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Management of *Paratrichodorus allius* Damage to Onion in the Columbia Basin of Oregon[1]

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Abstract: Production of storage and dehydration (dehy) onions is increasing rapidly in the north-central Oregon region of the Columbia Basin. Roughly circular patches of stunted onions have been observed in many fields and are often numerous and (or) extensive in area. Onions in these patches often exhibit symptoms typical of stubby-root nematodes, and *Paratrichodorus allius* has been collected from several damaged areas. This study examined the relationship of *P. allius* densities to onion yield reduction and benefit from oxamyl application. Transect samples and onions harvested across areas with varying *P. allius* densities revealed that the total number of onions was not affected by *P. allius* but that onions were in smaller, less valuable size classes. Yield of the largest size class of storage onions (colossals) declined substantially (57–61%) even at low (5–16/250 g soil) nematode densities. Treatment with oxamyl at 1.1 kg a.i./ha mitigated most of the damage, and the value of both storage and dehy onions was increased by more than $1,200/ha. Early applications were superior to later applications, whereas treatment at both times was no better than the early treatment alone. Damage at low (<10/250 g soil) nematode densities, low treatment cost ($86–172/ha), and high crop values suggest an economic benefit from treatment at population densities of four or more *P. allius*/250 g soil. However, stunted patches of onions may occur for reasons other than nematodes, and the presence of *P. allius* should be confirmed before treating fields. This is the first report of stubby-root nematode damage to dehy onions and to storage onions in the Columbia Basin.

Key words: Allium cepa, management, nematode, onion, oxamyl, *Paratrichodorus allius,* stubby-root nematodes, threshold, yield loss.

Production of dry bulb (storage) onions (*Allium cepa*) in the Columbia Basin area of north-central Oregon began in 1983 and has averaged 2,500 ha in Morrow and Umatilla counties since 1985. Dehydration (dehy) onions were introduced in 1989 and have rapidly increased in production to 11,000 ha in 1996 (D. Nickell and G. Clough, pers. comm.). In 1991, growers began noticing areas of stunted onions varying in size from a few to more than a hundred meters across (Ingham et al., 1998). Symptoms of the onions within these patches were similar to those associated with stubby-root nematode (*Paratrichodorus allius*) (Jensen, 1963) (Siddiqi, 1974) injury in the Lake Labish onion production area of western Oregon (Jensen et al., 1983). This nematode feeds preferentially on root tips, terminating further growth and inducing branching. These branch tips also are attacked, resulting in a root system that is short, branched, swollen, and discolored. This alteration of root growth reduces the ability of the plant to take up water and nutrients and causes plants to be stunted and off-color. Yield reduction and disease symptoms are generally most severe when plant growth is reduced during cool, wet springs.

Stubby-root nematode population distribution is generally patchy within fields (Decraemer, 1995), so damage also occurs in patches. Damage in a field can range from trivial to extensive depending on the distribution and density of the nematodes. Fields planted to onion at Lake Labish are routinely treated for this nematode by preplant soil fumigation or with an application of oxamyl at planting. Averaged over three sites, soil fumigation with 1,3-dichloropropene increased yield by 49% (20 mt/ha) (Jensen et al., 1964). Similarly, Jensen et al.

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(1983) recorded yield increases as high as 43% over controls in oxamyl-treated plots that contained an average density of 160 *P. allius*/250 g soil before treatment. Advantages to treatment with oxamyl, as opposed to preplant soil fumigation, include cost ($86–172/ha for oxamyl vs. $370–618/ha for fumigation), ease of application by air or ground spray equipment, and the option of application at or after planting.

The following studies were conducted to determine if an association occurred between damaged onions and *P. allius* in the Columbia Basin and to evaluate management options with oxamyl. Although some recommendations for control exist for the heavy organic soils of Lake Labish, no information is available for the deep sandy soils of the Columbia Basin production area. This is the first report of stubby-root nematode damage to dehy onions and to storage onions in the Columbia Basin.

Materials and Methods

1993 dehy onion trial: On 24 June 1993, soil samples were collected across patches of stunted dehy onions cv. Southport Whiteglobe within a field in Morrow County, Oregon. Four transects were sampled in an east–west direction across patches approximately 20 m in diameter. Soil samples were taken along each transect in six sites designated as east-outside, east-edge, east-inside, west-inside, west-edge, and west-outside. Oxamyl (2.2 kg a.i./ha in 187 liters/ha spray solution) was applied through a CO_2 backpack sprayer in a 2.7-m-wide pass across the sampled areas in one of these patches and incorporated by overhead sprinkler irrigation. On 15 September, onions were harvested from a 1.83-m length of an 0.86-m-wide bed in adjacent treated and untreated areas within each of the six designated sites sampled along the transect. Onions were sorted into size classes of less than or greater than 3.2 cm diam. according to industry standards, and the onions in each size class were counted and weighed.

1997 dehy onion trial: In early May 1997, several onion fields were sampled to find a site infested with *P. allius* before symptoms were present. An area in a field of dehy onions cv. Southport Whiteglobe in Morrow County, Oregon, with an average density of 15 *P. allius*/250 g dry soil, was selected for this trial. Plots (9.1 m × 12.1 m) were established and sampled on 2 June. Treatments consisted of an untreated check and oxamyl applications on 2 June, 22 June, or both 2 June and 22 June with six replications. Each application of oxamyl was delivered at a broadcast rate of 1.1 kg a.i./ha in a banded spray, which covered 60% of the ground area, delivering an actual rate of 1.9 kg a.i./ha to the treated area. Incorporation was from overhead irrigation. On 4–5 September, onions were harvested from the center 4.6 m of the two middle 0.86-m-wide beds of each plot. Onions were sorted into size classes of less than or greater than a diameter of 3.2 cm, according to industry standards, and the onions in each size class were counted and weighed.

1995 storage onion trial: To demonstrate the relationship between numbers of *P. allius* and onion yield, a trial was established in a field of young storage onions in Umatilla County, Oregon, where plants were beginning to show symptoms of nematode injury. Six transects were laid across the field to take advantage of the natural variation in nematode density. Along each transect, five 9.1 m × 12.1 m plots were placed at 30.5-m intervals without regard to appearance of onions in that area. Each of the 30 plots was split in half, and each plot half randomly designated as control or treated. Soil samples were taken from each half of each plot on 9 June 1995. Plots without *P. allius* were excluded from the evaluation of oxamyl. The field was commercially treated with oxamyl at 1.1 kg a.i./ha in 187 liters/ha spray solution and incorporated with 0.64 cm water via overhead irrigation on 12 June. In the process, one plot half was treated and one half was not treated by shutting off the spray boom as it crossed over the designated control areas. Onions were harvested on 22 September from the middle 3 m of the center bed in each plot half, graded for size, and weighed. Market values for the different size classes ($165/mt for mediums, 5.1–7.6 sq cm diam.; $220/mt for jumbos 7.6–9.5 cm diam.; and $264/mt for colossals, >9.5 cm diam.) were used to estimate the gross value of each plot. The effect of initial nematode density on yield in each size class was examined by averaging data from plots containing 0, 1–10, 11–20, 21–30, 31–40, 41–100, 101–150, or 151–250 *P. allius.*

Nematode sampling: All nematode samples consisted of 10 2.5-cm-diam. cores, 30 cm deep. Samples were sieved and mixed. Nematodes were extracted from a 250-g aliquot of soil with wet sieving-sucrose centrifugation (Ingham, 1994) and counted. Soil moisture content was determined for each sample, and nematode densities were adjusted to numbers per 250 g dry soil.

Data Analysis: Yield and number of onions in each size class and total yield and number of all onions were compared between treated and control plots with a paired *t*-test or ANOVA. All differences reported are at $P \leq 0.05$, unless otherwise stated. Linear regression was used to examine the relationship between total onion yield per plot and the number of *P. allius* in the plot in the 1995 storage onion trial.

Results and Discussion

1993 dehy onion trial: Paratrichodorus allius population density increased markedly between the outside and edge sites, but there was little difference between densities in the edges of the patches and those of poor areas inside. Population densities across the four transects sampled averaged 25, 162, 180, 205, 346, and 135/250 g dry soil from the east-outside, east-edge, east-inside, west-inside, west-edge, and west-outside sites, respectively. Differences in population densities between inside and outside of patches may have been even more dramatic if west-outside areas had been sampled farther out from the edges. The average density for the west-outside was skewed by one high-density sample. The discrete nature of the patches was illustrated by the fact that no *P. allius* were recovered from three of the four east-outside sites even though these samples were taken only a few feet from where symptoms were apparent and *P. allius* densities were high.

There was little difference in onions between the outside and edge sites, but onions inside the patch were severely impacted by *P. allius.* Most (64–99%) onions harvested were greater than 3.2 cm diam., and the total number of onions per plot changed little across the transect or between treated and untreated areas (Fig. 1A). However, the untreated plots in the inside sites had nearly five times as many small (<3.2 cm diam.) onions as in the untreated edge or outside sites (data not shown). This was reflected by the smaller average onion weight in the untreated inside sites (Fig. 1B). Thus, *P. allius* appeared to have a greater effect on the average weight of onions than on the number of onions per plot. Yield in the oxamyl-treated areas inside the patch was 53% greater than in the inside areas that were not treated, but was still 27% less than in untreated outside areas (Fig. 1C) where *P. allius* density was very low. Therefore, it does not appear that the oxamyl treatment compensated for all yield loss, suggesting that an earlier application may have alleviated more of the nematode damage. Over all sites, yield averaged 36.1 and 44.2 mt/ha in untreated and treated plots, respectively. At a market value of $110/mt, this represented an increased value of $891/ha from a $172/ha nematicide application.

1997 dehy onion trial: Paratrichodorus allius averaged 4/250 g dry soil across all plots in June, a decline in population density since the May sample. There was no difference in total number of onions between treatments. However, the number of onions over 3.2 cm diam. averaged 439, 542, 494, and 495/plot in the untreated, early treatment, late treatment, and combination treatment, respectively, and was greater in plots treated early than in the untreated plots. Yield averaged 35.9, 48.0, 41.9, and 44.8 mt/ha in untreated, early, late, and combination treatments, respectively. All oxamyl treatments had higher yields than untreated plots, and plots treated early (2 June) had higher yields than those treated late (22 June). Two

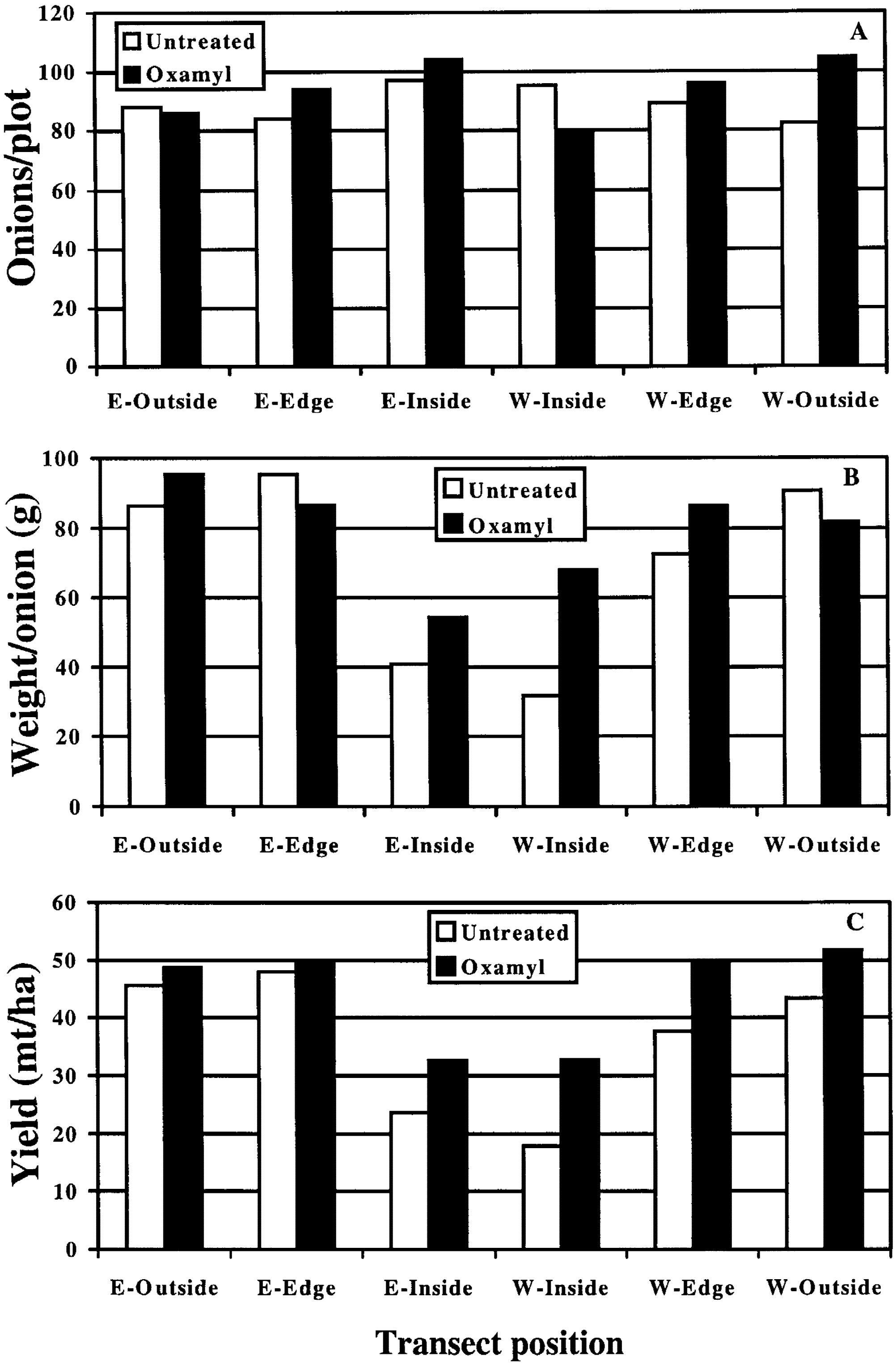

FIG. 1. Effect of oxamyl treatment (9.35 liters/ha) on dehy onions. A) Onion numbers. B) Onion weight. C) Onion yield. Plots were sampled along an east (E)–west (W) transect across an area with varying densities of *Paratrichodorus allius*, Morrow County, Oregon, 1993. The six sites sampled were designated as E-outside, E-edge, E-inside, W-inside, W-edge, and W-outside, based on position in the patch as defined by the appearance of onions.

applications were not better than one early treatment even though twice as much oxamyl had been applied. Based on an onion price of \$110/mt and a cost of \$86/ha for each oxamyl application, the increase in net value over the untreated control averaged \$1,245, \$574, and \$807/ha for the early, late, and combination treatments, respectively.

1995 storage onion trial: Treatment with oxamyl had no effect on the total number of onions but did influence distribution of onions among the different size classes (Table 1). Treated plots had more ($P \leq 0.001$) colossal onions but had fewer ($P \leq 0.05$) medium onions than untreated plots. Similarly, while the total weight of smaller (medium size class) onions was higher (31%, $P \leq 0.04$) in untreated plots, yield of the largest (colossal size class) onions was much greater (72%, $P \leq 0.001$) in treated plots (Table 1). At the prices used for this trial, the value of colossal onions was \$2,419/ha greater ($P \leq 0.001$) in the treated plots than in the untreated plots. A larger number of smaller onions in the untreated plots partially compensated for some of this difference so that total yield was only marginally higher ($P \leq 0.08$) in treated plots. Nevertheless, total crop value averaged \$1,684/ha greater ($P \leq 0.05$) in treated plots from an \$86/ha treatment due to the higher value of the colossal-sized onions.

No relationship was observed between density of *P. allius* and yield of medium or jumbo onions until nematode density was very high. However, yield of colossal onions declined sharply and steadily with increasing nematode density (Fig. 2). This relationship was apparent in untreated and treated transects in 1995, although overall yields were greater for oxamyl-treated onions. As nematode density increased, there was an apparent increase in yield of jumbo onions as nematode damage caused onions to shift from the colossal size class to the smaller jumbo size class (Fig. 2). Regression analysis of *P. allius* density against yield of colossal onions from the 30 treated and 30 untreated plots produced the equations $Y = 41.7 - 18.4 \times \log(x + 1)$, $r^2 = 0.38$, $P = 0.0002$, for untreated plots, and $Y = 39.0 - 11.6 \times \log(x + 1)$, $r^2 = 0.16$, $P = 0.03$ for treated plots where Y = yield in mt/ha and x = *P. allius* per 250 g soil at time of treatment.

Both storage and dehy onions appear to be sensitive to even low levels of *P. allius*. When market value was calculated for the data in Figure 2, regression analysis of average nematode density vs. marketable value/ha from untreated plots (Y = \$14,761–53.4x, $r^2 = 0.58$, $P = 0.03$) suggested that crop value was reduced by \$53.40/ha for each *P. allius* extracted from a 250-g soil sample. Therefore, at the low treatment cost of \$86/ha, the threshold for benefit from treatment would be very low, even if oxamyl did not alleviate all crop loss. There was no relationship between market value and nematode density in treated polts (Y = \$14,971–39.8x, $r^2 = 0.21$, $P = 0.15$). Similarly, in the dehy onion trial of 1997, increase ($P \leq 0.05$) in net value was obtained by treating plots that averaged only 4 *P. allius*/250 g soil.

TABLE 1. Effect of oxamyl application on number, yield (metric tons), and value of storage onions per hectare in a field infested with stubby-root nematodes (n = 30 plots/treatment), Umatilla, Oregon, 1995.

	Untreated			Oxamyl-treated[b]		
Bulb size class[a]	Number	Yield	Value	Number	Yield	Value
Culls	42,725	4.1	—	37,295	5.1	—
Mediums	65,665	7.6	\$1,258	50,055*	5.8*	\$952*
Jumbos	118,155	29.2	\$6,446	116,940	27.3	\$6,017
Colossals	38,930	13.3	\$3,526	60,235*	22.5***	\$5,945***
Total yield	265,475	54.2	\$11,230	264,525	60.7[c]	\$12,914*

[a] Onion classes: culls <5.1 cm diam., mediums = 5.1–7.6 cm diam., jumbos = 7.7–9.5 cm diam., colossals >9.5 cm diam.
[b] Oxamyl applied at 9.35 liters/ha (1.1 kg a.i./ha). Means with * and *** are different from corresponding untreated values at $P \leq 0.05$ and $P \leq 0.001$, respectively.
[c] Different from the untreated control ($P \leq 0.08$).

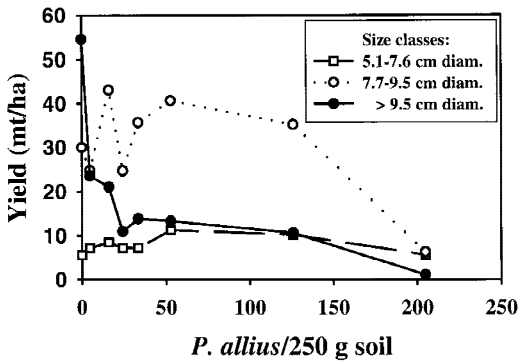

FIG. 2. Effect of *Paratrichodorus allius* density on yield of different size classes of storage onions. Umatilla County, Oregon, 1995.

Because the damage threshold of onions to *P. allius* is low, growers may be inclined to treat with a nematicide without sampling, but it is important to confirm the presence of *P. allius* before treating. Patches of stunted onions were sampled for nematodes in a number of fields during July, 1993. Many of these fields had high populations of *P. allius* (up to 210/250 g soil) within patches of onions that had symptoms characteristic of *P. allius* damage. However, other fields had patches of stunted onions that superficially resembled above-ground symptoms of nematode damage, but did not have root symptoms characteristic of *P. allius* damage and had few or no *P. allius* present in the soil. Wind erosion of soil soon after planting may have been responsible for these patches. Since *P. allius* is often distributed in small, discrete areas, as demonstrated in the 1993 trial, sampling before planting may miss areas with damaging levels. By being alert to the first appearance of symptoms and then confirming the presence of *P. allius,* growers may avoid unnecessary treatments and also have the option of treating only impacted areas. These applications could be made much earlier and may be more effective than those described here, since there would be less time delay between grower observation and treatment than occurs when a research trial is being organized.

In summary, yield of storage and dehy onions in the Columbia Basin was significantly reduced by even low numbers of *P. allius.* Nematode damage did not reduce the total number of onions, which suggested that *P. allius* did not affect survivorship unless it occurred between planting and plot establishment. *Paratrichodorus allius* reduced onion size, however, and most of the yield reduction was in the larger, more valuable size class of onions. This is important to the grower, since larger onions are worth more per unit weight than smaller size classes. Much of the yield loss could be prevented by an application of oxamyl at 1.1 kg a.i./ha as soon as symptoms appear.

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