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COMPARISONS OF NEMATODE CONTROL AND POTATO YIELDS IN LARGE PLOTS TREATED WITH DIFFERENT COMBINATIONS DURING 1977-1981[1]

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Abstract. **Nematode control and potato yields were monitored following the use of various nematicides in 1/12 acre nonreplicated plots during 1977-1981. The nematicide treatment schedules were selected so that some of the plots were treated with the same nematicide combinations during each season whereas treatment combinations were varied in others. Some of the more important observations included: 1. a given preplant population density of** Belonolaimus longicaudatus **did not affect yields equally each year; 2.** B. longicaudatus **population densities were usually decreased and potato tuber yields increased for two seasons following use of an aldicarb 15 G plus 1,3 D (at 3.0 lb ai and 6.0 gal/acre in-the-row, respectively) combination; 3. yield response following nematode control varied considerably from season to season; 4. tuber yields in the best nematicide treatment averaged 256 cwt/acre/year as compared to 173 cwt/acre/year in a nontreated area.**

Nearly all Irish potato (*Solanum tuberosum* L.) and cabbage (*Brassica oleracea* var *capitata* L.) fields in northeast Florida (NEF) are severely affected by plant parasitic nematodes (Table 1). Sting *Belonolaimus longicaudatus* Rau) and southern root-knot [*Meloidogyne incognita* (Kofoid and White) Chitwood] are considered to be the most important ones directly affecting tuber yields of potato. Stubby root (*Trichodorus* and *Paratrichodorus* spp) nematodes are important principally as vectors of tobacco rattle virus, the cause of corky ringspot (CRS), which is a serious disease affecting potato tubers in NEF (8, 9). Due to the widespread nematode problem and dramatic increases in plant vigor and tuber yields following application of nematicides in NEF (5, 6, 7), grower use of these chemicals increased rapidly during 1968-1980 (Fig. 1). Based on average potato yields for eight year periods, production/acre in NEF increased 15.7% during 1968-1980; improving from 159 cwt/acre in 1968 to > 184 cwt in 1980. The increase in average production is attributed largely to nematode control since this was the single major grower production practice to change throughout NEF during the past decade.

Even though use of nematicides is now a standard practice in NEF, we have had questions concerning effects of perennial use of nematicides on potato production and nematode population dynamics. The principal objective of the study reported in this paper has been to observe year to year differences in potato yields and nematode population densities following perennial use of nematicides in the same fields. We have been particularly interested in learning whether gradual decreases in peak nematode population densities and corresponding increases in potato yields would follow perennial use of nematicides; observing the effect of alternating the use of soil fumigants and non-volatile nematicides on yields and soil-borne diseases such as bacterial wilt; and following the magnitude of yield differences and changes in nematode population densities from season to season in nontreated soil.

Table 1. Percent northeast Florida farms affected by various plant parasitic nematodes.[z]

Scientific name	Common name	% Farms affected
Belonolaimus longicaudatus	Sting	96
Meloidogyne incognita	Root-Knot	85
Paratrichodorus minor	Stubby Root	82
Trichodorus spp.	Stubby Root	
Pratylenchus scribneri	Lesion	61
Tylenchorhynchus claytoni	Stunt	70
Criconemoides ornatus	Ring	99
Hemicycliophora sp.	Sheath	79
Hopolaimus sp.	Lance	55
Hemicriconemoides sp.	Spiral	93
Helicotylenchus sp.	Spiral	26
Dolichodorus heterocephalis	Awl	23
Scutellonema bradys	None	27

[z]Summarized from 2123 soil samples analyzed for presence of nematodes by the University of Florida Cooperative Extension Service during 1968-1980.

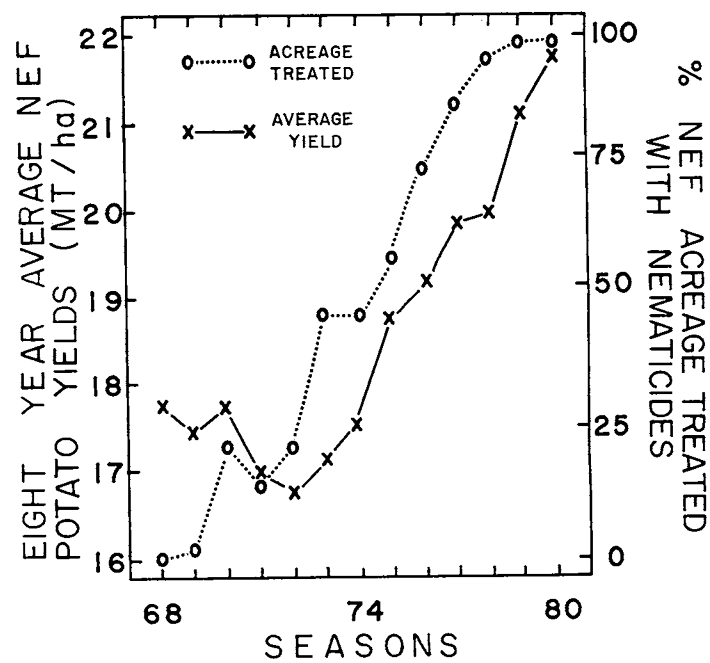

Fig. 1. Percent northeast Florida (NEF) potato acreage treated with nematicides during 1968-1980 compared to eight year average potato yields during the same periods. Potato yields are expressed as the average of the eight year period ending in the year shown.

Materials and Methods

Fields. The potato fields used in the study are on the Hastings Agricultural Research Center farm and have been seasonally monocultured to potatoes for > 50 years and planted to a sorghum (*Sorghum vulgare* Pers. Martin x sudan grass hybrid) summer cover crop for > 15 years. The soil is a Rutledge fine sand having < 2% organic matter

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and is both irrigated and drained with a prototype subsurface tile system (1). Each of nematodes listed in Table 1 except *Scutellonema bradys* is known to occur in the test area. Sting and southern root-knot nematodes are the most important in terms of numbers present and in their effects on tuber production.

Cultivars. 'Sebago', which until 1981 has been the leading cultivar planted in NEF, was used in 1977 and 1979. The new and rapidly accepted 'Atlantic' (3) was used in 1978. Alternating rows of 'Sebago' and 'Atlantic' were planted in 1980 and 1981.

Nematicides. During the course of the study aldicarb 15G (Temik®), carbofuran 10G (Furadan®), phenamiphos 15G (Nemacur®), ethoprop 10G (Mocap®), and 1,3D (Telone II®) were used in various combinations and sequences. Discussion is limited to aldicarb (A) and 1,3D (T) because these chemicals were used every year and are the two most frequently used by NEF growers. The soil fumigant was injected with a single chisel/row 6-10 weeks before planting. Soil was immediately bedded into ridged rows thereby sealing the fumigant in the row. Nonvolatile chemicals were applied at planting with an applicator attached to the potato planter.

Cultural practices. Routine NEF growing practices and pest control procedures were used throughout the study. Metribuzin 50W (Lexone® or Sencor®) was applied premergent for weed control; Captan 7.5 D was used for seed piece decay; foliage diseases were held in check with applications of mancozeb 80W, (Dithane M-45® and Manzate 200®) or chlorothalonil (Bravo®) scheduled according to Florida Blitecast (4); depending upon the season, insects were controlled with methomyl (Lannate®), parathion, or methamidophos (Monitor®). Depending upon the season, the potato crop was planted in February and harvested during the last week in May or first week in June.

Field plots. During 1977 eight 250 ft. long X eight rows wide (i.e. 30 ft.) blocks were treated with nematicides. Grower application and planting methods were simulated as closely as practicable. In 1978 the plots were halved into 125 X 30 ft. blocks and this size was used for the remainder of the study. Nematicide treatments were not replicated during any season.

Harvest. All of the potatoes from the test area in 1977 were harvested, washed and weighed. During subsequent years only four rows from each plot were harvested.

Nematode counts. Composite samples consisting of ca. one quart of soil accumulated from 15-20 soil probes in each plot were taken at various times during 1977-1981. Nematodes were extracted using a modification of the sugar flotation method (2).

Results

Nematode Population Densities

Belonolaimus longicaudatus. The greatest population densities of *B. longicaudatus* (Table 2) were observed in the nontreated field (Treatment No. 6). The numbers of nematodes recovered were greatest at the end of the cover crop (7 Sept 1979) and potato seasons (24 May 1978, 29 May 1979, 19 May 1980, 19 May 1981). The lowest average of 7.1 nematodes/100 cm^3 soil observed throughout the test period was in the field treated with T + A (Treatment No. 1). Sting nematode population densities generally remained low for two seasons following use of T + A (e.g. 20 Mar 1979 and 7 Sept 1979 samples).

Meloidogyne incognita. Populations of *M. incognita* (Table 3) tended to be more variable both among and within seasons than those of *B. longicaudatus*. Population densities of *M. incognita* were generally lowest during March-April and greatest in May near or at the time of harvest. Numbers were lowest each year in the field treated with T + A (Treatment No. 1).

Table 2. Population densities of *Belonolaimus longicaudatus* following use of various nematicides in large plots during 1977-1981.

Treatment number	Season and nematicide treatment[z]					*Belonolaimus longicaudatus*/100 cm^3 soil[y, x]								
	1977	1978	1979	1980	1981	11 Apr 1977	24 May 1978	20 Mar 1979	24 May 1979	7 Sept 1979	19 May 1980	2 Oct 1980	25 May 1981	Average
1	TA	TA	TA	TA	TA	47	0	0	0	8	2	0	0	7.1
2	A	T	A	T	A	8	0	105	0	105	6	29	0	31.6
3	NT	TA	NT	TA	NT	134	0	15	44	317	0	15	22	68.4
4	A	TA	T	NT	TA	8	0	0	0	148	93	36	0	35.6
5	TA	T	T	A	T	47	0	18	33	173	20	4	8	60.4
6	NT	NT	NT	NT	NT	134	206	162	108	378	42	76	0	138.3

[z]T = Telone II® (1,3D) at 6.0 gallons/acre; A = Temik 15G® (aldicarb) at 3.0 lb ai/acre; TA = Telone II + Temik 15G; NT = Nontreated. Nematicides applied in-row using a 40 inch row spacing.
[y]Soil samples were composites of 15-20 probes from each plot.
[x]Potato season extends from February-early June; cover crop season June-early October.

Table 3. Population densities of *Meloidogyne incognita* following use of various nematicides in large plots during 1977-1981.

Treatment number	Season and nematicide treatment[z]					*Meloidogyne incognita*/100 cm^3 soil[y, x]								
	1977	1978	1979	1980	1981	11 Apr 1977	24 May 1978	20 Mar 1979	24 May 1979	7 Sept 1979	19 May 1980	2 Oct 1980	25 May 1981	Average
1	TA	TA	TA	TA	TA	4	0	11	0	29	82	0	0	15.8
2	A	T	A	T	A	0	652	11	238	22	37	0	4	120.5
3	NT	TA	NT	TA	NT	11	4	15	1570	11	127	15	36	223.6
4	A	TA	T	NT	TA	0	0	8	306	58	955	18	0	168.1
5	TA	T	T	A	T	4	0	0	627	11	231	22	33	116.0
6	NT	NT	NT	NT	NT	11	832	51	267	0	119	4	33	164.6

[z]T = Telone II® (1,3D) at 6.0 gallons/acre; A = Temik 15G® (aldicarb) at 3.0 lb ai/acre; TA = Telone II + Temik 15G; NT = Nontreated. Nematicides applied in-row using a 40 inch row spacing.
[y]Soil samples were composites of 15-20 probes from each plot.
[x]Potato season extends from February-early June; cover crop season June-early October.

Trichodorids (*Trichodorus* and *Paratrichodorus* spp.). Population densities of trichodorids (Table 4) were less than those of *B. longicaudatus* and *M. incognita.* Numbers of trichodorids near harvest varied from 0 to 20/100 cm^3 soil following use of T + A. Following fumigation with T, at harvest population densities of trichodorids varied from 0 to 80, averaging 40.8/100 cm^3 soil.

Tuber yields. Potato tuber yields (Table 5) from the field treated with T + A each year (Treatment No. 1) varied from 180 cwt to 299 cwt/acre, averaging 244 cwt. The nontreated field (Treatment No. 6) produced 120 to 207 cwt/acre with a mean yield of 173 cwt. The % variation in yield [% variation in yield = (greatest yield − smallest yield/greatest yield) X 100%] in the nontreated and the T + A fields were essentially the same being 42.0% and 39.8%, respectively. The average tuber production for the five season period from those fields which were treated with the several different nematicide combinations were surprisingly similar, varying from 241 to 256 cwt/acre or only 5.9%. The least variation in production from season to season was observed in Treatments 2 and 5 (36.1 and 27.8%, respectively), which were treated during the last four seasons with single applications of either T or A. When a season of no nematicide use followed use of T + A (e.g. 1979 and 1981 in Treatment No. 3), tuber production exceeded that of the nontreated field (Treatment No. 6) and was nearly as great as from those fields which were treated with nematicides during those seasons.

Soil Borne Diseases

Bacterial wilt and tuber brown rot (*Pseudomonas Solanacearum*). Observations of bacterial wilt made in commercial NEF potato fields during 1975-77 suggested that the disease was more severe in fields which were treated for nematode control with A after they had been treated for several season with soil fumigants. Treatment combinations 2 and 5 which included various use sequences of T and A were placed in this test to study this possibility. Unfortunately the incidence of bacterial wilt in the test area was insufficient to draw conclusions.

Corky ringspot disease. Corky ringspot occurred nearly every season in the test area, however, differences in incidence and severity of the disease were due to location in the field rather than to differences in nematode population densities and nematicides used. Data are therefore not presented.

Discussion and Conclusions

The large plot technique reconfirmed several observations concerning nematode damage and nematode counts made in our small replicated plots since 1969. First, sting nematodes can be devastating on potatoes grown in sandy soils when conditions favor their activity. Secondly, compared to certain other nematodes such as *M. incognita, B. longicaudatus* is more ubiquitous and uniformly distributed in NEF potato fields. Crop damage due to sting nematodes is usually spread throughout the crop rather than being strongly clustered or confined to small "hot spots." Thirdly, a comparable population density of sting nematodes during the early part of the growing season can have a markedly different affect on tuber yields. Population densities of sting nematodes (Table 2) were consistently > 100/100 cm^3 soil in the nontreated field (Treatment 6), yet yields from this field (Table 5) varied from 120 cwt in 1977 to 207 cwt/acre in 1980. Part of the variation was undoubtedly due to *M. incognita,* however, differences in magnitude of stress

Table 4. Population densities of trichodorids following use of various nematicides in large plots during 1977-1981.

Treatment number	Season and nematicide treatment[z] 1977	1978	1979	1980	1981	Trichodorids/100 cm^3 soil[y, x] 11 Apr 1977	24 May 1978	20 Mar 1979	24 May 1979	7 Sept 1979	19 May 1980	2 Oct 1980	25 May 1981	Average
1	TA	TA	TA	TA	TA	18	0	33	0	47	20	47	0	20.6
2	A	T	A	T	A	26	33	4	4	29	26	29	0	19.9
3	NT	TA	NT	TA	NT	58	0	11	29	65	4	44	0	26.4
4	A	TA	T	NT	TA	26	0	33	47	33	8	33	0	22.5
5	TA	T	T	A	T	18	18	22	80	36	4	18	0	24.5
6	NT	NT	NT	NT	NT	58	22	0	4	15	6	0	0	13.1

[z]T = Telone II® (1,3D) at 6.0 gallons/acre; A = Temik 15G® (aldicarb) at 3.0 lb ai/acre; TA = Telone II + Temik 15G; NT = Nontreated. Nematicides applied in-row using a 40 inch row spacing.
[y]Soil samples were composites of 15-20 probes from each plot.
[x]Potato season extends from February-early June; cover crop season June-early October.

Table 5. Yields of US size A potato tubers following use of various nematicides in large plots during 1977-1981.

Treatment number	Season and nematicide treatment[z] 1977	1978	1979	1980	1981	Yield US size A potato tubers (cwt/acre)[y] 1977	1978	1979	1980	1981	Mean	% Variation in yield[x]
1	TA	TA	TA	TA	TA	197	180	299	268	275	244	39.8
2	A	T	A	T	A	191	215	299	295	282	256	36.1
3	NT	TA	NT	TA	NT	120	179	280	289	311	236	61.4
4	A	TA	T	NT	TA	191	152	319	215	327	241	53.5
5	TA	T	T	A	T	197	208	258	273	272	242	27.8
6	NT	NT	NT	NT	NT	120	211	162	207	166	173	42.0

[z]T = Telone II® (1,3D) at 6.0 gallons/acre; A = Temik 15G® (aldicarb) at 3.0 lb ai/acre; TA = Telone II + Temik 15G; NT = nontreated. In-row rates using a 40 inch row spacing.
[y]The following potato cultivars were used: 'Sebago' in 1977 and 79; 'Atlantic' in 1978; and alternating rows of 'Sebago' and 'Atlantic' in 1980 and 81.

$$^{x}\% \text{ variation in yield} = \frac{\text{Greatest yield} - \text{least yield}}{\text{Greatest yield}} \text{X } 100.$$

placed on the host crop due to differences in precipitation and daytime temperatures were probably more important. Fourthly, large population densities of root-knot nematodes can develop on the crop even when the nematode is not found in early or preseason soil samples. In 1979, zero *M. incognita* (Table 3) were found in the treatment 5 block, yet 627 larvae/100 cm^3 soil were present at harvest.

Based on our data, there is little doubt that over the long term, nematode control in NEF is worth the investment in time and dollars. Although an actual dollar loss can be experienced by the grower during certain seasons such as in 1980 when plant stress and yield losses due to nematode injury were minimal, potentially disastrous yields such as those occurring in 1977, 1979, and 1981 in Treatment 6 (Table 5), can be prevented with nematode control. The data also suggest that the economics of the combined use of a nonvolatile nematicide and a soil fumigant, especially if the crop is destined for the chip market, may over the long term be questionable. Our data, however, have not been corrected for defects in tuber quality associated with CRS and other soil borne problems which are controlled with the combined treatment (5, 6, 8, 9) and which may effect the dollar value of the crop for table stock.

There is some indication in our data that nematode control following use of T + A may be sufficient to increase potato yields for two seasons. In 1979 and 1981 Treatment 4, which was nontreated during those seasons, produced, respectively, 118 and 145 cwt/acre > the nontreated Treatment 6 (Table 5). Even with this, however, there would be little economic gain over using A or T each season as in Treatments 2 and 5. In fact, the variations in yield in Treatments 2 and 5 were the least of any treatments; suggesting a more consistent performance and return to the grower than the other nematicide combinations.

In conclusion, our data support the following statements: 1. use of nematicides should be an integral part of NEF potato production. Any field with sting nematode should be treated since comparable population densities of *B. longicaudatus* can have drastically different, and unpredictable, affects on potato yields. 2. use of A + T may have effectively reduced populations of *B. longicaudatus* for two seasons, however, growers should very carefully analyze the economics of combined nonvolatile nematicide and soil fumigant treatments before using them. 3. No undesired effects on the crop, incidence of disease or population densities of the target nematodes have been observed following perennial use of nematicides in our research plots.

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REDUCING CELERY LEAFMINER DAMAGE WITH PLANT GROWTH REGULATORS[1]

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Abstract. **Two plant growth regulators, gibberellic acid (GA_3), 6-benzyladenine (BA), and combinations thereof were used as root dips before transplanting or applied as foliage sprays on celery two weeks before harvest. The combination of 25 ppm of GA_3 and 25 ppm of BA used as a root dip restricted early root growth, reduced transplant survival, and restricted marketable weight. The use of GA_3 and BA did not increase marketable yield or average stalk weight, but some treatments did increase plant height. The per cent leaves infested with leafminer (*Liriomyza trifolli*) was somewhat reduced by trimming the taller GA_3, BA, and GA_3 + BA sprayed plants.**

Gibberellin is one of a number of growth-promoting substances produced by the fungus, *Gibberella fujikuroi*, or is found in plant extracts. The physiological and morphological processes of gibberellins on plant growth and development have been studied in depth (8, 10). Gibberellic acid or gibberellin A_3 (GA_3) can be synthesized in a laboratory. Although much emphasis has been placed on commercial use of synthetic or exogenous GA_3 in fruit production (2, 4), GA_3 can be used to advantage in other stages of plant growth including stimulation and ripening of seeds (3, 7, 11), promotion of root initiation (5), reversal of induced dormancy (6), increasing yields (1, 2, 9, 10, 15), and promotion of flowering in certain conifers and ornamentals (12, 13).

GA_3 promotes growth of celery by increasing plant

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