UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION

Department of Entomology

The Eelworm Disease of Red Clover

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BULLETIN NO. 130 MARCH, 1922

Published by the University of Idaho, Moscow, Idaho.

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THE EELWORM DISEASE OF RED CLOVER

RALPH H. SMITH

A disease of red clover popularly known as "winter killing" has been the cause of growing concern and considerable financial loss to the farmers of southern Idaho during the past few years. The disease is characterized by the plants rotting off at the crowns, chiefly during the cooler seasons of the year, and is caused by a minute parasitic worm commonly mentioned in European literature as the stem and bulb eelworm.* It is probable that the pest was introduced into Idaho or other parts of the Northwest in clover seed imported from European countries. Since this eelworm is destructive to numerous cultivated crops in Europe, together with the fact that eelworms are among the most difficult pests to control, its presence in this country may well be looked upon with grave concern.

This bulletin is intended to supply information of general interest concerning the parasite and the disease caused by it, and to report preliminary investigations which have been made in Idaho.

History of the Eelworm in Idaho

According to information gathered from farmers in Canyon County, more or less trouble has been experienced with the disease since the winter of 1913-14. The malady commonly was diagnosed as winter killing until in 1918 when the writer investigated the disease and established the fact that it was produced by the eelworm organism above referred to. As might be expected under irrigated conditions, the disease has spread rapidly and now is generally distributed in most of the large clover growing sections of the state.

Known History in North America

The first published report of the occurrence of the parasite in North America was made by Dr. E. A. Bessey (1) who found it damaging a field of rye at Edgerton, Kansas, in 1907. So far as the writer has been able to ascertain the pest has not been found anywhere in Kansas subsequent to the report mentioned. During the summer of 1913 it was found to be the cause of a disease of hyacinths in a bulb propagating garden at Bellingham, Wash., (3) where it probably had been introduced in bulbs imported from Europe. In 1915 Prof. A. L. Lovett (4) found it attacking red clover at Redmond, Oregon, and the following year he observed it on strawberry plants at Corvallis, Oregon, (5). The occurrence of the

* *Tylenchus dipsaci* Kuhn.

pest in Idaho, eastern Oregon and Washington, and northern Utah was reported by the writer (4). During the summer of 1921, it was found by officials of the Oregon Experiment Station to have become established on alfalfa at Hermiston, Oregon, in an irrigated section. Judging from the results of experiments made in Idaho and from the work of European investigators, there are reasons for believing that the occurrence of the eelworm on rye in Kansas, on hyacinths in Washington, and on strawberries in western Oregon, has no connection with the development of the pest on red clover; neither does it seem probable that there is any relationship between the infection of alfalfa at Hermiston, Oregon, and the red clover disease. (See topic Biological Strains).

The eelworm is believed by German scientists (6) to have been present in parts of Germany as early as 1819 in which year Schwartz (7) published an account of a disease of red clover which agrees with remarkable accuracy with the disease as it is known today. The parasite was described by Julius Kuhn in 1859 (8) from infected blossoms of *Dipsacus* or teasel. Following this the same organism was redescribed under different names from various plants, one of the later names being *Tylenchus devestatrix* Kuhn, by which the pest commonly is known in European literature. Subsequent to 1870 this eelworm has been reported from Hungary, Holland, Denmark, Belgium, Norway, Sweden and the British Isles, attacking a large number of cultivated plants including potatoes, beans, sweet peas, oats, rye, buckwheat, wheat, hops, clover, onions, lilies, tulips, narcissus, hyacinths, phlox, daisies, cornflower, shepherd's purse, buttercup, sow thistle and many other species of flowers and wild plants. In 1908 it was reported as a pest in New Zealand (9), the following year it was reported as a pest of potatoes in New South Wales (10) and of alfalfa in South Africa (11), (12). It has been known as a pest on onions in parts of Australia since 1890, (13).

Characteristics of the Disease

Ordinarily the farmer does not notice that anything is particularly wrong with his red clover until he observes that the plants fail to start growth as they should when the weather becomes favorable in the spring. Casual examination of the field indicates that many plants apparently have died during the winter. The crowns of many other plants are much stunted and are easily kicked from the ground when struck with the toe of one's shoe. Closer examination of an affected crown shows that the buds and young shoots are stunted, swollen and spongy. A larger number of buds than usual occur in the crowns but these all are swollen. The bases of the buds and shoots are brown and decayed so that they easily break away from their attachment to the top of the root. Brown, decayed places occur elsewhere on the buds, shoots, and leaf stipules. The leaves

are crinkled and the stems of the leaves are short, thickened, distorted and often partially decayed. Commonly a much larger number of leaves than usual occur in the crowns. The roots, altho not directly attacked by the worms, gradually die and decay as a result of the rotting of the stems and buds.

Altho a small percentage of fields may die out the first spring after seeding, the greater injury usually occurs during the fall, winter and spring of the second year.

Figure 1.—Red clover plants that were killed during the winter and early spring by the eelworm parasite. Photograph taken April 20, 1920.

Habits and Life History of the Eelworm

The eelworm belongs to a group of worm-like animals known to science as nematodes. There are a great many different species of nematodes but only a very small percentage are parsitic on plant life. The clover nematode is only about 1-25th inch in length and about 1-500th inch in width, and is too small, therefore, to be seen with the naked eye, as it occurs in the tissues of the plants. If the diseased parts of a clover plant are finely shredded in a glass of clear water, however, and then held to the light, the minute, wriggling, eel-like organisms may be observed. The eelworm subsists on and reproduces in the tissues of the plants and also in moist soil containing decaying plant matter. It enters the stems of the plants at the surface of the soil by means of a minute spear which is protruded from the mouth.

Enormous numbers of eggs are deposited in the tissues of the plants.

The eggs hatch into larvae or young worms which after undergoing a number of molts, become mature. The egg is surrounded by a chitinous-like membrane and is very resistant to changes of temperature, to drying, and to the influence of chemicals. As the plants mature the majority of the worms are said to migrate back into the soil but the eggs and many of the undeveloped worms dry up in the above-ground parts of the plants

Figure II.—(A) A cluster of diseased red clover buds(a): A healthy red clover stem (b). (B) A diseased crown of red clover as it appears in early spring, showing the numerous crinkled leaves, reading from left to right.

and regain animation when they come under favorable conditions of heat and moisture.

The eggs and immature worms have remarkable powers of viability especially when they are kept in a dried condition. Infested red clover plants collected in August 1918 were soaked for a few minutes in luke warm water in February 1921 and it was found that a number of the immature worms became active. Under field conditions where the soil is frequently wet and especially in cultivated fields where the soil is frequently stirred, the organisms probably retain their viability for only a short period.

Biological Strains

The eelworms attacking each of the different crops previously mentioned appear to be morphologically the same species of organism, yet

they present certain important biological differences. For example, the worms affecting red clover in Idaho do not under field conditions attack alfalfa, strawberries nor any of the cultivated crops which have been reported as hosts in foreign countries. Similar observations were early made in Europe. In explanation of this peculiarity of the eelworm, the Dutch scientist, Dr. Ritzema Bos, advanced the theory (14) that the parasite after subsisting for a period on a particular kind of plant, finally becomes specialized in its ability to attack and thrive on the one plant and

Figure III.—A number of red clover stems showing distortions and swellings typical of eelworm injury.

is not able to readily attack a plant of a different kind. Thus there appear to be several more or less distinct biological strains of the parasite, including the red clover strain, the alfalfa strain, the onion strain, the strawberry strain, the rye strain and others.

According to the biological strain theory, one might conclude that in the course of time the clover eelworm in Idaho will gradually adapt itself to alfalfa and to many other crops which are attacked in different foreign countries. Preliminary field observations that have been made, however, do not support this apprehension. Thus opportunity was afforded the past four years to study the behavior of the parasite in a seven acre orchard near Twin Falls, which has grown red clover continuously since 1916. The ground was not plowed in the six years. The clover was observed to have been badly diseased in the spring of 1918 and altho a

large percentage of the older plants died each year, enough seed fell to the soil to keep the crop from dying out. Originally there was a strawberry bed about fifty yards long on one side of the orchard and by the spring of 1918 the plants had spread into the clover, and clover plants also had become established in the strawberry bed. Scattered thruout the clover, also, were numerous plants of alfalfa, alsike clover and white clover. Altho these plants have grown for at least four years in soil

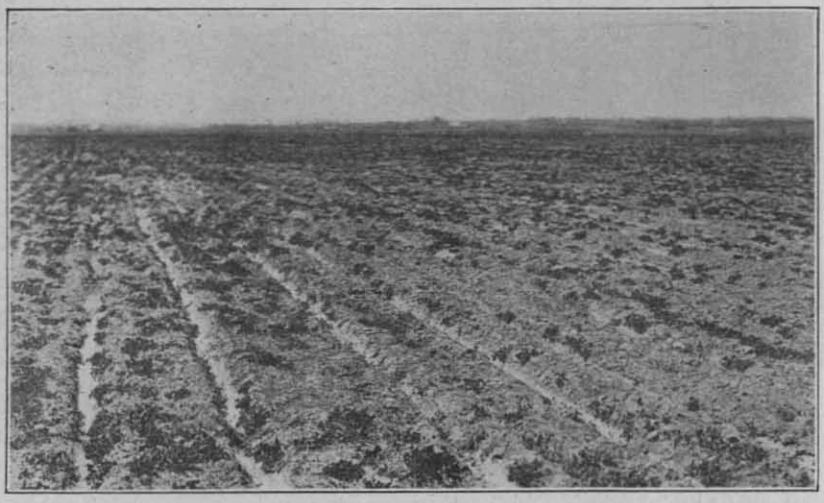

Figure IV.—Red clover field injured by the eelworm parasite. Photograph taken April 28, 1920.

thoroly permeated by the eelworms and in close proximity to diseased red clover plants, no infection of strawberry, alfalfa nor alsike clover has been detected. In the spring of 1921 slight infection of white clover was observed. There is the possibility, however, that after a still longer period the other plants might become subject to attack.

Host Plant Experiments

In the spring of 1919 a one-acre plot of badly diseased red clover was plowed in the usual manner and planted to potatoes, garden varieties of peas, beans and onions, and to rye. In a few instances small galls and brown infested places containing eelworms were observed on the beans just as they were coming thru the ground. A few of the plants succumbed to the attack but the majority overcame the injury. No injury was noticed on any of the other plants. Observations also were made in a number of diseased red clover fields which were plowed up in the spring and planted to various crops including beans, wheat, oats, rye and

potatoes but in no case were any of the crops found to be affected by the parasite in the slightest degree.

Flower pots were filled with soil that was removed from around the crowns of diseased red clover plants and parts of diseased crowns also were shredded into the pots. The following seeds were then planted in separate pots: garden varieties of peas, beans, and onions; different varieties of alfalfa (*Medicago sativa* Linn.) including Chilean, common, Grimm, smooth, Peruvian and hairy Peruvian; hairy vetch (*Vicia villosa* Roth), crimson clover (*Trifolium incarnatum* Linn.), Egyptian clover (*T. alexandrianum* Muhl.), alsike clover (*T. hybridum* Linn.), Carolina clover (*T. carolinianum* Michx,), low hop clover (*T. procumbens* Linn.), Japanese clover (*Lespedeze striata* Hook and Arn.), small hop clover (*Trifolium dubium* Libth.), the sweet clovers (*Melilotus alba* Desv.), and (*M. officinalis* Linn.), rye, wheat, and oats. Slight infections in the form of swellings and brown spots on beans, peas, fall vetch, Egyptian clover and alsike clover were observed on the plants just as they were coming through the soil or soon thereafter but with few exceptions the plants recovered from the attacks and the worms appeared to withdraw from the tissues as the plants developed.

A number of instances have been observed where fields of alsike clover have died out rather suddenly in autumn after the seed was cut. Growers often have associated this with the eelworm disease of red clover, but of several such fields examined, no trace of eelworm infection was found.

Methods of Dissemination

Altho investigations made in Europe show that the eelworms may be carried in dust particles by the wind, on the feet of animals, on farm implements, and in straw, seed and manure of animals, yet investigations in Idaho indicate that all of these are relatively negligible as compared with irrigation water as the disseminating agent in irrigated sections. It has been observed that infection in fields spreads in the direction that water flows across irrigated fields. Frequently all plants below a certain point in a corrugation were found diseased while those above the point were not affected. In view of the fact that diseased red clover plants occur in comparatively large numbers along the banks of irrigation ditches and that, in occasional instances at least, waste water from clover fields drains back into the ditches, it is probable that all irrigation water in infected sections is more or less contaminated with the eelworms.

It also has been ascertained that the eelworms are carried to some extent in particles of clover plants which get into the seed in the threshing process. Seed which has passed thru a cleaning mill, however, has been found to be practically free from the worms. An examination of

twenty-two samples of red clover seed as it came from the threshing machine revealed living eelworms in four out of the twenty-two samples while no worms were found in the same samples after the dirt and chaff had been removed from the seed.

Control Measures

Much experimental work has been done in Europe to determine methods of directly destroying the eelworms in infested soil by the application of chemical substances. The results obtained as reported at pres-

Figure V—Red clover field affected with the eelworm disease, as it appeared in spring. It will be noted that the plants on the low parts of the field are practically all dead.

ent indicate that this method of control would not be practicable under farming conditions such as are followed in Idaho. Based on the information available in European literature and on observations made in Idaho, the most dependable and most practicable way of control is crop rotation. Red clover fields should be plowed under not later than the third fall or winter after seeding and sooner if they become materially diseased. A considerable number of fields have been observed which were seriously affected the third spring after seeding but eventually they largely overcame the disease. The usual experience has been, however, that when any considerable proportion of the plants show definite signs of infection, the most profitable procedure is to plant the field to another crop.

No experiments have been made on rotations in Idaho but judging

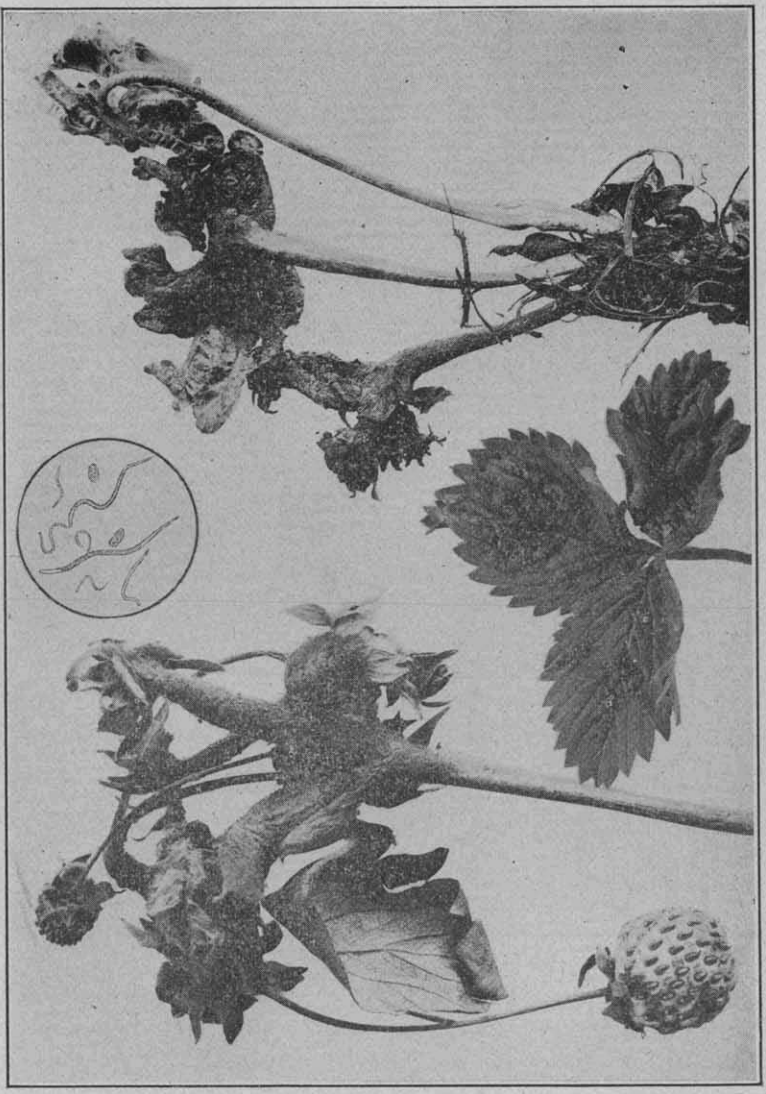

Figure VI—Strawberry plants affected with eelworms. (Courtesy of the Oregon Experiment Station).

from work done elsewhere, it would not be advisable to reseed red clover on a field until it had grown other crops for at least two years. Only thoroly recleaned red clover seed should be used for seeding, in order to eliminate the possibility of infection from the seed.

It has been determined that the excessive use of irrigation water such as flooding the corrugations, flooding low parts of fields and too frequent irrigation, tends to augment the rate of infection and the destructiveness of the eelworm. Level fields on which the water flows sluggishly invariably have been more susceptible to serious injury than fields having slope enough to afford quick drainage.

The Eelworm Diseases of Alfalfa and Strawberries

It will probably be only a comparatively few years until the alfalfa eelworm and the strawberry eelworm will have become established within the state of Idaho. Farmers should familiarize themselves with the characteristics of the disease so that they may be able to detect incipient infections and report them to Agricultural Experiment Station officials while there may yet remain the possibility of eradication.

Characteristics of Alfalfa Eelworm Disease

As with red clover, the eelworm disease of alfalfa is most noticeable during spring. Infected crowns appear sickly and make slow stunted growth as compared with healthy plants. The buds and shoots are swollen, distorted, more or less wrinkled and discolored. The pith of the stems is brown and the infected stems readily break from the top of the root. On older stems, swellings may occur any place from the bases to the tops, and enlargements may extend for several inches or they may be abrupt.

Characteristics of the Strawberry Eelworm Disease

The most obvious symptoms of the disease on strawberries are enlargements and distortions of the stems, petioles and runners. Commonly the tops of the flowering stems, petioles and leaves are swollen, dwarfed and abnormally shaped.

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