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Efficacy of Oxamyl Coated on Alfalfa Seed with a Polymer Sticker in *Pratylenchus* and *Meloidogyne* Infested Soils

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Abstract: A polymer sticker was used as a coating in which oxamyl was applied to seeds of alfalfa cultivar Saranac for the control of *Pratylenchus penetrans* and *Meloidogyne hapla*. The sticker, diluted 1:1 (sticker : water) to 1:5, delayed seedling emergence during the first 4 days after planting. By day 13, however, emergence from all sticker treatments was comparable to the control. Shoot growth of seedlings at day 21 was less than that of the control only from seeds coated with a 1:1 dilution; root growth and nodulation were not affected. Sticker-coated seeds absorbed 30–58% as much water in 3.5 hours as was absorbed by uncoated seeds. Oxamyl concentrations of 40–160 mg/ml in a 1:5 sticker : water mixture had no adverse affect on seedling emergence, growth, and nodulation over 3 weeks. Oxamyl at 160 mg/ml was more effective against *P. penetrans* than *M. hapla*. Growth of alfalfa in *P. penetrans*-infested soil was greater than that of the control in each sampling for 11 weeks. The reduction of number of *P. penetrans* in soil and roots moderated slowly over 11 weeks from 90% to 60%. Shoot and root growth of alfalfa from oxamyl-coated seed in *M. hapla*-infested soil were greater than those of the control for 7 and 11 weeks, respectively. The reduction in the number of *M. hapla* in the soil and roots changed from 80% at 7 weeks to 15% at 11 weeks.

Key words: alfalfa, lesion nematode, *Medicago sativa*, *Meloidogyne hapla*, oxamyl, *Pratylenchus penetrans*, root-knot nematode, seed treatment, sticker.

In earlier studies seeds of alfalfa (*Medicago sativa* L.) were soaked in an aqueous solution of oxamyl for 17 hours (5). With such a long soaking period, the integument on some seeds ruptured. In subsequent studies oxamyl was coated on alfalfa seeds with stickers. Acacia and gelatin stickers inactivated oxamyl, rendering it ineffective against nematodes (Townshend, unpubl.). Pelleting oxamyl on alfalfa seeds with clay also inactivated the nematicide. A 2% cellulose solution (6) and a polymer sticker were effective coating agents for oxamyl. This paper reports the optimum concentrations of a polymer sticker and oxamyl and the degree and duration of control of *Pratylenchus penetrans* Cobb and *Meloidogyne hapla* Chitwood with oxamyl-coated seed.

MATERIALS AND METHODS

A polymer sticker was used as the coating agent for the application of oxamyl to the seed of alfalfa cultivar Saranac. Seeds were coated as described in detail earlier (6). Briefly, 3 g of seed were placed in a tumbler and 0.5 ml sticker or sticker plus oxamyl was added drop by drop with a pipet. The seeds were then dried in a screened trough using warm air from a built-in hair dryer. The procedure was repeated two more times, adding 0.5 ml of material each time.

A series of five experiments were conducted, and all data were subjected to analysis of variance.

Influence of the polymer sticker on growth: In a preliminary experiment with the polymer sticker and oxamyl, there was an indication that the sticker, the oxamyl, or both adversely affected alfalfa. Consequently, the sticker was diluted 1:1, 1:2, 1:3, 1:4, and 1:5 (sticker : water) and applied to the seed without oxamyl. A Vineland silt loam (VSL) (61% sand, 28% silt, 11% clay) was steam sterilized for 1 hour and cooled for 12 hours before use. Sixty styrofoam pots (11.5 cm d × 7.5 cm high) were each filled with 425 g soil, and 20 indentions were made in the soil surface with a multipoint dibble. A single seed was inserted into each site. Seeds were dusted with *Rhizobium meliloti* Rangeard and cov-

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ered with 30 ml soil. The six treatments, five concentrations of sticker and a control, were replicated 10 times. The experiment was arranged in a randomized block design in a growth room with temperatures of 14 C at night and 17 C during the day at a light intensity of 11,000 lux for 16 hours. Seedling counts were made every 2 days from day 4 to day 13. The experiment was concluded at 3 weeks, and shoot and root weights and numbers of nodules determined.

Absorption of water by coated seeds: Four subsamples of 20 seeds were selected from each of the five lots of alfalfa seeds coated with dilutions of sticker, 1:1 to 1:5 (sticker : water), and from one lot of uncoated seeds. Each of the 24 lots of seed were weighed and placed in shallow plastic dishes (44 mm × 44 mm). Water (2.5 ml) was pipetted into each dish and floating seeds were submerged. The seeds were soaked for 3.5 hours after which the water in each dish was removed with a suction pipet and each lot of seed was weighed. The amount of water absorbed was calculated as milligrams per 20 seeds.

Influence of oxamyl on growth: Three concentrations of oxamyl (40, 80, and 160 mg/ml) were prepared with the sticker in a 1:5 (sticker : water) ratio. Three coats of these solutions were applied to 3-g lots of alfalfa seed as described (6). Two controls, untreated seed and seed with sticker only, and seed with the three concentrations of oxamyl were planted in steamed soil. Each treatment was replicated 10 times. Treatments were arranged in a randomized block design in a growth room with temperatures of 13 C night and 17 C day at 11,000 lux of light. Seedling counts were made on days 4, 8, and 13, and shoot and root weights and number of nodules were determined at week 3.

Control of Pratylenchus penetrans: Eighty styrofoam pots (11.5 cm d × 14 cm high) were filled with a VSL soil infested with *P. penetrans* (five/g soil) from a greenhouse ground bed culture. Forty pots were sown with untreated alfalfa seed and forty with alfalfa seed coated with 160 mg oxamyl/ml sticker (1:5 sticker : water) as described in the first and second experiments. The seed rows were dusted with *Rhizobium meliloti* and covered with 30 ml infested soil. The pots were arranged in a randomized block design in a growth room with a 16-hour day at 17 C with 11,000 lux of light and 13 C at night. Eight replicates of each treatment were harvested at 3, 5, 7, 9, and 11 weeks, and shoot and root weights and number of nodules were determined. *P. penetrans* were extracted from 50-g soil samples for 1 week and from the roots for 2 weeks by the pan method (4).

Control of Meloidogyne hapla: The control experiment was repeated with a VSL soil infested with *M. hapla* (six J2/g soil) from a greenhouse culture. In addition to the other data obtained root-knot galls were counted at each harvest.

Results

Influence of the polymer sticker on growth: The sticker applied to alfalfa seed delayed seedling emergence only during the first 11 days after planting (Table 1). Seedling emergence was delayed by all sticker dilutions in the first 4 days; by dilutions 1:3 to 1:1 for 6 days; and by dilution 1:1 through 11 days. On day 13 after planting seedling stands of the five treatments were comparable to the control (Table 1).

Shoot weight of seedlings from treated seed at 21 days was less ($P \leq 0.10$) than that of the control only when seed had been coated with sticker at a dilution of 1:1 (Table 1). Neither root weight nor nodulation were affected by the sticker applied to the seed (Table 1).

Absorption of water by coated seeds: In 3.5 hours, 20 uncoated alfalfa seeds absorbed 25.1 mg water; seeds coated with 1:5 dilution sticker, 14.6 mg; 1:4 dilution sticker, 13.1 mg; 1:3 dilution sticker, 11.3 mg; 1:2 dilution sticker, 7.7 mg; and 1:1 dilution sticker, 7.7 mg ($LSD_{5\%} = 5.0$). Uncoated seeds were visibly larger than the coated seeds, particularly those coated with 1:1 dilution sticker.

Influence of oxamyl on plant growth: The three concentrations of oxamyl used to coat

TABLE 1. Effect of five concentrations of a polymer sticker coating on alfalfa seed on seedling stand, growth, and nodulation of alfalfa.

Sticker : water concentration	Seedlings emerged					Shoot weight†	Root weight†	Nodules/ pot
	4 days	6 days	8 days	11 days	13 days			
0	16.1	17.9	18.8	18.8	18.8	2.4	1.7	25
1:5	12.4	17.8	19.2	19.5	19.5	2.2	2.0	28
1:4	12.3	17.6	18.6	19.0	19.0	2.2	1.9	29
1:3	8.5	14.5	18.5	18.8	18.8	2.0	1.6	27
1:2	4.7	13.1	16.6	17.5	18.0	2.0	1.5	28
1:1	7.3	13.5	16.6	17.5	18.0	1.8	1.5	28
$LSD_{5\%}$	2.0	1.9	0.9	1.1	n.s.	n.s.	n.s.	n.s.

Values are means of 10 replications.
† Shoot and root weights are fresh weights in grams per pot at day 21.

alfalfa seed had no adverse effects on growth over 3 weeks. Seedling stands at day 4 ranged from 13.8 to 15.0 seedlings per pot and at day 13 from 16.4 to 17.1 seedlings per pot. Shoot weights at harvest ranged only from 2.3 to 2.4 g per pot and root weights from 1.3 to 1.4 g per pot. Number of nodules varied from 88 to 112 per pot of roots.

Control of Pratylenchus penetrans: Shoot weight of alfalfa seedlings from seed treated with oxamyl + sticker was consistently greater than that of the control for 11 weeks in *P. penetrans*-infested soil (Table 2). Shoot weight increase reached a peak of 30% over the control at week 7 and was still 12% greater at week 11. Root weight of seedlings from oxamyl-treated seed was 37% greater than that of the control at week 7 and was still 15% greater in week 11. The number of nodules on the roots of alfalfa seedlings from oxamyl-treated seed was greater than on the control. The greatest increase in nodulation (159%) occurred in the first 3 weeks and then declined to a low of 7% by week 7.

The numbers of *P. penetrans* in the roots of alfalfa seedlings that grew from oxamyl

TABLE 2. Growth of alfalfa and numbers of nematodes in *Pratylenchus penetrans*-infested soil planted with seed treated with oxamyl (160 mg/ml sticker) in a polymer sticker or with sticker alone (1:5 sticker : water).

Weeks after planting	Treatment	Shoot weight†	Root weight†	Nodules/pot	*P. penetrans*/pot	
					Soil	Roots
3	Control	2.6	1.6	56		510
	Oxamyl	3.3	1.8	145		60
	$LSD_{5\%}$	0.6	n.s.	25		100
5	Control	6.6	4.5	344	320	610
	Oxamyl	8.2	6.1	492	25	170
	$LSD_{5\%}$	0.8	0.8	86	170	206
7	Control	13.3	10.6	313	930	874
	Oxamyl	17.3	14.5	336	45	258
	$LSD_{5\%}$	2.6	1.7	n.s.	340	170
9	Control	20.2	21.9	304	1,580	1,061
	Oxamyl	23.9	27.0	376	220	352
	$LSD_{5\%}$	3.3	2.8	70	440	345
11	Control	28.3	37.9		1,980	1,700
	Oxamyl	31.8	43.4		400	638
	$LSD_{5\%}$	2.6	5.3		930	356
$LSD_{5\%}$ for weeks	Control	2.2	2.6	54	352	328
	Oxamyl	2.6	2.7	61	111	112

Values are means of eight replications.
† Shoot and root weights are fresh weights in grams per pot.

TABLE 3. Growth of alfalfa and numbers of galls and juvenile nematodes in *Meloidogyne hapla* infested soil planted with seed treated with oxamyl (160 mg/ml sticker) in a polymer sticker or with sticker alone (1:5 sticker : water).

Weeks after planting	Treatment	Shoot weight†	Root weight†	Nodules/pot	*M. hapla*/pot		
					Galls	Juveniles	
						Soil	Roots
3	Control	1.3	0.4	5.6	54	1,350	
	Oxamyl	2.7	0.6	7.4	16	720	
	$LSD_{5\%}$	0.5	0.1	0.7	24	360	
5	Control	6.3	2.3	169	202	1,500	
	Oxamyl	8.9	4.9	215	98	810	
	$LSD_{5\%}$	1.4	0.2	n.s.	37	530	
7	Control	13.0	8.1	185	275	6,350	6,680
	Oxamyl	16.0	11.4	196	150	1,200	1,680
	$LSD_{5\%}$	1.4	1.8	n.s.	58	2,600	4,600
9	Control	16.0	13.7	285	290	13,670	9,200
	Oxamyl	16.8	16.8	257	140	5,330	3,750
	$LSD_{5\%}$	n.s.	2.7	n.s.	75	5,400	3,980
11	Control	23.0	24.6	1,110	810	23,850	9,300
	Oxamyl	24.1	28.8	1,280	480	15,530	7,900
	$LSD_{5\%}$	n.s.	3.4	n.s.	210	7,200	n.s.
$LSD_{5\%}$ for weeks	Control	1.3	2.4	160	118	7,000	n.s.
	Oxamyl	1.7	1.7	128	77	6,070	5,000

Values are means of eight replicates.
† Shoot and root weights are fresh weights in grams per pot.

sticker-coated seeds was approximately 12% of the numbers in the roots of the control at week 3 (Table 2). Over the next 8 weeks the numbers of *P. penetrans* in roots of seedlings from treated seeds increased to 38% as many as in the controls. There were 8% as many *P. penetrans* in soil in which oxamyl-treated seedling were growing as in the control soil at week 5 and 20% as many at week 11.

Control of Meloidogyne hapla: Shoot and root weights of alfalfa seedlings from oxamyl-coated seeds exceeded that of the control seedlings at 7 and 11 weeks, respectively (Table 3). Shoot weight of seedlings from treated seeds was 141% of the control at week 3 and 123% at week 7. Root weights of seedlings from treated seeds were 210% of the control at week 5 and 117% at week 11. The number of nodules on alfalfa seedling roots from oxamyl-coated seeds was 132% of the control at week 3 but not significantly different thereafter.

There were only 30% as many root-knot galls on the roots of alfalfa seedlings from oxamyl-coated seeds as on the roots of the controls at week 3 but the number increased to 59% as many at week 11 (Table 3). There were 19% as many juveniles in the soil around seedlings from treated seeds at week 7, compared with the control soil, but at week 11 there were 65% as many (Table 3). At week 7, 25% as many juveniles were extracted from the roots of alfalfa seedlings from oxamyl-coated seeds as from the roots of the control; by week 11 the difference was 85% as many.

DISCUSSION

A sticker such as the polymer used in this study may have to be diluted to allow greater absorption of water and an acceptable rate of seed germination. Coating alfalfa seed with this sticker diluted 1:1 to 1:3 delayed seedling emergence either because of inhibition of water absorption or a direct seedling inhibition. At week 3, however, the effect had disappeared regardless of the concentration of sticker on the seed. This commercial sticker apparently should be diluted 1:5 for coating alfalfa seeds. Other types of stickers may require a different dilution.

The use of stickers on seeds without the addition of pesticides could be advantageous in dryland farming. Sticker-coated seeds could delay germination until adequate moisture is available, not only for germination but also for seedling establishment. With uncoated seeds rainfall may be adequate for germination but inadequate for seedling establishment, resulting in the need for reseeding.

Alfalfa seeds were tolerant of oxamyl even when coated with high concentrations. The concentration of 160 mg oxamyl/ml, was more than three times that used in an earlier study (6), yet seedling emergence was not delayed nor were growth and nodulation adversely affected 3 weeks after planting. In studies with wheat, rye, oats, and rye grass, oxamyl applied to seed in solutions of 50 mg/ml affected germination and plant height (1–3). Oxamyl was also toxic to carrot when applied to seed in a solution of 40 mg/ml (Townshend, unpubl.) and to corn when applied to seed in a solution of 8 mg/ml (1). The hard cotyledons and integument of alfalfa seed may provide greater protection to the embryo than does soft seed such as tomato. The epidermis that protects the embryo of corn may provide even less protection against oxamyl than the integument and cotyledons of alfalfa. Alfalfa seeds are very small and smaller quantities of oxamyl may adhere even though high concentrations of oxamyl are used for coating, whereas larger quantities of oxamyl may adhere to larger seed such as corn even though low concentrations were used for seed treatment. In an earlier study (5) the duration of the application of oxamyl was found to affect toxicity; oxamyl was toxic at 16 mg/ml when alfalfa seeds were soaked for 17 hours in water. The integument on many of the seeds had ruptured after 17 hours, probably exposing the embryo to the oxamyl solution.

Oxamyl coated on seed was more effective as a control for *P. penetrans* than for *M. hapla*. The reduction in the numbers of *P. penetrans* in soil and roots was greater and lasted longer. The more effective control of *P. penetrans* was also reflected in increased shoot growth for 11 weeks; shoot growth of *M. hapla*-inoculated seedlings increased for only 7 weeks.

This study has shown that oxamyl-coated seed provides effective control of *P. penetrans* and *M. hapla* on alfalfa and assures better plant growth for a few weeks. Coating alfalfa seed is a precise means of applying oxamyl in the vicinity of alfalfa seedlings, whereas the application of granular oxamyl or aldicarb to the soil at planting is much less precise. Alfalfa seed are generally spread on the soil surface with a rotary seeder and then incorporated into the soil with a cultivator. Oxamyl and aldicarb granules are coarser than alfalfa seed. Consequently the rotary seeder must be readjusted before applying granular nematicides to the soil surface as a separate application before incorporation into the soil. This is inconvenient, time consuming, and an added expense. There is sophisticated equipment with which seed and granular nematicides can be spread on the soil surface in one application, but this, too, is costly.

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