The Impact of Plant Parasitic Nematodes on Alfalfa Hay Production

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ABSTRACT

Plant parasitic nematode are small microscopic worm-like aquatic animals commonly present in alfalfa fields. The Alfalfa stem nematode *Ditylenchus dipsaci*, the Root-knot nematodes, *Meloidogyne* spp., and the Root lesion nematodes, *Pratylenchus* spp., are the most common and economically important nematodes found in alfalfa fields. These nematodes can affect the alfalfa plants directly by damaging the stem and root system and they also play an important role in disease complexes, causing alfalfa to be more susceptible to other plant pathogens, i.e. fungi and bacteria.

This paper discusses the effects of stem, Northern, Columbia root-knot and lesion nematode on the yield of different alfalfa cultivars, each with varying levels of nematode resistance. Also determine the effect of these cultivars on the root-knot nematode populations.

INTRODUCTION

Plant parasitic nematode are present in alfalfa fields at high populations in the root zone. They only feed on living plant tissues (obligate parasite) and, they possess a hollow stylet (needle-like structure) that is used to puncture plant cells and draw digested cell contents to their intestine. They reproduce sexually, hermaphroditically, or parthenogenetically. The life cycle includes four larval stages, and requires 3-6 weeks under optimum conditions. Nematodes are easily spread with moving soil, irrigation water, wind, machinery, nursery stock, and seed or debris in seed and hay.

Symptoms on roots may include knots or galls, excessive branching, injured (stubby) root tips, or a reduced root system. Wounds from nematode feeding also permit entry of bacteria and fungi that may eventually cause root rots. Root-knot galls are prone to infection by *Fusarium* and other root-rotting fungi. As a result of root injury, aboveground plant parts may show reduced growth, excessive wilting in hot dry weather, or nutrient deficiencies. Yield and quality of hay may be reduced. Some nematodes invade foliage and cause galls, abnormal development in foliar and floral parts, and necrotic lesions. Some nematodes also transmit plant viruses.

Many plant-parasitic nematodes are associated with alfalfa, but the stem nematode, root-knot nematodes, and root-lesion nematodes are the most important economically. The importance of nematodes on alfalfa, however, is measured not only in their parasitic behavior but by the roles they play with other plant pathogens in disease complexes and their importance on other corps grown in rotation with alfalfa.

I. The impact of alfalfa stem nematodes on hay yield.

In Idaho and the northwestern states, this nematode has been found in many alfalfa producing areas. Particularly in areas where irrigation waste water is used, heavy soil, and high rainfall.

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Stem nematode is one of a few species of nematodes that feed on plants above ground as well as in the roots. All stages of the nematode except the first, [*which molt inside the eggs*], are able to attack the alfalfa plant. Infected buds become swollen and distorted and fail to elongate into normal stems, resulting in short internodes and significant yield reduction. Under cold, wet conditions, nematodes may migrate into the leaf tissue causing a curling and distortion of leaf chloroplasts which is usually called "white flagging" symptom. Alfalfa seed may become infected if the flower buds are infected. Seed is considered a major means of spreading the stem nematode. *Up to 17,000 nematodes have been recovered from one pound of uncleaned seed.* Roots may occasionally be infected causing internal cavities or there may be gall-like outgrowths that may girdle the root crown.

Stem nematodes overwinter in succulent alfalfa tissue in the crown of the plant, and as eggs in the soil. Stem nematodes have been reported to play an important role in the development of Bacterial wilt [**Corynebacterium**] by breaking the wilt resistance of alfalfa plants.

Damage of the stem nematode is usually confined to the first cutting during cool humid weather. Nematodes in the stems are removed with the first cutting. There is little danger of infection in later cuttings, unless alfalfa is cut when the soil is wet. The nematode is an aquatic animal and needs water to migrate to infection sites.

Table 1 shows the results of an experiment in which four commercial alfalfa cultivars (Apollo II, Lahontan, Ranger and Washoe) and two experimental cultivars (Exp. 49 and Exp. 107), all with varying levels of resistance, were evaluated for their response to stem nematode under greenhouse conditions. Cultivars foliage yield data were obtained from inoculated and non-inoculated plants, with a minimum of 60 plants in each cultivars treatment. Results showed that the magnitude of the yield reductions are influenced by cultivar resistance levels.

Alfalfa stem nematode management practices.

Plant Resistant Varieties: There are many stem nematode resistant varieties, both public and proprietary. These are the first line of defense when growing alfalfa on irrigated land.

2. **Sanitation and Exclusion**: May be achieved by planting nematode free seed and avoiding reinfestation through:

   a. Moving farm machinery from infested field to clean field without cleaning.
   b. Moving grazing livestock from infested field to clean field.
   c. Using irrigation waste water.
   d. Using manure fertilization from feed lots where cattle have been fed infected hay.

3 **Cultural Practices**: The spread and damage of the stem nematode, can be reduced by:

   Crop-rotation -- Planting non-host crops such as sorghum corn, potato or small grain, will reduce the nematode population. The old and volunteer alfalfa plants must be eliminated through a good weed control program.

   b. **Cutting infested** alfalfa fields when the soil surface is dry will reduce nematode populations.

4. **Chemical Control**: Many of the systemic nematicides have been used successfully in experimental trials but at the present time there are no chemicals registered for use on alfalfa for nematode control. Preplanting fumigation is probably too expensive.

II. The impact of root-knot nematodes on hay yield.

Root-knot nematodes *Meloidogyne* spp. are the most common plant pathogenic nematodes in the world. Root-knot nematode damages to alfalfa vary with species, Southern, Northern and Javanese root-knot are the most pathogenic species for alfalfa. Also, root-knot nematodes can interact with other alfalfa pathogens. For example, infection by the Southern root knot nematode (*M. incognita*), increases the incidence and severity of Fusarium wilt in alfalfa.

The Northern root-knot nematode, (*M. hapla*), is the most commonly found root-knot species in the northern states. This nematode infects and parasitizes the roots of plants and form galls which are easily identified by the lateral root growth from galls. Young seedlings may die as a result of heavy infection even when roots fail to show galling. *M. hapla* on alfalfa also creates more problems for the high value, susceptible crops that are grown in rotation with alfalfa, such as potatoes, beans, and sugarbeets.

The Columbia nematode is similar to the Northern but is less pathogenic to alfalfa. Wheat and barley are susceptible host corps for the Columbia nematode but not for the Northern root-knot.

Newly hatched 2nd stage Root-knot juveniles are the infectious stage. After penetration, the 2nd stage larvae go through three molts and mature to female and male. The life cycle of *M. hapla* on alfalfa is approximately 30 days at 77°F. Root-knot nematodes also initiate the infection or lower plant resistance to bacterial and fungal diseases.

Table 2 shows the results of an experiment in which four commercial alfalfa cultivars (Apollo II, Lahontan, Ranger and Washoe) and two experimental cultivars (Exp. 49 and Exp. 107), all with varying levels of resistance, were evaluated for their response to Northern root-knot nematode under greenhouse conditions. Cultivars foliage yield data were obtained from inoculated and non-inoculated plants, with a minimum of 60 plants in each cultivar treatment. Results showed that the magnitude of the yield reductions are influenced by cultivar resistance levels.

In a separate experiment, four different cultivars (Lobo, Archer, Nevada Syn-XX and Lahontan), with varying levels of resistance to the Northern root-knot nematode, were evaluated for their effect on the Columbia root-knot reproduction and population build up, under greenhouse conditions. Results showed that Lobo, Archer and Nevada Syn-XX reduced the Columbia root-knot nematode root populations by 92, 89 and 77% respectively, in comparison with the susceptible cultivar Lahontan (Table 3).

Root-knot nematode management practices.

Resistant varieties: The most practical means of Northern Root-knot nematode control is using resistant varieties. There are a number of these now available.

2. **Crop rotation**: Planting non-host crops such as grain and grass for 2-3 years in the rotation will reduce nematode populations.

Chemical control: Soil fumigation can control the Northern Root-knot nematode when used as a preplanting treatment. However, this is expensive and not economically feasible. There are no non-fumigant nematicides registered on alfalfa.

III. The impact of root lesion nematodes (Pratylenchus spp.) on hay yield.

Root lesion nematodes are the most important and common plant parasitic nematodes found in crop lands. They attack a wide host range of plants and play an important role in damaging many crops, including alfalfa. *Pratylenchus penetrans* is the most important lesion nematode species on alfalfa. It is found throughout the United States, and has a wide host range but it is not known to be common in Idaho.

The life cycle of root lesion nematodes is simple. Females lay eggs inside the root tissue or in the soil. Both juvenile and adult forms enter roots by forcing their way between or through the epidermal and cortical cells and then feed on the cells contents as they migrate through the root tissue. The points of entrance to the roots provide access for other soil bacteria and fungi. Root discoloration and lesion formation are the common symptoms. Lesion nematodes can interact with other soil pathogens and act as a predisposing agent and aggravator.

A study was conducted to determine the effect of the lesion nematode *Pratylenchus penetrans* on foliage and roots of alfalfa cultivars with varying degrees of nematode resistance. Three commercial alfalfa cultivars (Baker, Ranger and Nevada Syn-XX) and two experimental cultivars (AP 8831 and AP 8821) were evaluated for their response to lesion nematode infestations under greenhouse conditions. Cultivar foliage and root weight (fresh and dry) were obtained from inoculated (3,000 nematodes/10 cm pot) and non-inoculated plants, with a minimum of 30 plants in each cultivar treatment. In all cultivars foliage and root fresh and dry weight were significantly reduced due to nematode infection (Tables 4 and 5). The magnitude of foliage and root reduction were influenced by cultivar resistance levels. Foliage and root fresh and dry weight of the three commercial cultivars (Baker, Ranger and Nevada Syn-XX) were significantly lower than the two experimental ones (AP 8831 and AP 8821) in the inoculated treatments.

Root lesion nematode management practices:

Crop Rotation: Lesion nematodes have a very wide host range and more than one species may occur in one field, therefore, crop rotation is not effective for control. Leaving a field fallow followed by treatment with a nematicide can reduce populations.

2. **Resistant Varieties**: Both Idaho and Minnesota have released alfalfa germplasms with resistance to lesion nematode. However, alfalfa varieties with adequate resistance are not yet available. Cultivars with satisfactory resistance to one or more *Pratylenchus* species will probably become the best means of controlling lesion nematodes since the cost of chemical control is prohibitive.

Table 1. **The effect of stem nematode *Ditylenchus dipsaci* on growth and herbage weight of different alfalfa cultivars under greenhouse conditions.**

	Total Herbage Weight g/plant			
	Fresh weight		Dry weight	
Variety	Inoculated	Non-inoculated	Inoculated	Non-inoculated
Exp 49	34.7	44.7	7.4	11.9
Exp 107	28.5	37.9	6.3	10.0
Lahontan	28.8	40.2	5.9	10.0
Apollo II	27.6	38.5	6.0	9.6
Washoe	32.3	38.2	7.1	10.0
Ranger	23.4	37.6	4.8	12.9
LSD 0.05 Inoc vs Non-inoc	3.61		1.31	

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Table 2. **The effect of Northern root-knot nematode on growth and herbage weight of different alfalfa cultivars under greenhouse conditions.**

	Total Herbage Weight g/plant			
	Fresh weight		Dry weight	
Variety	Inoculated	Non-inoculated	Inoculated	Non-inoculated
Exp 49	53.3	46.7	11.9	11.2
Exp 107	47.8	47.5	12.6	13.1
Lahontan	38.0	50.5	9.2	12.2
Apollo II	32.8	49.3	8.1	12.5
Washoe	37.0	40.0	8.8	9.4
Ranger	48.2	56.8	11.8	13.9
LSD 0.05 Inoc vs Non-inoc	3.51		1.12	

Table 3. **The effect of different alfalfa cultivars with varying levels of root-knot nematode resistance on the population of the Columbia root-knot.**

Cultivar	2nd Juvenile/gdw (roots)		% Reduction
Lobo	541	A	92
Archer	782	A	89
Nevada Syn-XX	1,624	B	77
Lahontan	6,925	C	

Means followed with the same letter are not significantly different.

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Table 4. **The effect of lesion nematode *Pratylenchus penetrans* on growth and herbage weight of different alfalfa cultivars under greenhouse conditions.**

	Total Herbage Weight g/plant			
	Fresh weight		Dry weight	
Variety	Inoculated	Non-inoculated	Inoculated	Non-inoculated
AP 8831	1.23	2.43	0.31	0.59
AP 8821	1.92	2.47	0.34	0.64
Baker	0.89	2.31	0.21	0.59
Ranger	1.07	2.55	0.21	0.60
Nevada Syn-XX	0.95	2.38	0.17	0.56
LSD 0.05 Inoc vs Non-inoc	0.073		0.022	
LSD 0.05 between varieties	0.117		0.034	

Table 5. The effect of lesion nematode *Pratylenchus penetrans* on the root growth and weight of different alfalfa cultivars under greenhouse conditions.

	Total Herbage Weight g/plant			
	Fresh weight		Dry weight	
Variety	Inoculated	Non-inoculated	Inoculated	Non-inoculated
AP 8831	1.14	2.61	0.29	0.72
AP 8821	1.65	2.79	0.28	0.67
Baker	0.92	2.41	0.22	0.60
Ranger	1.27	2.59	0.27	0.66
Nevada Syn-XX	0.77	2.22	0.18	0.53
LSD 0.05 Inoc vs Non-inoc	0.146		0.041	
LSD 0.05 between varieties	0.231		0.065	