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The Effect of Planting Time Insecticides and Liquid Fertilizer on the Russian Wheat Aphid (Homoptera: Aphididae) and the Lesion Nematode (*Pratylenchus thornei*) on Winter Wheat[1]

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ABSTRACT: Organophosphate (OP) insecticides, disulfuton and phorate, applied in combination with liquid fertilizer (10-34-0) at planting, suppressed the Russian wheat aphid, *Diuraphis noxia* (Mordvilko) (RWA) in 'Carson' winter wheat for a longer period of time than carbofuran used with and without liquid fertilizer. However, yields from carbofuran treated plots were greater (average of 631 kg/ha) than those treated with OP insecticides. Based on post-harvest soil samples, lesion nematodes (*Pratylenchus thornei*) were found to be the yield limiting factor in the OP + liquid fertilizer treatments, the untreated control and the treatments with liquid fertilizer alone. Carbofuran provided increased yield, test weight and seed weight per head when compared with the other treatments. The lesion nematode was the more economically damaging pest of winter wheat in this study, compared with the Russian wheat aphid.

The cumulative and estimated economic impact of the Russian wheat aphid (RWA) *Diuraphis noxia* (Mordvilko), on agricultural loss in Colorado has exceeded 90 million dollars (Peairs, 1990). Foliar applications of organophosphate (OP) class insecticides have been used almost exclusively to protect against yield loss. Winter wheat producers in northeastern Colorado commonly utilize liquid "starter" fertilizer in the seed furrow to allow healthy plant establishment and growth. Preliminary data on the use of at-planting systematic insecticides show that control of RWA can be achieved through the fall and into early spring (mid April) in northeastern Colorado with granular and liquid forms of OP insecticides (Armstrong et al., 1990). Applications of insecticides in furrow at planting have some advantages over foliar applications in terms of reduced hazard and lower cost of application.

Plant parasitic nematodes have not been recognized as serious economic threats to Colorado winter wheat. However, it is common knowledge that some fields or some areas in a field do not respond to fertilizing or other cultural practices that would normally increase yields in dryland wheat production. Survey data are needed on nematodes of economic importance to dryland wheat production in Colorado.

Lesion nematodes (*Pratylenchus* spp.) have a wide host range. Wiese (1987) lists tobacco, corn, rye, peanuts, red clover, fruit trees, and vegetables as hosts.

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Norton (1959) lists small grains and several different species of native grasses as hosts of *Pratylenchus* spp. Lesion nematodes are free-living in the soil and do not cause cysts or nodules but penetrate and migrate through cortical tissue. This penetration of tissue predisposes host root systems to secondary infection from soil-borne pathogens and increases plant water stress (Agrios, 1978).

In Oklahoma, Russell and Singleton (1984) have determined that lesion nematodes (*P. neglectus, P. thornei*) can be an economic threat to wheat production. Furthermore, Russell and Singleton (1990) found that carbofuran is the most effective compound in controlling lesion nematodes at a rate of .29 kg/ha on alternate drill row treatments.

This study was designed to determine if organophosphate or carbofuran products could be used with liquid "starter" fertilizer at planting to effectively control the Russian wheat aphid.

In the process of sampling the RWA test plots, noticeable differences in visual characteristics such as plant height and general plant healthiness were noted between treatments, with consistency across replications. In addition, comparisons of RWA numbers with yield resulted in a poor correlation and appeared unusual. These observations prompted the authors to take post-harvest nematode samples.

Materials and Methods

The winter wheat 'Carson' *Triticum aestivum* was planted on 16 September 1989, with seven different combinations of insecticides and fertilizers included in the seed furrow at planting. Plots (1.8 m × 15.2 m) were arranged in a randomized complete block design with four replications. The treatments included liquid fertilizer (LF) 10-34-0 (7.5 kg/ha actual N and 25.5 kg/ha actual P_2O_5); an untreated control; Furadan^R 4F (Fur 4F) (.57 kg ai/ha); Furadan^R 4F + liquid fertilizer (Fur 4F + LF) at the same previous rates; Disyston^R 8E (Dis 8E) (.43 kg ai/ha) + Furadan^R 4F (.29 kg ai/ha) + liquid fertilizer; Thimet^R 20G (Thim 20G) (.88 kg ai/ha) + liquid fertilizer; and Disyston^R 15G (Dis 15G) (.88 kg ai/ha) + liquid fertilizer.

The plots were planted with a double risk opener drill (30.5 cm row spacing) with a seeding rate of 137,500 seeds per ha. Granular OP materials (Disyston^R 15G, Thimet^R 20G) were applied with modified Wintersteiger meters (Wintersteiger of America, Salt Lake City, Utah), with drop tubes that delivered the material within the seed furrow. Liquid materials (liquid fertilizer 10-34-0, Furadan^R 4F, Disyston^R 8E) were pumped into the seed furrow using an Agri-Inject system (Agri-Inject Systems, Yuma, Colorado). Planting depth was 6.5 cm in a Weld silt-loam soil.

The test plot site was central Washington County, Colorado, in a commercial producers field that had been in winter wheat without rotation for at least two years.

A core designed to remove a plug of soil (12.5 cm deep × 10 cm diameter) and place it in a pvc sleeve was used to remove one core containing plants from each plot. Test plots were cored on 8 October, 29 November, and 1 December 1989, and 9 April 1990. Potted plants were transported to a greenhouse for the remainder of the study, including an acclimation period of one week. The temperature in the greenhouse was 21°C ± 4°C. Soil core samples were trimmed at the soil surface so that only one plant remained in the center. Plants were watered with 70 ml of water every other day. Following the one week of acclimation, five apterous RWA's

Table 1. Mean[a] number of Russian wheat aphids from potted wheat plants, sweep net samples and mean lesion nematodes from insecticide and liquid fertilizer treatments, Washington County, CO, 1989–1990.

Treatment	Mean RWA's/ potted plant		Mean RWA's/ ten sweeps	Lesion nematodes/ 100 ml soil
	12-01-89	4-09-90	6-05-90	8-18-90
LF[b]	41.3 a	46.3 a	98.3 ab	281 b
Untreated	31.3 a	54.0 a	158.8 a	527 a
Fur 4F	4.0 b	32.0 a	127.3 ab	87 c
Fur 4F + LF	4.5 b	18.5 b	79.3 bc	106 c
Dis 8E + LF	0.8 b	0.0 b	24.3 bc	201 bc
Dis 8E + Fur + LF	0.8 b	1.0 b	36.3 bc	47 c
Thimet 20G + LF	0.0 b	0.0 b	22.8 cd	107 c
Dis 15G + LF	0.0 b	0.0 b	23.3 cd	207 b

[a] Means within each column followed by the same letter are not significantly different, Duncan's multiple range test ($P = 0.05$).

[b] For a complete explanation of treatments, see Methods and Materials.

were placed on each plant with a camel-hair brush. Post-infestation counts were made one week after initial infestation.

Experimental plots were also evaluated with ten sweeps from a 15″ sweep net on 6 June 1990 when wheat plants were in anthesis. The contents of ten sweeps per plot were placed in a 4 liter Ziploc[R] bag and counted in the laboratory under magnification.

Test plots were harvested with a Hege[R] (Hans-Ulrich Hege, Westdeutschland, Germany) small plot combine on 14 July 1990. Grain test weight and percent moisture were taken during harvest with a Dickey-John GAC-10 grain analyzer (Dickey John Corp., Auburn, Illinois). The average number of seeds per wheat head and average weight of seed per head were obtained by clipping 20 random wheat heads per plot, hand threshing, counting, and weighing.

Samples for soil and root nematodes were taken with a soil probe (15 cm depth × 2.5 cm diameter) from the root soil zone of the standing wheat stubble. Six subsamples from each plot were mixed together in a plastic bucket then transferred to a 4 liter Ziploc[R] bag. An aliquot of 100 ml of soil was removed from each bag and nematodes were extracted using the Christie-Perry technique (Alby, 1975).

Analysis of variance was performed on RWA numbers, nematode numbers, yield, test weight, plants per row meter, and seed weight per head on MStat-C (1988). Mean separations were performed by Duncan's multiple range ($P = 0.05$) option. The mean number of lesion nematodes from each treatment (independent variable) was regressed against the mean wheat yield (dependent variable) in an attempt to further explain yield loss.

Results and Discussion

The early core samples of 8 October and 29 November 1989 resulted in low mean numbers (<4 RWA's) one week post infestation from Furadan[R] 4F, Furadan[R] 4F + liquid fertilizer, liquid fertilizer alone, and untreated check plots. The remaining treatments resulted in no RWA's on these two sampling dates. There were no significant differences between means and these data are not presented in tabular form.

Table 2. Yield components of var. Carson after being planted with different combinations of insecticides and fertilizer and following infestations of Russian wheat aphids and lesion nematodes, Washington County, CO, 1989–1990.

Treatment	Mean yield[a] kg/ha	Mean test weight lb/bu	Mean plants/ row m.	Mean seed weight per head (g)
LF[b]	2021 c	51.1 de	26.0 abcd	0.655 bc
Untreated	1687 d	49.3 e	29.0 ab	0.515 d
Fur 4F	2483 b	57.5 a	37.0 a	0.783 ab
Fur 4F + LF	2987 a	52.9 cd	24.0 bcd	0.683 bc
Dis 8E + LF	2086 c	54.1 bc	16.0 cd	0.678 bc
Dis 8E + Fur + LF	2674 b	57.4 a	28.0 abc	0.828 a
Thimet 20G + LF	1994 c	53.5 bc	15.0 d	0.707 abc
Dis 15G + LF	2171 c	55.4 ab	28.0 abc	0.715 abc

[a] Means within each column followed by the same letter are not significantly different ($P < 0.05$), Duncan's multiple range test.

[b] For a complete explanation of treatments, see Methods and Materials.

The LF and Untreated plots had significantly higher numbers of RWA's compared to the remaining treatments on 1 December (Table 1). However, on 9 April, Fur 4F ($\bar{x} = 32.0$) did not differ significantly from the LF ($\bar{x} = 46.3$) or untreated plots ($\bar{x} = 54.0$) followed by Fur 4F + LF ($\bar{x} = 18.5$). The remaining treatments had a mean of 0 with the exception of Dis + Fur + LF which had a mean of one.

The sweep samples are actual numbers of RWA's from the test plots, while the RWA numbers from the potted core samples were based on bioassay numbers and do not have a direct effect on final yield (Table 2). The sweep sample means in Table 1 may appear to be high in comparison with the core sampled plants, but they probably do not surpass the economic threshold of greater than 20% plants infested for wheat plants in anthesis.

The most noticeable results of this study are that while the Furadan[R] treatments were not as effective as OP insecticides, especially in terms of residual control of the RWA, and regardless of whether fertilizer was used, yields were higher in the Furadan[R] 4F treatments (Table 1). The average yield of the Furadan[R] 4F, Furadan[R] 4F + liquid fertilizer, and Dis 8E + Fur 4F + LF plots was 2715 kg/ha compared to 2084 kg/ha from the Disyston[R] 8E + liquid fertilizer, Thimet[R] 20G + liquid fertilizer, and Disyston[R] 15G + liquid fertilizer. This represents a 631 kg/ha increase in yield for Furadan[R] 4F combinations over OP combinations. The yield components in Table 2 show a general trend that Furadan[R] combinations increased test weight and seed weight per head. This prompted the authors to sample for nematodes.

The predominant, economically damaging nematodes recovered from the soil and root tissue samples were *P. thornei* (Table 2). Although there are no data on the economic threshhold of lesion nematodes, the quadratic equation in Fig. 1 shows that a strong ($r^2 = 0.83$) relationship existed between increased numbers of lesion nematodes and decreased yields.

The complex of biotic and abiotic factors such as soil moisture, nematodes, soil fungi, temperature, and the invasion of secondary organisms in winter wheat needs further research. It is likely that environmental conditions were highly

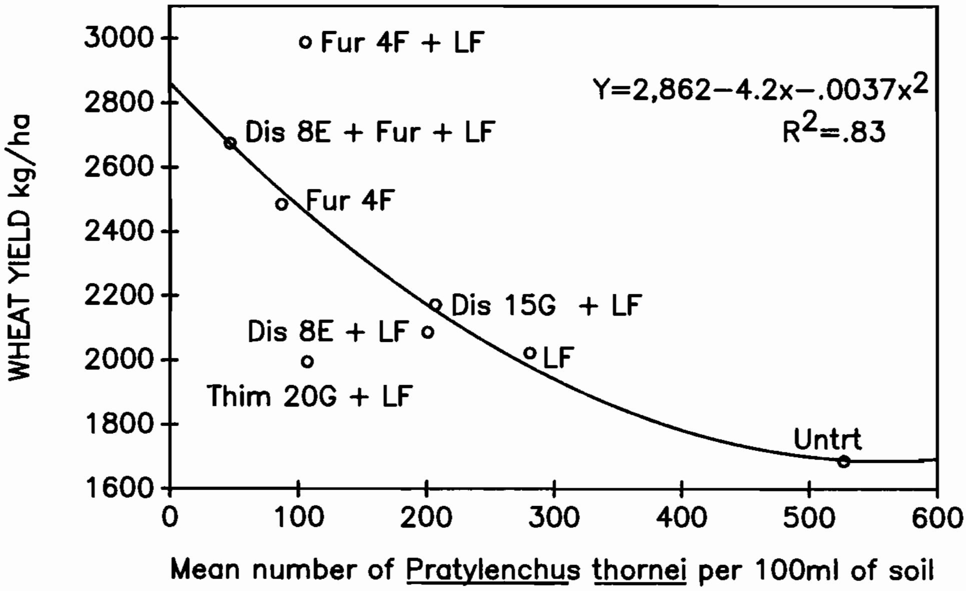

Fig. 1. Mean number of lesion nematodes (*Pratylenchus thornei*) regressed against 'Carson' winter wheat yields, Anton, CO 1990–1991. The abbreviations for different insecticide and fertilizer treatments are given in materials and methods.

conducive to lesion nematode development at this particular research site, and therefore allowed for a greater yield reduction when compared to the Russian wheat aphid.

The results of this research serve as a warning for researchers working on agronomic aspects of winter wheat in the Central Great Plains area. Yield data should be interpreted with the idea that lesion nematodes may have affected the results, and thus the results are possibly incorrect.

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