties were noticibly freer from the infection than the rest, namely, No. 12,398, No. 12,671, No. 12,784, and P. L. H. 3,251. It is a matter of considerable practical interest, that the first three of these are from seed which we may consider as home grown; the first is from Colorado, the second, Kansas; the third, Utah. If we are so fortunate as to find high resistance in plants from local seed, the question of obtaining resistant varieties will be much more easily solved than if we are compelled to breed up a strain from foreign seed. Table No. 7 gives the detailed observations on the variety plats, made June 11, 1909.

TABLE NO. 7

Showing Condition of the Different Varieties of Alfalfa when Two Years Old. June 11, 1909.

Variety	Vigor	Prevalence of the Disease
9451.....	Fair	Present
11275.....	Fair	Present
12398.....	Good	Present, but not serious
12409.....	Fair	Present
12671.....	Good	Present, but not serious
12702.....	Good	Present
12747.....	Good	Present
12748.....	Fair	Present
12784	Good	Present, but not serious
12801.....	Poor	Present
12816.....	Fair	Present
12820.	Good	Present
12846.....	No plants	No plants
13291.....	Fair	" "
13259.... ..	Fair	" "
13857.....	Poor	" "
17698.....	Good	" "
18751.....	Fair	" "
19508	Good	" "
3251.	Very good	Present, but not serious
3252.....	Fair	Present
9322.....	No plants	No plants
12694.	Very good	Present, but not serious
9453.....	Poor	Present
13437.....	Fair	Present, but not serious
GypsumNo.1	Good	Present, but not serious

We shall continue this part of the investigation with the same, as well as additional varieties, since the only practical way of testing out the disease resistance of these different kinds of alfalfa is to grow them under actual field conditions on infected soil, where natural agents are at work. We shall introduce, also, legumes other than alfalfa, in order to determine the susceptibility of these to the disease, so that we may be in a position to recommend other crops as substitutes where the land is so badly infected as to make profitable alfalfa growing no longer possible.

PREVENTION AND TREATMENT.

Where the areas under cultivation reach such tremendous proportions as the alfalfa fields on the mountain ranches, all schemes for soil sterilization are obviously impracticable at the outset. The same may be said of the use of germicides to be applied to the plants either in the form of sprays or otherwise, for even though some such means should be discovered by which the infection could be prevented, the cost would undoubtedly make it prohibitive. Obviously, then, as stated before, the only practical way of combating and controlling the blight is by the introduction of resistant varieties. What is being done in this direction has been mentioned before.

Our field observations during the past year seem to indicate that immunity to the disease is closely related to resistance to late spring freezing. On the one hand, those plants which were severely injured by the late spring frost were, without exception, the first to show the disease and were the worst infected later in the season; on the other hand, those varieties which grew from hardy stock and which suffered only slightly from the frost, were more nearly free from the blight. This coming year we shall endeavor to determine whether the relation between disease resistance and frost resistance is a constant one, and if it proves to be such, then we shall attempt to stamp out the trouble by securing frost resistant varieties.

In the meantime, we recommend, as a means of control, that the frosted alfalfa be clipped as soon as one is reasonably certain that there is no more danger from frost. By this means, the frost split stems, in which the disease appears to originate, will be gotten rid of, thus affording an opportunity for the early growth of a new cutting. Prof. P. K. Blinn, who has charge of the Experiment Station work at Rocky Ford, informs the writer that this practice of early clipping to remove the frost bitten shoots, which retard growth, is rapidly growing in favor among the farmers in his locality.

ACKNOWLEDGMENT.

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EXPLANATION OF PLATE.

Fig. 1, Alfalfa stem, inoculated by smearing the freshly scraped stem with a 48 hour culture of Ps. medicaginis, x 2; 40 days after inoculation.

Fig. 2, Diseased alfalfa stem showing the yellowish, olive green color, characteristic in the early stages, x 2. Field specimen, natural inoculation.

Fig. 3, Diseased alfalfa stem showing the blackened condition in the

late stages of the blight, x 2. Field specimen, natural inoculation.

Fig. 4, Alfalfa stem, inoculated with a 48 hour agar culture of Ps. medicaginis by means of needle pricks, x 2; 15 days after inoculation.

Fig. 5, Alfalfa leaf showing diseased, yellow areas, apparently of water pore or stomatal infection, x 2. Field specimen, natural inoculation.

SUMMARY.

The disease has been known in Colorado since 1904, where, in some localities, it has caused the loss of practically eighty per cent of the first cutting.

Within the state, it is known to occur in Eagle, Garfield, Mesa, Delta and Otero counties.

The blight makes its first appearance from the first to the fifteenth of May, depending somewhat upon the locality.

The stems appear watery, semi-transparent in the early stages, and have a yellowish, olive-green color which soon changes to amber, due to the appearance and subsequent drying of a thick, clear exudate. This dried excretion gives the stems a shiny, varnished appearance, and a slightly rough feel to the touch. These stems blacken in six to eight weeks, become very brittle and are easily broken, which fact makes it almost impossible to handle the crop without an immense amount of shattering.

The disease seems to run its course with the first cutting, and is not seen again until the next year.

The cause of the blight is a germ, **Pseudomonas medicaginis, n. sp.**, which, presumably, lives in the soil and enters the plants with soil through stems which are cracked and split by late freezing.

No varieties of alfalfa entirely resistant have been obtained up to the present time.

As a means of control, we recommend that the frosted alfalfa be clipped, with the mower set low, as soon as it is reasonably certain that the danger from late frosts is past. This will rid the plants of the diseased portions, and afford an opportunity for the early growth of a new cutting. If this is done in time, the regular number of cuttings should be secured with little or no loss in tonnage.