PROGRESS IN DEVELOPING RESISTANCE TO ROOT ROTS IN HIGHLY NONDORMANT ALFALFAS

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The major areas of adaptation for highly nondormant alfalfas in the United States are the low desert valleys of California and Arizona where root rots have been the most important cultural problem since alfalfa was first grown. Three root rots contribute to most of the stand depletion caused by these diseases. Phytophthora root rot canker and scald or flooding injury occur only during the hot summer months. Since all of these root rots are aggravated by excessive water, the problem is also closely related to irrigation techniques, the slope of the land, and land leveling.

It is generally agreed that varieties can be developed with resistance to most root rots. However, it is also agreed that there are limits to the amount of resistance that can be placed into an alfalfa variety. The plant breeder will be unable to place enough root rot resistance into alfalfa to make it into an aquatic plant or as one Farm Advisor said, "You cannot expect to find an alfalfa variety that will grow in the bottom of an irrigation ditch." The alfalfa breeder can add resistance to varieties, but the grower can reduce or eliminate the benefits of this added resistance by using poor irrigation practices, leveling his fields with less fall (making them flatter), and increasing the length of water run.

In the past, growers attacked the root rot problem by drying their fields during the latter part of the summer, renovating, replanting, and then starting another alfalfa growing season by irrigating about October 1. This meant alfalfa was grown almost as an annual. These fields had fairly steep grades in order to remove most standing water. Very often growers would plant about 30 pounds of barley per acre when reseeding so they would have some forage to harvest before the end of the year. Most drying and renovating of entire fields was discontinued by the early 1960s due largely to the development of the variety Moapa and better land leveling techniques. However, it is possible some drying and renovating may still be used. Today it is a common practice to spot renovate and reseed the poor spots in fields. This year it seems many entire fields had to be renovated and reseeded because damage was more severe than usual.

Even though root rots were a major problem for a long period of time, little or no work was done on them for many years because growers had learned to live with them and because the diseased roots were hard to see unless the plant was removed from the soil.

When the spotted alfalfa aphid was introduced into the desert Southwest, all the efforts of plant breeders seemed to turn toward solving that problem. Varieties resistant to the spotted alfalfa aphid were soon released. Later varieties resistant to biotypes of the spotted alfalfa aphid and to the blue alfalfa aphid were also released. These problems were severe, but they were also on the tops of the plants where they could be seen easily. In addition, they were new problems and we had not learned to live with them. During this "aphid period" only limited work was done on root rots.

PHYTOPHTHORA ROOT ROT

Phytophthora root rot is the first root rot on which considerable progress has been made. The organism causing this disease was first described in 1952 by Dr. D. C. Erwin. It was later found to be an important problem in the large alfalfa producing areas of the Midwest. This helped considerably because it meant that some of the many alfalfa scientists in the Midwest would start working on this disease. Germplasm having resistance was soon developed and good techniques to select resistant germplasm were also developed. Most progress in developing varieties was made in the Midwest on winter dormant alfalfas, but work was also being done on highly nondormant alfalfas. The first highly nondormant germplasm with some resistance to Phytophthora root rot (UC 38, 46, and 47) was released

in 1967. The first highly nondormant variety (UC Salton) with resistance was released in 1972. Since that time several varieties with resistance to Phytophthora root rot have been released. Most of the acreage in the low desert valley areas is now planted to these varieties.

The level of resistance to Phytophthora root rot in most highly nondormant alfalfa varieties released since 1972 is about 20 to 40%. This is lower than plant breeders would like, but resistance to aphids was the primary selection objective in most breeding programs for a long time. In addition, plant breeders were also trying to obtain multiple resistance in the highly nondormant varieties. That is, they were trying to get as many resistance factors as possible into the varieties before they were released. This meant that useable levels of resistance would be available for several factors rather than having high levels of resistance for only two or three factors.

There is a potential for more progress in improving Phytophthora root rot resistance in highly nondormant alfalfas. Resistance levels are increasing with the release of each new variety. Plant breeders can make progress with this disease since good techniques and germplasm are available. However, plant breeders are also trying to maintain and increase other resistance factors in highly nondormant alfalfas while doing this.

RHIZOCTONIA ROOT CANKER

Rhizoctonia root canker is another old disease which was probably a problem in some of the first alfalfa fields planted in this area. The disease is most severe late in the summer and, like Phytophthora root rot, is aggravated by excessive amounts of water. This disease was severe in many fields after the hurricanes in August and September of 1976 and 1977. The organism causing the disease attacks the small root hairs, moves through the root hairs to the main tap root where circular disease spots occur. Active disease spots are yellow in color. The inactive phase of the disease is seen as spots or pits on the root which are charcoal in color. The disease spots may girdle the root, and if this happens high enough, the plant may die. These diseased roots are very prevalent and easy to see when alfalfa fields are disked in late summer.

Since Rhizoctonia root canker is found primarily in the low desert valley areas of the United States and other hot areas of the world where few alfalfa scientists are working, this disease has received little attention. Some of the earliest work was done in the early 1940s by Dr. Oliver Smith, the developer of the alfalfa varieties Moapa and Lahontan. This work was done primarily with soil and plant material from Yuma, Arizona, and dealt mainly with the description of the disease. The first disease resistance work was done from 1954 to 1956 at the Imperial Valley Field Station, El Centro, by Stanford and Erwin. This work was discontinued when the spotted aphid was found in order to devote more effort to this insect. All these Rhizoctonia root canker lines were found to be susceptible to the spotted alfalfa aphid, but seed from this material was used to make the alfalfa germplasm pool from which UC Salton was later selected.

In 1980 a new Rhizoctonia root canker resistance program was activated. The objectives of this program were to develop resistant germplasm, selection methods, and testing procedures. The field plots used in these experiments were inoculated with the disease organism grown on oats. Seed was planted in the fall and the spring. New plots were started every year for the first three years. Tentative conclusions drawn from these experiments were: 1) Levels of infection similar to those found in many growers' fields were not obtained. 2) Rates of inoculum from 50 to 100 g of wet oat inoculum per square foot applied one or two times each year seemed to have no differential effect on alfalfa. 3) Plant infection was greater when planted on soils used for tests in one or more previous years. 4) Plant selection appeared ineffective when all plants in the experiment classed as resistant were combined into germplasm pools. Apparently too many plants with little or no resistance (escapes) were saved and this diluted the resistance. 5) Selection for resistance to root rot in general seemed to be as effective in improving resistance to Rhizoctonia root canker as selecting only on the basis of root canker symptoms.

More work has to be done to perfect the selection procedures and testing techniques. Questions to be answered are:

Should tests be conducted over a period of two or more years instead of the

year test now being used?

2 How can the level of infection be improved to the level found in many growers fields?

3. Can high levels of resistance be obtained?

4. Will the tests provide consistent results over several years?

The Rhizoctonia root canker work is being continued. We are attempting to discover all the details involved in growing plants under disease conditions which will permit us to make reliable selections with few escapes and to provide a test that will give repeatable and reliable results. Some resistance to Rhizoctonia root rot appears present in the latest group of alfalfa variety releases for this area, but reliable classifications of this material are unavailable at this time.

SCALD OR FLOODING INJURY

All alfalfa growers in the low desert valley areas have at one time or another lost large portions of their fields to scald or flooding injury. This disease is the most dramatic of all the alfalfa problems found in these areas. The stand may appear perfect prior to an irrigation. Then, after extra irrigation water is inadvertently applied or a rainfall occurs soon after an irrigation, enough extra water may be added to kill large portions of the field. The damaged field may change from a healthy green to light brown in a few days.

Scald or flooding injury occurs in other areas of the United States also, but because their temperatures are lower, the action is slow and often the water drains away before much damage is done. Individuals in other areas have various names for scald or flooding injury, but most often it is called drowning. Few people outside the low desert areas seem to realize these two problems have the same origin. Most scientists that have worked with scald believe it is due to replacement of air in the soil. High temperatures then hasten plant death by decreasing the oxygen levels in the water and increasing the plant's demand for oxygen.

The symptoms of the disease are a yellow to brown discoloration in the xylem or woody tissue in the root. Often the roots become spongy or soft and mushy, and the above ground portion of the plant is bleached. If only the top of the plant is affected and if no further overirrigation occurs, many of the plants having live roots will recover.

From 1956 to 1958 we did a series of experiments on scald. From these studies we learned that: 1) The soil must be in a saturated condition for 30 or more hours for scald to develop. 2) Scald will be more severe on freshly cut fields. We felt this was because some oxygen is transported from the leaves to the root. When there is little foliage available or it is covered by water, there is no way for the plant to obtain oxygen. 3) Fields should be allowed to grow for a few days before irrigating back after a cutting. 4) Driving over growing alfalfa plants is similar to cutting. Injured plants are then more susceptible to scald. 5) Irrigating at night will not prevent scald. The common belief is that water is heated as it passes over the hot soil and when this water strikes the plant, it is hot enough to damage or scald the plant. This cannot be substantiated by temperature records which show that the maximum temperature of standing water in alfalfa fields did not exceed that of the air temperature and was usually 4 to 8 degrees F lower. Maximum soil temperatures at a 2" depth were considerably below air temperature.

Essentially no plant breeding work has been done on developing resistance to scald. However, most of the highly nondormant varieties released in the past 10 years appear to have tolerance to scald. Apparently while plant breeders were developing germplasm with resistance to aphids and Phytophthora root rot, there was also some natural selection for resistance to scald. There are no scientific tests to show this as yet. Most evidence is circumstantial. For example:

> It is possible to obtain two crops of seed per year on newer varieties. If this was done on older varieties, the chances are that the field would be subject to severe scalding when starting the second crop of seed.

2. Newer varieties appear to withstand scalding conditions better than the older varieties both in growers' hay fields and in experiments where research workers are testing for resistance to other root rots.

During the past year we have started a program designed to develop germplasm with resistance to scald. Our first experiment was conducted in a cage where the plants were shaded and extra water had to be added because of shallow tile lines. We were able to obtain differential loss after completely submerging recently cut plants. Varietal differences significant at the 10% level were found. Because the differences were significant at only the 10% level and the test conditions were less than optimum, we are uncertain if the data will be repeatable.

A series of four scald experiments are planned for the summer of 1984 using named varieties from several locations in the United States. Some of these lines are expected to be susceptible to scald, others tolerant. Various test conditions and times will be examined and varieties will be classified.

Our first experiment on scald was encouraging. It seems that developing resistance and testing procedures for scald might be easier than for Rhizoctonia root canker. We hope we can repeat and improve on the 1983 experiment.

SUMMARY

Growers now have highly nondormant varieties with resistance to Phytophthora root rot and improvements should be found in newly released varieties. There appears to be some tolerance in most new varieties to Rhizoctonia root canker and scald, but tests have not been developed that can measure this accurately. Developing varieties with good resistance to these latter two diseases seems possible, but the work may be slow.

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