PROGRESS IN BREEDING ALFALFAS WITH RESISTANCE TO NEMATODES

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Nematodes are microscopic roundworms that may enter and feed within the plant tissue or feed on the surface of the plant. There are above-ground nematodes and soil nematodes that attack alfalfa. This paper will discuss only the soil nematodes. Of the group of nematodes found in the soil and feeding on plant roots, the root-knot nematodes (Meloidogyne spp.) have been shown by present research to be the most damaging to alfalfa. Other root nematodes such as the root-lesion nematode (Pratylenchus spp.) and stubby-root nematode (Trichodorus spp.) have been shown to have a detrimental effect on alfalfa, but more information is needed to understand these effects clearly. Nematodes such as the stunt nematode (Tylenchorhynchus spp.), ring nematode (Criconemoides spp.), and dagger nematode (Xiphinema spp.) can also be found in alfalfa fields, but their damage, if any, is either unknown or unclear.

Populations of a single species of soil nematode are seldom found in the alfalfa soils with which we have worked. Instead, one or more of the root-knot nematodes, along with other species capable of feeding on alfalfa roots, are usually found in soil samples (Tables 1, 2, and 3). Since different species of nematodes can be found in alfalfa soils and their relationship to one another and to damage is unclear, this paper will simply refer to this group of nematodes as root or soil nematodes.

Populations of soil nematodes can be found in some locations in all of the major alfalfa growing areas in California. Damage may be light to undefined in many areas, but damage can be very severe in certain limited areas. Locations with the most severe root nematode problems tend to be those with sandy or sandy loam soils.

In general, root nematodes have been given less attention and consideration than other alfalfa pests like the aphids, Egyptian alfalfa weevil, and root rots. Part of this may be because these nematodes live and do most of their direct damage in the soil where they cannot be seen or because the stand decline and stand loss is usually relatively slow and undramatic. However, to growers with severely infested soils, root nematodes are a very real and frustrating problem. For many of these growers the damage can often be rapid and dramatic. A good example is a field planted to CUF 101 near Blythe, California, on December 12, 1979. By October 13, 1980, there was an estimated 35% stand in one of the poorer areas of the field where a trial was located. By January 15, 1981, there had been some recovery during the cool winter, but by September, 1981, only 28% of the stand remained (Table 4). If the grower does not expect a root nematode problem or the problem develops after the crop is planted, he must try to live with the damaged field or take out the alfalfa and plant another crop. Unlike an aphid infestation, treating the field with a growing crop of alfalfa is not practical. Treating the field prior to planting can be expensive.

Symptoms exhibited by plants infected with root nematodes are stunting, unthrifty growth, and reduced stands. Roots tend to be excessively branched, and plants affected with root-knot nematodes may have small galls. The galls should not be mistaken for beneficial nitrogen-producing Rhizobium nodules which tend to dislodge easily from the root when the roots are rubbed.

Damage by the root-knot nematodes has been proven to be severe, but damage by the other root feeding nematodes is often unclear. The root-lesion nematodes have been shown to reduce spring-seeded stands in Kentucky (4). High populations of root-lesion nematodes have also

decreased cold tolerance and increased infections by Fusarium, a common disease in California.

Root nematodes in alfalfa can be managed or controlled by using chemicals, crop rotation, or resistant varieties. Since alfalfa is a relatively low income field crop, chemical control is usually, but not always, too expensive to use. In addition, if chemicals are used, they may destroy other soil organisms and the user must be careful to comply with the many restrictions involved with the use of chemicals and their effect on the environment. Crop rotation seems to be the best weapon presently available, but the grower may find he is severely limited in the crops he will be able to grow.

Resistant varieties are generally believed to be the most practical and effective means of control for alfalfa root nematodes. Since resistance is built into an alfalfa cultivar, it is available at little if any, extra cost. The root nematode protection is "built into" the seed and should be available to protect the plants when and if there should be a nematode problem.

In the late 1960's, Dr. E. H. Stanford and others at the University of California, Davis, found good resistance to northern root-knot nematode in the cultivars Vernal and Hilmar. They were released to plant breeders as breeding stock. O. J. Hunt, B. Hartman, B. Thyr, and others from the U.S.D.A. and University of Nevada used this germplasm to develop breeding lines of alfalfa like Syn XX and Syn YY which had very high resistance to the three most damaging root-knot nematodes (northern, cotton, and Javanese). These two lines of alfalfa were released as breeding lines to plant breeders and also used in studies to learn more about the effects of these nematodes on alfalfa and other crops.

One of the very interesting experiments conducted on these resistant breeding lines by B. Hartman and others from the U.S.D.A. and University of Nevada (5) showed the potential value of resistance to nematodes. In working with only the northern root-knot nematode, they found that highly resistant alfalfa cultivars could be used to reduce nematode populations in the soil to levels low enough to enable a susceptible crop to be grown without the use of a nematocide or with a significantly reduced application. They also conducted small plot experiments where nematode resistance was mechanically varied from 0 to 100%. This work indicated that satisfactory root-knot nematode control could be obtained with resistance of 70% or above. This work is significant because it shows that if resistance to important root-knot nematodes can be increased to 70% (a very practical level) or better, alfalfa could be effectively grown in nematode-infested soils. In addition, it shows these resistant alfalfas could be used as a nematode-resistant crop in the rotation, a crop capable of reducing nematode populations in the soil where it was being grown.

Development of breeding lines conducted by the U.S.D.A. and the University of Nevada relied primarily on controlled selection for individual nematode species and controlled crosses. A slightly different approach was used by workers from the University of California. This approach involved selection of superior plants from fields severely infested with root-knot nematodes (the species or number of species was usually unknown) and also with other soil nematodes such as stubby, root-lesion, and dagger. One line selected by Dr. W. H. Isom and subsequently released to plant breeders for breeding purposes was UCPX 1971 (7). In tests through the southern half of California (especially in soils infested with root nematodes), UCPX 1971 invariably had the best stand at the end of the experiment (7). Tests have shown UCPX 1971 has moderate to high levels of resistance to the three common species of root-knot nematodes (Table 5). It is suspected this line may also have resistance or tolerance to some of the other soil nematodes attacking plant roots and causing direct or indirect damage to alfalfa plants. At present, no good tests are available to determine the alfalfa plants' reaction to other soil

nematodes. Work is needed to identify these nematodes and/or nematode-related diseases. Precise tests may be needed before rapid progress can be made.

In a continuation of the field selection work, an experimental variety (UC 127) was selected from a field on the Fisher Ranch near Blythe which was severely infested with four types of soil nematodes (Table 2). This field was planted in 1974 and selections of the parent plants of UC 127 were made in 1977 after plant damage and stand loss became apparent (Table 6). The root-knot nematodes involved were not identified to species, but M. arenaria is suspected as being important since this field is located a short distance away from another field on the same Fisher Ranch which was studied by Ferris, Goodell, and McKenry (2). The root-knot nematode M. arenaria was found in high numbers in the field sampled by these workers.

About 28% of the plants in UC 127 were selected from UCPX 1971, from UC 76, and 46% from UC Salton.

The first good test on the reaction of UC 127 to nematodes was obtained in a field severely infested with nematodes located on the Hull Ranch near Blythe, California. The soil type in this field and the proximity to the Colorado River were essentially the same as the field on the Fisher Ranch where the parents of UC 127 were selected. Nematode counts from this field were high and from five genera (Table 3). M. arenaria was identified as the dominant root-knot species in this field.

Stand depletion in the Hull field was rapid for most cultivars tested during the first year (Table 3). There was some recovery during the moderate winter months, but the stand for almost all cultivars was lower in September, 1981 than in October, 1980. UC 127, which was among the best cultivars in 1980, was definitely the best in September, 1981. Nevada Syn XX and Nevada Syn YY, which were in the top group in 1980, lost more stand than expected for cultivars with high resistance to three nematodes considered most damaging on alfalfa. UCPX 1971 was also significantly lower than UC 127. CUF 101, the variety planted by the grower, had an unproductive 28% stand after two years. Lahontan, the susceptible check variety, had essentially no stand after one year. Since UC 127 was significantly superior to the best variety in the 1974 trial on the Fisher Ranch (UCPX 1971), this indicated selection was effective for factors causing stand depletion in alfalfa stands planted on these sandy soils which also had large populations of soil nematodes.

It might be argued that stand depletion was not due to the nematodes present in the soil but to other factors, primarily disease organisms. However, it seems most evidence indicates that root nematodes are the basic problem. Lines with known root nematode resistance were among the best in the trial. Lahontan usually used as a susceptible check variety in root nematode experiments was the poorest cultivar in the trial. However, since Nevada Syn XX and Nevada Syn YY have excellent resistance to the most damaging root-knot nematodes, it appears other factors are operating. These factors might be M. arenaria and the other soil nematodes or interactions with them and diseases. Many varieties with poor stands like CUF 101, Maxidor, and UC Cargo have high resistance to Fusarium, an important disease in the area. These varieties also have some resistance to root rots. If these diseases were of primary importance, these cultivars might be expected to perform better. Lahontan, the poorest variety in the trial, has resistance to stem nematodes, bacterial wilt, and Phytophthora root rot. This seems to rule out these problems as stand-depleting factors working alone. After making similar comparisons with other varieties and individual diseases, it seems the best conclusion is that root nematodes, acting alone and in combination with other factors, primarily diseases, are the probable major cause of stand depletion in the Hull field.

UC 127 is now being tested for its reaction to the three important nematode species as well as other diseases and insects. At present, it seems UC 127 is adapted to nematode-infested fields in the Blythe, California, area. It will have to be determined if UC 127 will perform as well in other areas with different nematode species or population levels of these species.

Results to date indicate that field selection for resistance to root nematodes should be profitable. Therefore, many alfalfa breeders are using field selection in their programs. However, they will also be combining field selection with laboratory or controlled selection and testing. Experimental lines from these programs are now being tested in various trials through the state. These tests should help determine how valuable the resistance will be if the selections are made in one part of the state with one set of conditions and tested in another part of the state with different conditions. Work with UCPX 1971 indicates the cultivars will be fairly broadly adapted. If so, we can expect to find some relief for alfalfa growers with soils heavily infested with soil nematodes.

Areas with severe nematode problems cover only a relatively small part of the acreage where alfalfa is being grown. However, nematodes are the overriding alfalfa problem for growers in these areas. Fortunately, this problem is now receiving some attention. It seems possible that some of the first root nematode resistant cultivars may be lacking in resistance to some pests like the blue alfalfa aphid or leaf diseases which can be controlled or may be less devestating to stands. The new cultivars will provide some relief from nematode infestations which are difficult to control. Growers in non-root nematode areas, on the other hand, may wish to continue growing cultivars with superior production and resistance to the most important diseases and insects on their farms. The Cooperative Extension and local seedsman will continue to watch the available cultivars and provide advice, when needed.

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Table 1. Nematode population levels in a field in Stanislaus County.

Type of nematode	Nematodes per 100 ml of soil
Root-knot (*Meloidogyne* spp.)	33
Stubby-root (*Trichodorus* spp.)	31
Root-lesion (*Pratylenchus* spp.)	61
Stunt (*Tylenchohynchus* spp.)	45

Table 2. Nematode counts made on soils from a field on the Fisher Ranch near Blythe, California, in 1974. UC 127 was selected from this field.

Type of nematode	Number in one pint of soil
Root-knot (*Meloidogyne* spp.)	156
Stubby-root (*Trichodorus* spp.)	336
Root-lesion (*Pratylenchus* spp.)	60
Stunt (*Tylenchorhynchus* spp.)	48

Table 3. Nematode counts made on soil from a field on the Hull Ranch near Blythe, California, in 1979. UC 127 was evaluated in this field.

Type of nematode	Number in one pint of soil
Root-knot (*Meloidogyne* spp.)	26
Root-lesion (*Pratylenchus* spp.)	7
Dagger (*Xiphinema* spp.)	127
Ring (*Criconemoides* and *Criconema* spp.)	4

Table 4. Estimated number of plants and plant stems remaining in alfalfa cultivars planted on the Hull Ranch near Blythe, California, December 12, 1979.

Cultivar	Date of stand estimates[1] 10-13-80			3-12-81		9-24-81		
UC 127[2]	75	group	1[3]	83	ab[4]	65	group	1[3]
AZ BAA[2]	58	"	2	68	bcdef	45	"	2
Valador	58	"	2	71	abcde	45		2
UC 146[2]	43	"	3	64	cdefg	43		2
UC 118[2]	63	"	2	73	abcd	40		2
Nevada Syn XX[2]	83	"	1	84	a	40		2
AZ-CAP[2]	55	"	2	73	abcd	38		2
UC 131[2]	38	"	3	60	cdefghi	38		2
UC 133[2]	53	"	2	64	cdefg	38		2
UC 126[2]	48	"	2	65	cdef	38		2
UC 143[2]	55	"	2	63	cdefgh	38		2
UCPX 1971[2]	65	"	2	68	bcdef	38		2
UC 177[2]	38	"	3	45	ijk	35		2
UC Cargo	40	"	3	63	cdefgh	35		2
WL 514	50	"	2	66	cdef	33		3
Nevada Syn YY[2]	73	"	1	75	abc	30		3
UC 103[2]	33	"	3	49	ghij	30		3
Mesa Sirsa	35	"	3	48	hij	28		3
AZ RKN[2]	33	"	3	54	fghij	28		3
Pioneer Brand 572	53	"	2	63	cdefgh	28		3
CUF 101	35	"	3	59	defghi	28		3
UC 121[2]	40	"	3	56	efghi	28		3
Maxidor	38	"	3	66	cdef	25		3
K7-702[2]	33	"	3	55	fghij	23		4
WL 512	38	"	3	55	fghij	18		4
Ardiente	25	"	4	40	jkl	15		4
Pioneer Brand 581[2]	33	"	3	40	jkl	15		4
AZ Hayden PX[2]	18	"	4	30	l	13		4
Matador	20	"	4	33	kl	5		5
Lahontan	10	"	4	9	m	0		5

1/ Estimated number of plants and plant stems remaining. 100% is a full stand.
2/ Experimental line.
3/ Groups significantly different from each other at the 1% level (odds 99:1).
4/ Cultivars followed by the same letter are not significantly different at the 5% level (odds 19:1).

Table 5. Percent of plants resistant to three species of root-knot nematode (Meloidogyne spp.) for UCPX 1971 and resistant and susceptible check cultivars.

Entry	M. hapla	M. javanica	M. incognita
UCPX 1971	27	52	78
Syn XX	85	91	74
Moapa 69	16	54	96
Lahontan	2	5	22
Mesa Sirsa	33	13	89
Caliverde 65	16	3	64

Table 6. Estimated percent of stand remaining in alfalfa cultivars planted on the Fisher Ranch near Blythe, California, November 15, 1974. Stand estimates were made in March, 1977.

Cultivar	Percent of stand remaining
UCPX 1971	41
UC 76	33
UC Salton	25
Moapa 69	23
Mesa Sirsa	23
UC Cargo	21
FM 411	17
Sonora	13