Supplement to Journal of Nematology 22(4S):775–778. 1990.

Control of Nematodes and Soil-borne Diseases in Florida Potatoes with Aldicarb and 1,3-D[1]

D. P. Weingartner and J. R. Shumaker[2]

Abstract: Yields of U.S. Size A potato tubers were increased by 1,3-dichloropropene (1,3-D) (56 liters/ha) and 1,3-D (56 liters/ha) + aldicarb (3.4 kg/ha) in 1982 and 1983 and by aldicarb (3.4 kg/ha) in 1982. Treatments that included aldicarb provided the best control of corky ringspot disease, whereas those including 1,3-D were more effective against bacterial wilt. The most effective nematode control (nematodes included *Meloidogyne incognita, Belonolaimus longicaudatus,* trichodorids, *Criconemella ornata, Tylenchorhynchus claytoni,* and *Helicotylenchus* sp.) was provided by the combination of 1,3-D + aldicarb.

Key words: aldicarb, bacterial wilt, *Belonolaimus longicaudatus,* corky ringspot, *Criconemella ornata, Helicotylenchus* spp., *Meloidogyne incognita,* nematicide, *Paratrichodorus minor, Pratylenchus* spp., *Pseudomonas solanacearum,* soil fumigation, *Solanum tuberosum,* tobacco rattle virus, *Trichodorus viruliferous, Trichodorus proximus,* trichodorids, *Tylenchorhynchus claytoni,* 1,3-dichloropropene (1,3-D).

More than 10,000 ha of potato (*Solanum tuberosum* L.) are grown annually in northeastern Florida (4). Although Florida's spring potato production makes up < 2% of the total annual potato production in the United States, the crop is important because it represents > 25% of U.S. fresh potatoes produced from mid-April to mid-June (4). Florida ranks eighth among all states in the annual value of its potato crop.

Without chemical controls, nematodes and nematode-related soil-borne diseases cause major economic losses in Florida potatoes. Thirteen genera of phytoparasitic nematodes frequently infest Florida potato fields (9,10). Also, corky ringspot disease (CRS), caused by tobacco rattle virus vectored to potato by stubby-root nematodes, is found in approximately one-third of the hectarage (9). Bacterial wilt caused by *Pseudomonas solanacerarum* E. F. Smith apparently is indigenous to northeastern Florida, and its importance has resurged in recent years because of increased hectarages being planted to more susceptible potato cultivars such as Atlantic (8). We report here the relative control of nematodes, CRS, and bacterial wilt in Florida by 1,3-dichloropropene (1,3-D), aldicarb, and 1,3-D + aldicarb.

Received for publication 7 March 1990.

[1] Florida Agricultural Experiment Station Journal Series No. R-00611.

[2] Associate Professors, IFAS Agricultural Research and Education Center, Hastings, FL 32145.

We thank Jill Meldrum and Louis Wallis III for technical assistance.

Materials and Methods

The raised-bed cultural system used for potato production in northeastern Florida has been described previously (1,2,6,7) and only pertinent information is present here. The experiments were performed in 1982 and 1983 at the Agricultural Research and Education Center Yelvington Farm in Hastings. The soil is an Ellzey fine sand (sandy, siliceous, hyperthermic Arenic Ochraqualf) averaging 91.7% sand, 5.6% silt, 2.7% clay; pH 5.5–6.0 (4). A polyspecific nematode community including *Meloidogyne incognita* (Kofoid & White) Chitwood, *Belonolaimus longicaudatus* Rau, *Tylenchorhynchus claytoni* Steiner, *Criconemella ornata* (Raski) Luc & Raski, *Paratrichodorus minor* (Colbran) Siddiqi, *Trichodorus viruliferous* Hooper, *T. proximus* Allen, *Pratylenchus* spp. (principally *P. zeae* Graham), and *Helicotylenchus* spp. occurred in the experimental field. CRS and bacterial wilt had been severe in previous seasons in this potato field.

The field was fumigated with 56 liters 1,3-D/ha (570 ml/100 m of row) on 16 December 1981 and 1 December 1982. The fumigant was injected 25–30 cm deep with a single chisel per row (1.0-m spacing). Potatoes were planted and aldicarb was applied on 4 February 1982 and 16 February 1983. Aldicarb was applied at 3.4 kg a.i./

ha (34.1 g/100 m of row) as 25-cm-wide bands over the row after potatoes were placed in the rows. Bedding of the rows after planting incorporated the chemical in the soil. Treatments (1,3-D, aldicarb, and 1,3-D + aldicarb) and the untreated control were replicated five times in a randomized complete block design. Plots were 28 m long × four rows wide. Data were taken from the center two rows which consisted of a single row each of the potato evltivars Atlantic and Sebago. Sebago is tolerant to bacterial wilt and highly susceptible to CRS, whereas the converse is true of Atlantic. The 28-m plots were subdivided into four 7-m subplots for collecting data, which were pooled and averaged for statistical analyses.

Soil samples were taken on 28 April–3 May 1982 and 26–27 May 1983. Ten soil cores (2.5-cm-d × 20–25-cm-deep) were taken from each row of each subplot. Soil from the two data rows was bulked prior to extraction. Nematodes were extracted from 100-cm^3 aliquants with a modification of the sugar-centrifugation method (3). Nematode data were transformed to $\sqrt{\text{nematodes} + 1}$ prior to analysis of variance.

Counts of bacterial wilt were made at the time of maximum wilt development, 80 and 84 days after planting on 24 April 1982 and 10 May 1983, respectively. Data were expressed as the proportion of the final number of emerged plants that wilted in each plot and were transformed to arcsine values prior to analysis of variance.

Potatoes were mechanically harvested, washed, graded, and weighed 25–26 May 1982 and 26–27 May 1983. Incidence of CRS was determined by examining 20 U.S. Size A tubers sampled randomly from each row of each subplot. Symptoms of CRS were observed along 5–10 transverse slices through each Atlantic tuber or by observing typical external lesions of CRS in Sebago. Severity of CRS was rated on a scale of 1–10 in Sebago tubers, with 1 = all tubers free of CRS and 10 = 100% surface of all tubers affected. Data were expressed as the proportion of tubers with CRS and were transformed to arcsine values prior to analysis of variance.

Results and Discussion

The yields of U.S. Size A tubers from all fumigated plots exceeded those of the controls in both years (Table 1). Largest yields were from plots with 1,3-D + aldicarb; however, they were not significantly greater than yields from plots treated with 1,3-D alone. Yields of plots with 1,3-D alone exceeded those of plots with aldicarb in 1983, but not in 1982. There was no difference ($P \leq 0.05$) in yield between the cultivars in 1982 (data not shown). In 1983, however, due mainly to severe bacterial wilt, Atlantic produced only 14.7 t/ha compared to 19.6 t/ha produced by Sebago. There was also a significant cultivar × nematicide effect on yield in 1982. The interaction was due to untreated Atlantic yielding 3.7 t/ha more than Sebago, whereas following treatment with 1,3-D + aldicarb, Sebago yielded 30.2 t/ha compared to 25.6 t/ha for Atlantic.

Effects of nematicides on nematode populations varied with nematode genera and with the season (Table 1). Lowest populations were generally in plots with 1,3-D + aldicarb. The most damaging nematodes to potato in northeast Florida usually are *M. incognita* and *B. longicaudatus* (9,10). There were no differences ($P \leq 0.05$) between treatments in populations of *M. incognita* in 1982. Relative to the control, population densities of *M. incognita* in 1983 were reduced 75.3% by 1,3-D + aldicarb and 62.0% by 1,3-D. All nematicides reduced populations of *B. longicaudatus* in 1982, with the highest reduction occurring in 1,3-D + aldicarb plots.

Bacterial wilt was more prevalent in 1983 than in 1982 (Table 2). More Atlantic than Sebago plants wilted both years, especially in 1983 when 34.1% of Atlantic and only 2.6% of Sebago plants wilted. The lowest incidence of wilt in both years occurred in 1,3-D plots. There were no differences in wilt incidence between the untreated controls and aldicarb plots.

Trichodorids are important in northeast

TABLE 1. Nematode populations, incidence and severity of corky ringspot (CRS), and yields of U.S. size A tubers as affected by nematicides, 1982 and 1983.

Treatment and in-row rate (a.i./ha)	Nematodes/100 cm³ soil†							Incidence of CRS (%)	Severity of CRS (1–10)‡	U.S. size A tubers (t/ha)
	MI	TR	CR	TY	BL	HE	PR			
					1982					
1,3-D (56 liters)	281 a	49 b	18 a	9 a	10 ab	49 a	49 a	66.2 b	8.4 d	23.9 ab
Aldicarb (3.4 kg)	154 a	7 a	43 a	5 a	26 b	94 a	94 a	34.4 a	4.2 b	22.1 b
1,3-D (56 liters) + aldicarb (3.4 kg)	63 a	16 a	43 a	3 a	2 a	14 a	14 a	23.0 a	3.2 a	27.9 a
Untreated	256 a	15 a	42 a	70 b	88 c	747 b	747 b	59.5 b	5.1 c	15.8 c
					1983					
1,3-D (56 liters)	148 a	42 b	28 a	4 a	6 a	27 a	3 a	54.3 c		20.0 a
Aldicarb (3.4 kg)	191 b	4 a	37 a	8 a	6 a	81 a	17 cb	12.8 b		13.9 b
1,3-D (56 liters) + aldicarb (3.4 kg)	96 a	5 a	16 a	2 a	4 a	113 a	6 ab	10.3 a		21.7 a
Untreated	389 b	19 ab	26 a	22 b	10 a	246 a	33 c	80.0 c		12.9 b

Data are means of five replicates and are averaged across Sebago and Atlantic cultivars. Means in columns within a year followed by the same letter do not differ significantly ($P \leq 0.05$) according to Duncan's multiple-range test on transformed data. Data are presented an untransformed values.

† MI = *Meloidogyne incognita*; TR = mixed trichodorids, primarily *Paratrichodorus minor, Trichodorus viruliferous,* and *T. proximus*; CR = *Criconemella ornata*; TY = *Tylenchorhynchus claytoni,* BL = *Belonolaimus longicaudatus*; HE = *Helicotylenchus* spp.; and PR = *Pratylenchus* spp. (principally *P. zeae*).

‡ Where 1 = all tubers free of CRS and 10 = 100% surface of all tubers affected.

Florida potatoes mainly as vectors of tobacco rattle virus (9,10). In 1982, trichodorid populations following 1,3-D were increased over those in the control plots. A similar but nonsignificant trend occurred in 1983. Resurgence of trichodorid populations following fumigation has been reported previously in Florida potatoes and other crops (9).

TABLE 2. Bacterial wilt in potato cultivars. Atlantic and Sebago as affected by nematicides, 1982 and 1983.

Nematicide treatment	Wilted plants (%)		
	Atlantic	Sebago	Mean
	1982		
1,3-D	8.7	8.8	8.7 a
Aldicarb	17.5	10.3	13.9 b
1,3-D + aldicarb	9.8	5.8	7.8 a
Untreated	17.5	11.0	14.3 b
Mean	13.4 n	9.0 m	
	1983		
1,3-D	23.4	0.7	12.0 a
Aldicarb	49.3	4.4	26.8 b
1,3-D + aldicarb	25.2	3.3	14.2 a
Untreated	38.4	2.0	20.2 b
Mean	34.1 n	2.6 m	

Aldicarb applied at 3.4 kg a.i./ha and 1,3-D at 56 liters/ha in-the-row (1.0-m row spacing). Values within a treatment level (nematicide [a–b] and cultivar [m–n]) and year followed by the same letter do not differ significantly ($P \leq 0.05$) according to Duncan's multiple-range test. Lack of letters within a treatment level denotes no significant ($P \leq 0.05$) differences.

Incidence of CRS was reduced by both treatments containing aldicarb in both seasons. The incidence of CRS in aldicarb and aldicarb + 1,3-D plots in 1982 was greater than levels usually observed following these treatments (9). The CRS lesions were largely superficial, indicating that infection probably occurred late in the season after aldicarb efficacy had diminished.

The results were typical of many others obtained in northeast Florida (10). Use of fumigant or nonvolatile nematicides generally reduces nematode populations and greatly increases tuber yields. However, soil fumigants have failed repeatedly to control CRS in northeast Florida, whereas nonvolatile nematicides, particularly aldicarb, have provided highly effective control. Conversely, soil fumigants applied at standard dosages provide some control of bacterial wilt, whereas nonvolatile nematicides fail to control this disease. Soil fumigation coupled with planting of the

wilt-tolerant Sebago is generally sufficient to avoid severe losses due to bacterial wilt.

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