STEM NEMATODE MANAGEMENT IN ALFALFA HAY PRODUCTION

Rachael Long[1] and Becky Westerdahl[2], and Dan Putnam[3]

ABSTRACT

The alfalfa stem nematode is the most serious nematode pest of alfalfa in the United States, causing serious yield, forage quality, and stand losses in infected fields to seedling as well as established stands. However, in recent years this pest was not a major concern to California growers as it was only occasionally found in alfalfa fields. Then, beginning in the winter of 2009, serious and devastating losses occurred to spring produced alfalfa hay in the Sacramento and San Joaquin valleys, which persisted into 2010. All varieties were affected, including those that have high resistance to nematodes (up to 50%). Why these outbreaks occurred so suddenly and were so widespread in the Sacramento and Northern San Joaquin valleys may be due to a combination of two factors. First, minimum winter temperatures (November to January) in the Davis area have increased by about 3^{o}F since 1983 (CIMIS data), reaching the lower limit of reproduction for the stem nematode (41^{o}F, Figure 1). In contrast, winter minimum temperatures during these same months are still well below the threshold in the Shafter area (Figure 2). Secondly, organophosphate and carbamate use in alfalfa has declined by 50% since 2005 (Figure 3). These classes of pesticides, which can suppress stem nematodes, have primarily been replaced by pyrethroids, which do not affect this pest. This information suggests that the stem nematode will continue to be a significant pest of alfalfa in the northern part of the Central Valley, not an ephemeral one. Recommendations for controlling stem nematode in alfalfa include planting highly resistant crop varieties, crop rotation, equipment sanitation, and irrigation management to prevent the spread of this pest. Currently there are no pesticides registered for use in alfalfa that control stem nematode in the plant. Until higher levels of stem nematode resistant alfalfa varieties are developed for California, ounces of prevention are potentially worth tons of forage in return.

Key Words: Alfalfa, stem nematode, management recommendations

INTRODUCTION

The alfalfa stem nematode, *Ditylenchus dipsaci*, is a serious pest of alfalfa in many areas of the United States, causing significant reductions in yield, forage quality, and stand

[1] R. Long, UCCE Farm Advisor, Yolo County, 70 Cottonwood St., Woodland, CA 95695, email rflong@ucdavis.edu and [2]B. Westerdahl, CE Specialist and Professor, Department of Nematology, University of California, Davis, CA 95616, email bbwesterdahl@ucdavis.edu, D. Putnam, CE Specialist, Department of Plant Sciences, University of California, Davis, CA 95616, email dhputnam@ucdavis.edu. IN Proceedings, 2010 California Alfalfa & Forage Symposium and Corn/Cereal Silage Mini-Symposium, Visalia, CA, 1-2 December, 2010. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa symposium Proceedings)

health in infested fields. This nematode is a microscopic roundworm that belongs to a group known as stem and bulb nematodes. As parasites of alfalfa, they are unusual as they feed entirely on the above ground portions of plants instead of the roots. They often have specific host preferences. For example, the alfalfa stem nematode attacks and reproduces only on alfalfa *(Medicago sativa)*. Sainfoin *(Onobrychis viciifolia)* is also a reproductive host for stem nematode, but does not occur in California's Central Valley. Sainfoin was originally introduced from Europe as a forage crop and is currently found at elevations above 3,000 feet. The alfalfa stem nematode is also likely an introduced pest in that it was first found in Germany in 1881 and later reported in the U.S. in 1923.

SYMPTOMS

Feeding damage by the alfalfa stem nematode includes stunted plants with enlarged and discolored stems, swollen nodes, short internodes, and dieback in the crown tissue. A good indicator of stem nematode presence in a field is 'white flagging' whereby individual stems of infected plants appear almost albino white. Stem nematode may appear as stunted patches or uneven plant growth in infected fields. In other cases stands may be badly damaged with the alfalfa showing very little if any plant growth and the stand has a dieback appearance. The alfalfa will start to recover as the weather warms, but the first and likely second cutting yields of infected stands will be significantly reduced.

Alfalfa stem nematode is most common in soils with high clay content. It occurs on both flood and sprinkle irrigated fields and tends to be most severe during years with heavy rainfall. Levees often look better than rest of the field, but it is not known if this is related to water movement via irrigation or storm water runoff, or drainage.

The health of stands can quickly deteriorate in stem nematode infested fields as a result of secondary pathogens weakening or killing alfalfa crowns that are infected with stem nematodes. Of particular concern are seedling fields as newly established alfalfa on stem nematode infested ground often declines rapidly with poor seedling stand, increased weed pressure, and poor forage yield. For example in a field in Utah, after planting, less than 50% of plants remained due to die-out from the infected seedlings. As a result it is important for fields to be stem nematode free prior to planting to ensure that seedling fields are protected from this pest

LIFE CYCLE

The stem nematode can be found in alfalfa all year, but is favored by cool, wet weather (optimum 59-68^{o}F), so is most often observed from late fall to early spring. Females have a reproductive range of 41-86 ^{o}F, can produce 200-500 eggs during their lifetime, and have a generation time of 19-23 days. After egg-hatch, the nematode will go through two additional molts to become a pre-adult or infective juvenile. At this stage the nematodes can dessicate and go dormant under adverse conditions, allowing them to withstand extremes of freezing or drying on plant debris or seed for long periods of time.

When there is sufficient moisture and favorable temperatures, the infective juveniles become active and enter the plant by colonizing seedlings as they germinate or by swimming up on the surface and entering through the plant's stomates. When feeding, the nematodes secrete enzymes and plant-affecting hormones that stunt and swell plant tissues. Within the host plant, the nematodes molt a fourth time to become male and female adults. Nematodes escape to the soil when living conditions within the plant become adverse when heavily infected plants can no longer support the nematode's growing population, or when plants are dying.

Alfalfa fields can be infected with stem nematode through contaminated seed, water, plant debris (such as straw), dust, and equipment. Volunteer alfalfa in crop rotations as well as residual alfalfa in overseeded crops (for example grass hay) can also be a source of stem nematode in alfalfa stands. Additionally, manure from livestock fed stem nematode infested hay can also be a source of this pest.

DETECTION AND MONITORING

The first step in managing stem nematode is detection and sampling to make sure stem nematode is the cause for the stand decline. If symptoms of stem nematode are evident, such as stunted growth and open patches in the field, cut several stems with symptoms from several different plants, place them in a plastic bag, and send them to a laboratory for positive identification. Soil samples can also be taken. Sample from within the root zone, 6 to 18 inches deep. Divide the field into sampling blocks of not more than twenty acres each representing crop history, crop injury, or soil texture. Take several subsamples randomly from a block, mix them thoroughly and make a composite sample of about 1 quart (1 liter) for each block. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current/previous crop and the crop you intend to grow. Keep samples cool (do not freeze), and transport as soon as possible to a diagnostic laboratory. Contact your farm advisor for more details about sampling, to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results.

MANAGEMENT RECOMMENDATIONS

Equipment sanitation: Avoid moving contaminated farm machinery from stem nematode infested to clean fields. Harvest nematode-free fields before infested fields. Clean equipment when moving from a stem nematode infested field to a clean field. This can be done using a high-pressure washer or blower, or by cutting grass hay prior to moving back into alfalfa.

Crop rotation: Rotation with non-host crops such as tomatoes, sunflowers, and wheat on a 2 to 4-year basis will reduce alfalfa stem nematode populations (longer rotations are better). Note in particular that overseeding with grasses is not a rotation, since alfalfa hosts remain in the field.

Water management: Although this is hard to prevent in some cases, if water is moving

off of infected fields, growers should attempt to prevent moving this water to non-infected fields, or reduce runoff. High numbers of stem nematode have been found in irrigation and storm water runoff from infected fields. Where water is reused on fields, this may be a major source of infection for healthy fields.

Livestock. Uncomposted manure from animals fed stem nematode infested hay may be a source of this pest. Likewise animals such as sheep grazing in the alfalfa for winter weed control can move the stem nematode around fields via tracking dirt on their hoofs.

Pesticides: No nematicides are currently registered for use against the alfalfa stem nematode in established alfalfa fields that control the nematode in the plant, though several are being investigated. In a Yolo County trial in 2009, pesticides applied during late winter showed some nematode reductions in the soil, Figure 4. However, in both Colusa and Yolo County trials, these pesticides did not control the nematodes in the plants nor did they enhance alfalfa yields. Fall treatments likewise did not show efficacy against nematodes. As a result, pesticides are not recommended for alfalfa stem nematode control at this time. Instead, the alfalfa industry needs to control the spread of this pest, and transition to developing and planting stem nematode resistant varieties. There are currently varieties with high level of resistance (HR) to stem nematode, and plant breeders are seeking even higher levels of resistance for severely affected areas.

Resistant varieties: Growers who know they have this pest should plant highly resistant (HR) varieties (Table 1). The use resistant varieties, on which nematodes are not able to reproduce is a well-known management technique. However, resistance is not immunity, and even the best highly resistant varieties may become infected and develop symptoms during years with extended periods of wet, cool conditions. Plant breeders are currently working on developing varieties with even higher levels of resistance (showing at least 70% stem nematode resistance). The mechanism for the resistance is not well understood, but may biochemical, whereby the nematodes are chemically prevented from reproducing in the plant. Enhanced levels of resistance should be available in about 3-4 years.

CONCLUSIONS

The increase in minimum winter temperatures reaching the lower reproductive threshold of the stem nematode combined with the decreased use of organophosphate and carbamate insecticides in alfalfa may have contributed to outbreaks of this pest in alfalfa. As a result, this pest is likely to continue to be a problem for California alfalfa growers. To prevent the spread of this pest, it is important to follow the management recommendations as outline above, including crop rotation, equipment sanitation, variety selection and irrigation management. Fields should also be sampled for stem nematode prior to planting to protect seedling stands. Once highly resistant stem nematode varieties are developed for California (>70%), these should be planted in fields with a known history of this pest.

LITERATURE CITED

CIMIS. California irrigation management information system. Department of Water Resources. http://wwwcimis.water.ca.gov/cimis/welcome.jsp

Hafez S and BB Westerdahl. 2004. Alfalfa nematodes. UC IPM Pest Management Guidelines: Alfalfa. UC ANR Publication 3430. http://www.ipm.ucdavis.edu/PMG/r1200111.html

Westerdahl BB and Frate C. 2007. Parasitic nematodes in alfalfa. *In:* Irrigated Alfalfa Management for Mediterranean and Desert Zones [Eds.] Summers and Putnam. UC ANR 3512.

Figure 1. Davis, CA Average minimum daily ambient temperatures (degrees Farenheit) November to January 1983-2010 (CIMIS weather data). The lower reproductive threshold of stem nematode females is 41 ^{o}F.

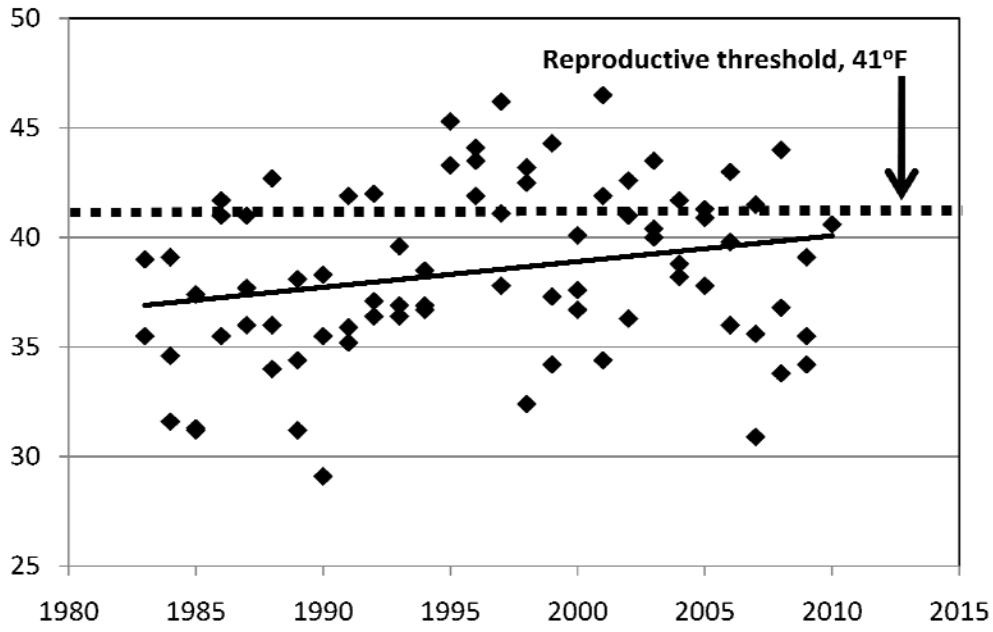

Figure 2. Shafter, CA Average minimum daily ambient temperatures (degrees Farenheit) November to January 1983-2010 (CIMIS weather data). The lower reproductive threshold of stem nematode females is 41 ^{o}F.

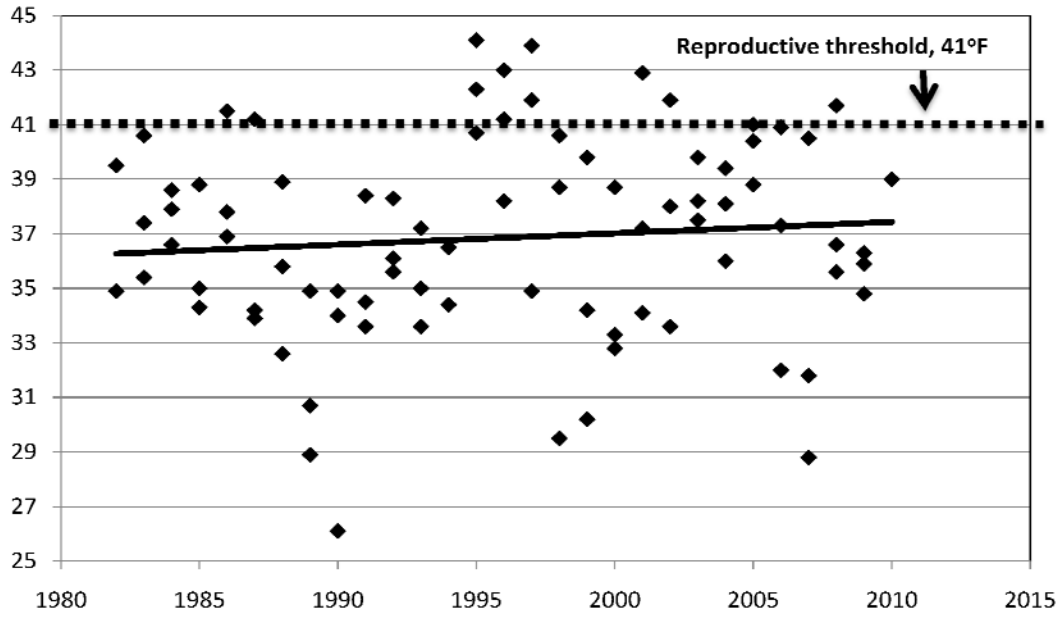

Figure 3. Acres of organophosphates and carbamates applied to alfalfa (chlorpyrifos, malathion, carbofuran, and methomyl) and acres of alfalfa harvested, California DPR statistics, 2005-09.

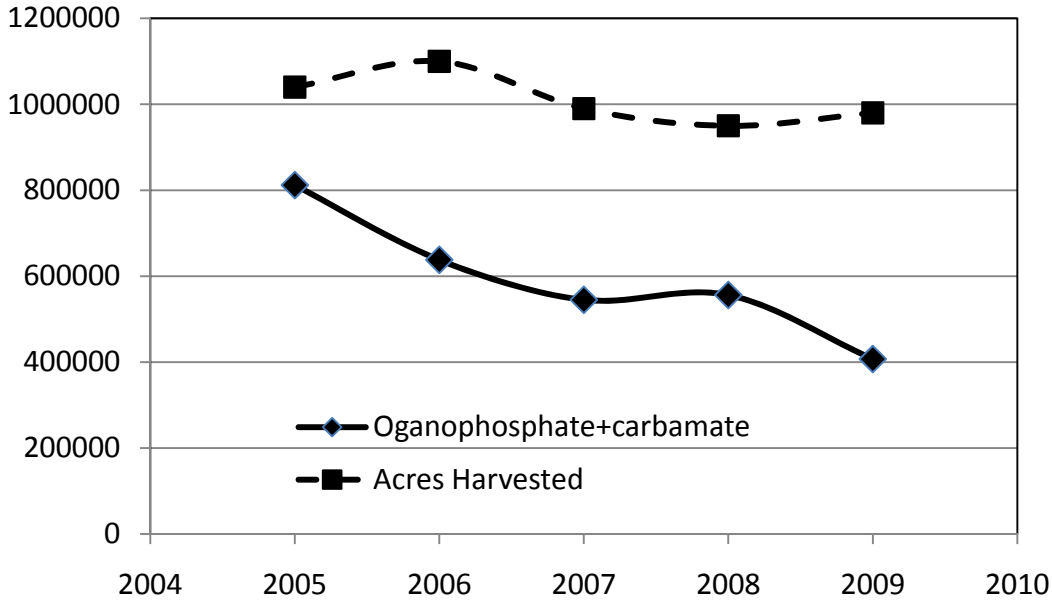

Figure 4. Number of stem nematodes per liter of soil, Yolo County, 2009. Plots treated March 13 and sampled April 23, 2009. All pesticides listed in the graph below are unregistered for use in alfalfa except Cobalt (Lorsban+pyrethroid).

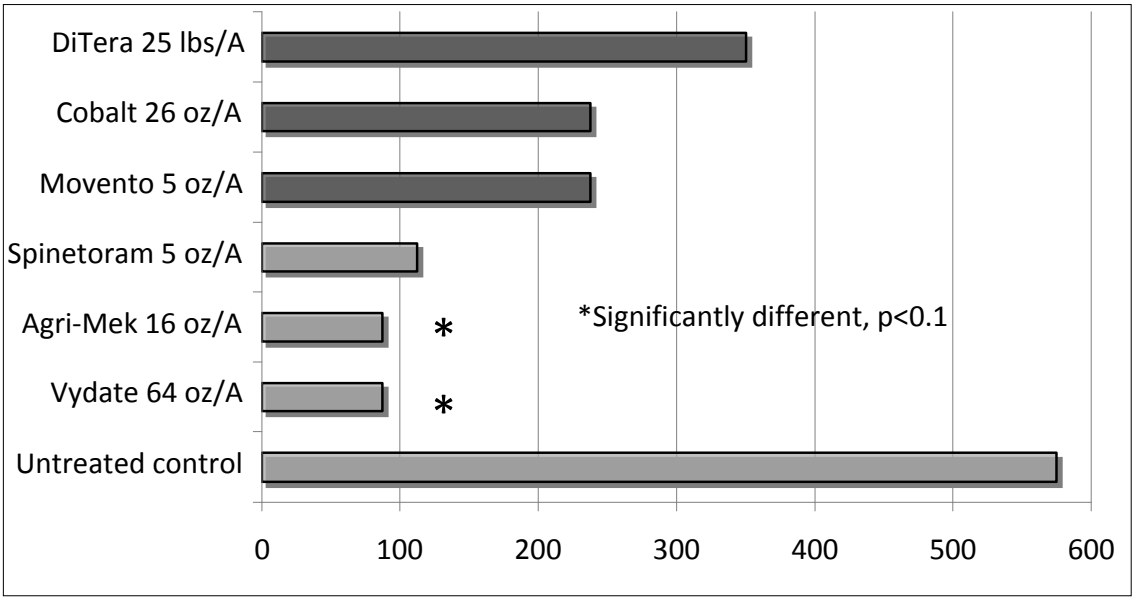

Table 1. Listing of HR Stem Nematode Resistant Varieties (2010). These were developed from the NAFA public listing, as well as from discussions with breeders and marketers.

Variety	Company	FD	Resistance to Stem Nematode*	Recommended as 'Best Bets'**
FSG309	Farm Science Genetics	3	HR	
6426	Syngenta Seeds	4	HR	
64321	Syngenta Seeds	4	HR	
54Q25	Pioneer Hi-Bred Int'l	4	HR	*
54V09	Pioneer Hi-Bred Int'l	4	HR	*
AmeriStand 444NT	America's Alfalfa	4	HR	
Boulder	Syngenta Seeds	4	HR	*
Focus	JR Simplot	4	HR	
FSG 429SN	Farm Science Genetics	4	HR	
HibriForce-2420/Wet	Dairyland Seed Co.	4	HR	*
Magnum VI-Wet	Dairyland Seed Co.	4	HR	*
Medalist	Union Seed	4	HR	
Persist II	Doebler's	4	HR	
PGI 424	Producer's Choice Seed	4	HR	*
Phabulouis III	Trelay Seeds	4	HR	
Plumas	Eureka Seeds	4	HR	
Power 4.2	1st Select Seed	4	HR	
Select	Union Seed	4	HR	
SW 435	S&W Seed Co.	4	HR	
Whitney	Eureka Seeds	4	HR	*
WL 326GZ	W-L Research	4	HR	
WL 327	W-L Research	4	HR	*
WL 342	W-L Research	4	HR	
WL 343HQ	W-L Research	4	HR	
WL 345LH	W-L Research	4	HR	
WL 347LH	W-L Research	4	HR	
WL 348AP	W-L Research	4	HR	
WL 353LH	W-L Research	4	HR	
6552	Pioneer Hi-Bred Int'l	5	HR	
55H05	Pioneer Hi-Bred Int'l	5	HR	*
55V12	Pioneer Hi-Bred Int'l	5	R+	*
55V48	Pioneer Hi-Bred Int'l	5	R+	*
Archer III	America's Alfalfa	5	HR	
CW 500	Producer's Choice Seed	5	HR	
DKA 50-18	DeKalb	5	HR	
Evermore	Syngenta Seeds	5	HR	
Expedition	Syngenta Seeds	5	HR	*
FSG 505	Farm Science Genetics	5	HR	
Magna 551	Dairyland Seed Co.	5	HR	
MasterPiece II	JR Simplot	5	HR	
WL 357HQ	W-L Research	5	HR	*
WL 363HQ	W-L Research	5	HR	*
56S82	Pioneer Hi-Bred Int'l	6	HR	*
FSG 639ST	Farm Science Genetics	6	HR	
HybriForce-620	Dairyland Seed Co.	6	HR	*
Integra 8600	Wilbur-Ellis Co.	6	HR	*
WL 440HQ	W-L Research	6	HR	*
CW704	Producer's Choice Seed	7	HR	*
HybriForce-700	Dairyland Seed Co.	7	HR	*
WL 442	W-L Research	7	HR	*
HybriForce-800	Dairyland Seed Co.	8	HR	
Integra 8800	Wilbur-Ellis Co.	8	HR	
Pacifico	Eureka Seeds	8	R+	*
PGI 801	Producer's Choice Seed	8	HR	*
Sequoia	Syngenta Seeds	8	HR	*
59N59	Pioneer Hi-Bred Int'l	9	HR	*
Magna 995	Dairyland Seed Co.	9	HR	
PGI 909	Producer's Choice Seed	9	HR	*
A-1086	Producer's Choice Seed	10	HR	
PGI 1007 BA	Producer's Choice Seed	10	HR	

*These listing of Stem Nematode resistant varieties are from 'Winter Survival, Fall Dormacy & Pest Resistance Ratings for Alfalfa Varieties-2010 edition'. Published by National Alfalfa & Forage Alliance. (see: www.nafa.org).

**These are recommendations provided by private breeders and seed marketing companies. These were considered to have the best chance of providing resistance to Stem Nematode for the Northern San Joaquin Valley and Sacramento Valley of California.