should prove acceptable. Other sources of improved tolerance have been reported (8) and new sources are presently being investigated at Bradenton.

Race 3 tolerant hybrid cultivars utilizing the Australian sources will require tolerance on each side of the cross since hybrids with susceptible parents had high disease incidence.

Genetics. In this study a genetic analysis was not pursued due to constraints of the genotypes used, such as different susceptible parents in the F_1 and F_2 generations of the US 629 crosses, and a lack of backcross generations. Genetic interpretation is also difficult since there were susceptible plants segregating in all tolerant parental lines. Volin (8) reported US 629, US 638 and BTN 472 were all phenotypically homozygous and had been screened and selected for tolerance for 2 and 3 generations before their introduction to Florida. Attempts to improve the resistance of BTN 472 by selection of resistant plants at Bradenton were not successful (J. W. Scott, unpublished data). Therefore, incomplete penetrance, as suggested by Volin and Jones (8), appears to be a plausible explanation for segregation reactions in the tolerant parents. This adds complexity to genetic interpretations. McGrath and Toleman (5) indicated resistance from BTN 472 material was polygenic with significant non-additive gene effects. In our experiment, the F_1 and F_2 generations from BTN 472 had less mean days without disease than the midparent value (60.0) which would indicate non-additive gene effects, such as dominance, favor susceptibility. This is supported by the low percentage of healthy plants in these generations. Volin and Jones (7) suggested 2 genes control resistance of BTN 421 since a derived F_2 generation fit a 9:7 ratio. In this study the F_2 from BTN 421 also fits a 9:7 ratio of healthy to diseased plants (data not shown). However, such a model would require all the F_1's to be healthy which was not the case. The mean days without disease for the F_1 and F_2 generations with BTN 421 are greater than the midparent value (62.8), which would indicate some dominance for tolerant expression. This additive-dominance reaction is supported by the relatively high recovery of healthy plants in the F_1 and F_2 generations.

The tolerance level of US 629 is not as great as BTN 421 or 472. The F_1 of US 629 x 'Flora-Dade' was slightly less than the midparent value (47.1) but the F_2 with 'Hayslip' was greater. Gene action is probably largely additive but further study is needed to verify this assertion.

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NEMATICIDE OPTIONS FOR NORTHEAST FLORIDA POTATO GROWERS[1]

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Abstract. **Detectible residues of aldicarb [(2-methyl-2 (methylthio) propionaldehyde O-(methylcarbamoyl)oxime] and EDB (ethylene dibromide), 2 nematicides which are widely used in northeast Florida (NEF) potato** (Solanum tuberosum **L.) production, have been found in well water in other sections of the state. Most uses of EDB have been suspended in Florida and those of aldicarb restricted. The relative efficacies of nematicides available to NEF potato growers are compared. Most consistent reductions in nematode population densities and increases in tuber yields have been associated with the soil fumigants 1,3D (100% dichloropropene and related C_3 hydrocarbons) at 5.5-6.2 gal dichloropropene/acre in-the-row, EDB at 1.5 gal/acre in-the-row, and aldicarb at 3.0 lb. a.i./acre in-the-row. All soil fumigants evaluated were ineffective in controlling corky ringspot disease (CRS) whereas aldicarb and oxamyl (methyl-N[1], N[1]-dimethyl N-[methyl carbamoyl)oxy]-1-thiooxamimidate) (when applications were adequately scheduled) were highly effective in reducing the incidence of CRS. The role of nematicides as part of a management system for nematodes and soil-borne diseases in NEF is discussed.**

Virtually all potato growers in Northeast Florida (NEF) use nematicides. Average potato production/acre has increased > 15% in NEF since the introduction and use of nematicides in the late 1960's (15, 19). The nematicides most widely applied in recent years have been aldicarb and EDB [see Table 1 for a summary of all nematicides discussed in this paper]. During 1982 aldicarb was used on essentially 100% of the 20-21,000 acres of potatoes grown in NEF. An estimated 6-7000 acres were treated with EDB, mostly in combination with aldicarb.

During 1983 nearly all agricultural uses of EDB were suspended by federal and state agencies; and uses of aldicarb restricted by Florida State Department of Agriculture and

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Table 1. Chemical composition, proprietary and common names, rates and relative costs of nematicides discussed.

Common name	Chemical name and composition	Proprietary name[z]	Approximate cost/unit[y] ($)	Suggested in-row rates[x]/acre	Approximate cost/acre ($)
Soil fumigants					
EDB	83% ethylene dibromide	Dowfume W-85®	NA	1.4-1.8 gal	NA
EDB	84.5% EDB	Soilbrom 85®	NA	1.4-1.8 gal	NA
EDB	92.8% EDB	Soilbrom 90®	9.00	1.0-1.4 gal	9-13
EDB+chloropicrin	54% EDB + 44.4% chloropicrin	Terr-o-cide 54-45®	19.25	1.9-2.0 gal	37-39
EDB+chloropicrin	40% EDB + 15% chloropicrin	Terr-o-cide 15®	NA	3.6-4.5 gal	NA
DD	chlorinated C_3 hydrocarbons, including 1,3-dichloropropene, 1,2-dichloropropane, 3,3-dichloropropene, 2,3-dichloropropene and other related chlorinated hydrocarbons. (40-55% dichloropropenes)[v]	D-D®	5.00	7.5-10 gal	38-50
1,3D	100% Dichloropropene and related chlorinated hydrocarbons (78% dichloropropenes)[v]	Telone®	NA	6-8 gal	NA
1,3D	92% dichloropropenes	Telone II®	8-11	4.5-6.0 gal	36-66
1,3D+chloropicrin	76.3% dichloroproprene +17.1% chloropicrin	Telone C-17®	11-13	5.5-7.3 gal	60-95
DD-MENCS	80% DD + 20% methylisothiocyanate	Vorlex®	13	Nematodes 1.4-3.1 gal; weeds+ diseases 5.1-10.2 gal	18-133
DD-MENCS + chloropicrin	68% DD+17% methylisothiocyanate +15% chloropicrin	Vorlex 201®	14	Nematodes 1.4 to 2.8 gal; weeds + diseases 5-10 gal	20-140
Metam-sodium	sodium-N-methyldithiocarbamate	Vapam® Busan 1020®	6.50	50-100 gal[w]	175-650
Nonvolatile Nematicide					
aldicarb	2-methyl-2(methylthio) propionaldehyde 0-(methylcarbamoyl) oxime	Temik 15G® Temik 10G®	2.10	3.0 lb. a.i.	42
carbofuran	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate	Furdan 10G®	1.45	3.0 lb. a.i.	43
ethoprop	0-ethyl S,S- diproyl phosphorodithioate	Mocap 10G®	0.94	3.0 lb. a.i.	28
oxamyl	Methyl-N[1],N[1]-dimethyl N-[methyl carbamoyl)oxy]-1-thiooxamimidate	Vydate 2L®	41/gal	3.0-5.0 lb. a.i.	62-103

[z]List includes some chemicals such as Telone® which are no longer being sold in NEF.
[y]Prices are those quoted by local vendors and could vary depending upon supplies, qualities ordered, etc. Prices do not include costs of application.
[x]Rates listed are those shown on label of products. Vorlex 201®, Vorlex®, and Busan 1020® will be tested at lower more economical rates in 1984.
[w]Rates expressed are overall. Busan 1020® will be tested at lower, economical in-row rates in 1984.
[v]Dichloropropene is considered to be the active ingredient of DD® and Telone®.

Consumer Services (4). This action was prompted following detection of residues of these pesticides in well water in Florida and in ground water and/or well water in other states (2, 7, 8, 22).

Approximately 25% of the shallow (<150 ft in depth) drinking water wells near NEF potato fields were sampled and analyzed during February 1983 for residues of aldicarb and its sulfoxide and sulfone metabolites. No detectible residues (at a sensitivity limit of approximately 1.0 ppb) were found in any of the water samples (Florida Department of Agriculture and Consumer Services, Chemical Residue Laboratory; Florida Department of Health and Rehabilative Services and Union Carbide Corp., unpublished data). To date NEF water samples have not been analyzed for presence of EDB. Positive artesian flow and presence of an impervious zone of clay beneath many NEF fields coupled with the ridged row, peripheral water system of irrigation (3, 12) may physically eliminate or greatly reduce the potential for residues of agricultural chemicals entering shallow drinking water wells in NEF. There may be, however, potential for run-off of pesticide residues in surface drainage water in this system (14) and this possibility is being studied.

Due to high solubility of many nematicides in water (9, 13) and present Florida regulatory definitions of ground water (5, 6) it is possible that additional restrictions on use of nematicides may occur.

The most important nematodes affecting potato production in NEF are the sting nematode (*Belonolaimus longicaudatus* Rau), the southern rootknot nematode (*Meloidogyne incognita* [(Kofoid and White) Chitwood], and stubby root or trichodorid nematodes (*Paratrichodorus* and *Trichodorus* spp). Trichodorids are principally important as vectors of the virus causing corky ringspot disease (CRS) (19). Many NEF growers, when deciding on a control program, must also consider the following diseases in addition to nematode pests: CRS, bacterial wilt and tuber brown rot (caused by *Pseudomonas solanacearum* E. F. Smith) (BW), early dying caused by *Verticillium* spp, and tuber scurf associated with *Rhizoctonia* sp. (16, 19). The intent of this paper is to summarize and compare efficacies of nematicides available to NEF potato growers and to discuss the role of these chemicals in the management of soil-borne disease problems. The most effective management program utilizes resistance and other factors as well as nematicides (20). Only nematicides are discussed in this paper.

General Methodology

The data presented were selected from experiments performed during 1970-1983 and are judged to be representative of many other tests. All nematicides discussed, with the exception of products containing EDB, can legally be used in Florida on Irish potatoes. Much of the data reported in this paper are from split plot and factorial design experiments in which various combinations of resistant cultivars, nematicides, rates of application, and nonchemical controls have been evaluated in order to develop control methods for each of the various soil-borne disease problems encountered in NEF (15, 16, 17, 18, 19, 20, 21).

The following methods were used in all experiments unless indicated otherwise. Soil fumigants were injected to a depth of 10-12 inches with a single chisel/row several weeks before planting. Nonvolatile nematicides were applied in 10-12 inch wide bands at or a few days before planting. They were incorporated into the soil during the planting operation. All rates are expressed as a.i. or formulation/acre in-the-row (40-inch row spacing). Unless stated otherwise, 'Sebago' was the test cultivar during each year. The crop was usually planted during the first 3 wk in February and harvested during the last 2 wk of May or first week of June. Replications of treatments varied from 3 to 6 depending on the experiment. Plot size varied from 2 to 8 rows wide x 19 to 125 ft in length. Cultural practices such as herbicides used and timing of fertilizer applications varied from year to year. Similar cultural practices, however, were used in a series of experiments performed over a number of seasons (e. g. Table 6). Tuber quality ratings (CRS severity, tuber brown rot severity, rootknot galling, etc. were generally made on a 1-10 scale (1 = 0 disease, 10 = surface of all tubers 100% affected) as tubers from each plot passed over a grading table. Incidence or percentage data were taken from samples of tubers from each plot. Nematodes were extracted from 100 cm³ soil samples using a modification of the sugar centrifugation method (10).

Results

The data presented are from 10 different seasons and therefore the relative population densities of nematodes, tuber yields and intensity of corky ringspot (CRS) varied considerably due to differences in weather and other factors. Results are organized by season for purposes of discussion.

1971 Season. Data from 2 experiments are presented. Soil fumigants were evaluated in a bed with high population densities of sting and stunt (*Tylenchorhynchus claytoni* Steiner) (Test 1), and efficacy of both soil fumigants and nonvolatile nematicides were tested in a bed with known populations of southern root-knot and sting neamtodes (Test 2).

Test 1. Population densities of both sting and stunt nematodes at midseason and harvest were significantly less from fumigated plots than from the nontreated controls. Tuber yields from fumigated plots were significantly greater than those from control plots. Yields from plots treated with D-D and D-D MENCS tended to be less than those treated with EDB or 1,3D although the differences were not significant (Table 2). There was a significant negative correlation on each sample date between nematode population densities of both sting and stunt and tuber yields (r = –0.75 and –0.62 for sting, and –0.76 and –0.71 for stunt on April 22 and June 4, respectively).

Test 2. Results were comparable to those of Test 1. Yields were significantly greater than those of the nontreated control in al lnematicide plots except for oxamyl 2L, carbofuran 10G and DD-MENCS applied at 1.9 gal/acre (Table 3). Although not significant, there was a trend for greater yields in plots treated with 1,3D at 8.0 gal and those treated with all rates of EDB and EDB + chloropicrin. Lowest population densities of root-knot nematodes at harvest were associated with 1,3D at 8.0 gal, and all rates of EDB and EDB + chloropicrin. Population densities of sting nematodes at harvest followed a similar trend except that fewer nematodes were observed in the plots treated with 1,3D at 6.5 gal than in those fumigated at 8.0 gal. There was a significant negative correlation between yields and population densities of root-knot and sting nematodes at harvest (r = –0.61 and –0.35, respectively). With the exception of DD-MENCS, carbofuran 10G and oxamyl 2L treatments tuber galling was significantly reduced (P = .05) in all nematicide treated plots when compared to the control.

1973 Season. Population densities of sting nematodes during May were significantly less in plots of all nonvolatile nematicides when compared to those of the control. Population densities of trichodorids were significantly lower in aldicarb plots than in the controls whereas those of carbo-

Table 2. Nematode population densities at midseason and harvest and potato tuber yields in a nematicide experiment, 1971.

Soil fumigant[z]	Rate (gal/acre in-the-row)	Nematodes/100 cm³ soil[y] 4/22/71		6/4/71		Tuber yields (cwt/acre)[x]
		BL	TY	BL	TY	
EDB	1.8	0a	5a	2a	2a	160a
1.3D	8.0	3a	1a	8ab	17ab	159a
DD	10.0	1a	8a	20b	44b	136ab
DD-MENCS	3.0	3a	7a	23b	42b	132b
Control	—	91b	213b	50c	133c	75c

[z]EDB as Dowfume W-85®, 1,3D as Telone®.
[y]BL = *Belonolaimus longicaudatus*, TY = *Tylenchorhynchus claytoni*. Population densities rounded to nearest whole number. Mean separation in columns by Duncan's multiple range test, 5% level.
[x]Yields include US Size A and Size B tubers.

Table 3. Comparison at harvest of nematode population densities, root-knot nematode tuber gall index and tuber yields of 'Sebago' potatoes in a nematicide evaluation experiment performed during 1971.

Nematicide[z]	Rate/acre in-the-row	Nematodes/100 cm³ soil at harvest[y] MI	BL	Tuber gall index[x]	Tuber yields (cwt/acre)[w]
1,3D	6.5 gal	199a-c	6a	3.3b-d	142ab
1,3D	8.0 gal	36a	19bc	2.8a-c	156a
EDB	1.3 gal	15a	3a	2.9a-d	158a
EDB	1.8 gal	6a	3a	2.3a	158a
EDB + PIC	3.0 gal	27a	2a	2.4ab	156a
EDB + PIC	4.2 gal	6a	1a	2.3a	154a
DD-MENCS	1.9 gal	239bc	14ab	3.8d	114cd
DD-MENCS	3.3 gal	164a-c	10ab	3.0a-d	136ab
Carbofuran 10G	3.0 lb. a.i.	139a-c	13ab	2.9a-d	123bc
Oxamyl 2L	4.0+2.0 lb. a.i.	515d	13ab	3.7cd	97d
Ethoprop 10G	3.0 lb. a.i.	58ab	21bc	2.1a	149a
Control		275c	32c	3.8d	113cd

[z]1,3D applied as Telone®, EDB as Dowfume W-85®, and EDB + PIC as Terr-o-cide 15®. Carbofuran applied in-furrow at planting 19 February. Ethoprop applied in 10-12-inch band and incorporated with a tandem rotary stalk chopper. Oxamyl applied as a foliar spray at bloom on 2 April and again on 23 April. Crop harvested 28 May.
[y]MI = *Meloidogyne incognita* and BL = *Belonolaimus longicaudatus*. Mean separation in columns by Duncan's multiple range test, 5% level.
[x]Root-knot gall index (1 = 0 galls and 10 = surface of all tubers 100% galled).
[w]US Size A + US Size B tubers.

furan and ethoprop were lower, but not significantly. Tuber yields and tuber quality were significantly improved in all nematicide plots when compared to the controls (Table 4).

1974 Experiment. Tuber yields were significantly increased over those of the control following use of aldicarb, but not ethoprop 10G, carbofuran 4F and oxamyl 2L. Differences in tuber yields among aldicarb, ethoprop and carbofuran plots were nonsignificant. Incidence and severity or CRS were significantly less in aldicarb and carbofuran treated potatoes than in ethoprop, or oxamyl treated plots or the control (Table 5).

1977-1983 Seasons. Tuber yields and % CRS were compared among aldicarb 15G, 1,3D, aldicarb 15G + 1,3D and nontreated control plots during 1977-1983. Data presented are the averages of main plot treatments (each main plot consisted of 4 25-ft long, 2-row wide subplots) from split plot experiments with 5 replications during each of 7 seasons (6 seasons for yields). Potato tuber yields were greater from all nematicide treated plots than from nontreated controls. Tuber yields tended to be greater from plots treated with aldicarb + 1,3D than from plots treated with either chemical singly (Table 6). Percent CRS was greater in 1,3D treated plots than in controls during 5 of 7 seasons (data not shown).

Table 4. Comparison of potato tuber yields, tuber quality ratings and nematode populations in an experiment performed during 1973.

Nematicide[z]	Nematodes/100 cm³ soil 7 May 73[y] BL	TR	Tuber quality[x]	Tuber yields (cwt/acre)[w]
Carbofuran 10G	49	3	3.5	243
Ethoprop 10G	37	3	4.2	229
Aldicarb	14	1	2.5	248
Control[v]	101	6	8.2	188
LSD .05	21	3	1.6	43

[z]All nematicides applied at 3.0 lb. a.i./acre in-the-row (40 inch spacing).
[y]BL= *Belonolaimus longicaudatus* (sting nematode) TR = trichodorids (*Paratrichodorus* and *Trichodorus* spp) = stubby root nematodes.
[x]Tuber quality rated 1 (no surface defects) to 10 (100% surface of all tubers affected) as potatoes passed across a grading table.
[w]US Size A tubers.
[v]Average of two sets (= 12 replications) of controls.

Table 5. Tuber yields, severity and incidence of corky ringspot disease observed in 'Sebago' cultivar potatoes in a nematicide evaluation experiment performed during 1974.

Nematicides[z]	US Size A tubers (cwt/acre)[y]	Corky ringspot[y] Severity[x]	Necrosis[x] (%)
Aldicarb 10G	189a	1.5a	5.5a
Ethoprop 6 EC	165ab	4.2bc	20.5bc
Carbofuran 4F	164ab	1.6a	4.5a
Oxamyl 2L	149b	4.4bc	23.5cd
Control	150b	5.1c	28.5d

[z]All chemicals applied at 3.0 lb. a.i./acre in-the-row (40 inch spacing) 2 days before planting. Crop planted 23 January and harvested 15 May 1974.
[y]Data for each treatment are from 12 subplot observations averaged across main plots of 3 soil fumigation treatments and 1 nontreated control. Mean separation in columns by Duncan's multiple range test, 5% level.
[x]Severity rated on a scale of 1-10 (1 = all tubers free of surface defects and 10 = surface of all tubers 100% affected); % internal necrosis determined in 20 tuber samples taken from each subplot.

Table 6. Tuber yields and incidence of corky ringspot disease (CRS) in 'Sebago' potatoes from plots treated with 1,3D, aldicarb, or 1,3D + aldicarb 15G and nontreated controls in 6 seasons from 1977-1983[z].

Nematicide treatment[y]	US Size A tubers (cwt/acre)	% CRS
Aldicarb (A)	225	9.4
1,3D	230	40.2
A + 1,3D	257	7.9
Control	180	33.7

[z]Data are averaged for 1977-1983 with exclusion of 1978. Data for each season consisted of main plot averages including 20 subplot treatments within each nematicide treatment.
[y]During each season 1,3D was applied several weeks before planting at 6.0 gal/acre in-the-row (40-inch spacing), and aldicarb 15G at 3.0 lb. a.i. in-the-row as 10-12-inch wide bands at the time of planting. The crop was planted during the first 2 weeks in February and harvested during the last week of May or first week of June.

1979 Experiment. Tuber yields and percentage tubers with CRS were compared in nontreated plots and in plots treated with aldicarb 15G, carbofuran 10G, EDB, 1,3D and combinations of the fumigants and nonvolatile nematicides (Table 7). Tuber yields were significantly greater than those of the nontreated control following treatment with all nematicides and nematicide combinations except when carbofuran was used singly. The percentage tubers affected with CRS followed a different pattern. The only treatments resulting in significantly fewer tubers affected with CRS than the control were those including aldicarb 15G.

Table 7. 'Sebago' potato tuber yields and percent corky ringspot (CRS) in a nematicide evaluation experiment performed during 1979.

Nematicide treatment[z]	Rate/acre in-the-row	US Size A tubers (cwt/acre)[y]	Tubers with CRS[x] (%)
EDB	1.8 gal	269a	23.5b
EDB + aldicarb 15G	1.8 gal+3.0 lb. a.i.	258ab	1.5a
EDB + carbofuran 10G	1.8 gal+3.0 lb. a.i.	246a-c	22.5b
Aldicarb 15G	3.0 lb. a.i.	254a-c	1.5a
Carbofuran 10G	3.0 lb. a.i.	212cd	17.0ab
1,3D	6.0 gal	242a-c	20.5b
1,3D + aldicarb 15G	6.0 gal+3.0 lb. a.i.	255a-c	0.0a
Control		176d	18.5b

[z]EDB applied as Soilbrom 85® and 1,3D as Telone II®.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.
[x]Percent CRS determined from random sample of 15 tubers from each plot.

1980 Experiment. Tuber yields and percentage CRS were compared among 3 different foliage application schedules of oxamyl 2L and a nontreated control which were superimposed on nontreated potatoes and plants grown in plots previously treated with aldicarb 15G, 1,3D, or aldicarb 15G + 1,3D. The percentage tubers with CRS was significantly reduced by all 3 application schedules when compared to plants not sprayed with oxamyl (Table 8). Tuber yields following oxamyl applications were significantly greater, however, only when oxamyl applications were extended over a period of 41-70 days after planting. There was a trend, although not significant, for more consistent yields in the application schedule of 3.0 lb. a.i. at 41 days 1.0 lb. a.i. at 50 days and 1.0 lb. a.i. at 60 days (data not presented).

1981 Experiment. The percentage of potato stem sections containing *Verticillium* spp. were determined in samples taken from plots treated with 1,3D, aldicarb 15G, 1,3D + aldicarb and a nontreated control (Table 9). *Microsclerotial Verticillium* (i.e. *V. dahliae* Kleb.) and total *Verticillium*

Table 8. Effect of foliar applications of oxamyl 2L on incidence of corky ringspot disease (CRS) and tuber yields in 'Sebago' potatoes.

Oxamyl schedule and application rates[z]				Yield US size A tubers (cwt/acre)[y]	Tubers with CRS[y] (%)
41 days	50 days	60 days	70 days		
3	2	0	0	285bc	3a
3	1	1	0	303a	6a
0	2	2	1	291ab	3a
0	0	0	0	276c	27b

[z]Rates are lb. a.i./acre overall. Days are from planting. Crop was planted 7 February and harvested 21 May 1980. Oxamyl sprayed to potato foliage using 6 cone nozzles/row delivering 100 gal/acre at 100 psi.
[y]Mean separation in columns by Duncan's multiple range test, 5% level. Data are averaged across mainplots consisting of aldicarb, 1,3D, 1,3D + aldicarb and a nontreated control.

Table 9. Effect of nematicides on the incidence of *Verticillium* spp. in stem tissue of potato.

Nematicide treatment 1981[z]	Rate/acre in-the-row	Sections (%)[y] MS Vert	Total Vert
1,3D	6.0 gal	1.3	4.8
Aldicarb 15G	3.0 lb. a.i.	0	2.3
1,3D + Aldicarb 15G	6.0 gal + 3.0 lb. a.i.	1.0	7.9
Control	—	31.5	36.9

[z]1,3D applied as Telone II®.
[y]Twelve random 1-1.5 inch long stem segments were sampled randomly from each plot and plated on potato dextrose agar. MS Vert = microsclerotial *Verticillium* (11) and total Vert includes all *Verticillium* (Microsclerotial, dark mycelial and others) observed. Data are mean values from 20 replications of each nematicide treatment.

microsclerotial, dark mycelial (= *V. albo-atrum* Reinke & Berth) and other *Verticillium spp* (11) were reduced by all treatments.

Discussion and Conclusions

Soil fumigants. Among the different fumigants and rates evaluated, reductions in population densities of sting, southern root-knot and stunt nematodes and increases in potato tuber yields have been the most consistent from plots treated with EDB (12 lb. a.i./acre) and 1,3D (at 58-65 lb. dichloropropene/acre) (Tables 2-9). None of the fumigants tested have reduced incidence of CRS. The greatest increases in tuber yields have been during seasons when soil moisture $\leq$ 15% $\pm$ 5% by weight at the time of fumigation (Weingartner, D. P. and J. R. Shumaker, unpublished observations). Percentage tissue with *Verticillium* spp. has been reduced consistently after fumigation (Table 9). Reductions in incidence of BW have been observed following use of soil fumigants, particularly EDB+ chloropicrin and 1,3D at standard rates and broadcast equivalent rates (i.e. 3 x in-row application rates) of EDB, EDB + chloropicrin and 1,3D. (Weingartner, D. P. and J. R. Shumaker, unpublished data).

Nonvolatile nematicides. Increases in tuber yields and reductions in incidence and severity of CRS have been most consistent from plots treated with aldicarb 15G at 3.0 lb. a.i./acre (Tables 2-8). Percentage of *Verticillium* spp. isolated from dying potato stems has also been reduced following use of aldicarb (Table 9). Yields have been significantly increased following use of ethoprop during some seasons (Tables 3 & 4), but not others (Table 5). Ethoprop at the rates tested (3.0 lb. a.i./acre) has been ineffective in controlling CRS (Table 5). The chemical is phytotoxic to potatoes when applied in-furrow (21) and can also cause injury to sorghum (*Sorghum vulgare* x sudan grass hybrid) when planted as a summer cover crop following potatoes (Weingartner, D. P. unpublished observations). Tuber production and control of CRS also has been erratic following use of carbofuran. Significant yield increases were associated with its use during 1973 (Table 4), but not during 1971, 1974, and 1979 (Tables 3, 5, and 7). Tuber quality was improved and/or CRS reduced in 1973 and 1974 (Tables 4 and 5), but not in 1979 (Table 7). Increases in tuber yields and reductions in CRS have been observed following use of oxamyl 2L (Table 8), however, our experience has been that the scheduling of applications is critical (17, 18). It is important for maximum effectiveness to apply 2.0-3.0 lb. a.i. during the first 30-50 days after planting and to make at least 2 additional applications of 1.0 lb. a.i. at 10-14 day intervals. Applications during 1971 (*Table 3*), *for example*, were made too late. The single 3.0 lb. a.i. application made at planting during 1974 (Table 5) was applied too early since no additional foliar sprays were applied. Generally nonvolatile nematicides have been most effective when soil moisture $\geq$ 10-15% by weight (D. P. Weingartner and J. R. Shumaker unpublished data).

Grower use of nematicides. Growers in NEF rapidly adopted the use of nematicides due to dramatic increases in tuber yields and improvements in external tuber appearance associated with their use (15, 16, 19). Initially most NEF growers used soil fumigants (mainly DD, 1,3D, and EDB) until aldicarb was registered for use in 1974. Beginning in 1975 many growers began to switch from fumigants to aldicarb and by 1978 > 70% of the NEF potato acreage was treated with aldicarb. For several reasons growers prefer aldicarb to soil fumigants (21) even though soil fumigants, when used as directed, provide outstanding nematode control and can cost less per acre than aldicarb. Fumigants are phytotoxic and must be applied several weeks before planting. This creates logistics and scheduling problems, particularly if heavy rains occur during the period between treatment and planting. Aldicarb is applied in a single operation at planting thereby avoiding these difficulties. In addition, aldicarb acts systemically and controls certain insects (1) and its use reduces the need for early to mid season insecticide applications. Also, as shown above, aldicarb is effective in controlling CRS whereas soil fumigants are not.

Some growers use aldicarb in combination with a soil fumigant. The fumigation treatment delays development of bacterial wilt and increased yields over the fumigation or aldicarb treatments are often realized (Table 6). Due to its low cost (Table 1) EDB has been most often used in combination with aldicarb, however, 1,3D is also used.

Conceptually, for maximum soil-borne disease and nematode control proper selection and use of nematicides and potato cultivars by NEF potato growers should be dependent upon the nematode problem present, presence or absence of CRS and BW, soil moisture at the time of application, and on the market destination of the crop (i.e. fresh or potato chip processing markets). The management options available to NEF potato growers (nonvolatile nematicides, soil fumigants, and tolerant cultivars) have been assembled in a 2 dimensional matrix. The matrix summarizes control options depending upon: 1) the market destination of the crop, 2) soil moisture at time of nematicide use and 3) the problems present in a particular field (20). Presently this management system is dependent upon availability of both soil fumigants and nonvolatile nematicides.

Nematicides are needed to maintain present levels of productivity because of the extensive nematode and soil borne disease problems in NEF. However, unless there are changes in present regulatory policies and public opinion regarding pesticides in ground water or new developments in application technology, the use of existing nematicides in NEF may be in jeopardy. It seems clear that future research should be directed towards 1) developing more information on the dynamics and fate of agricultural chemicals in flatwood soils; 2) finding biological means such as alleopathy, antagonism and antibiois to deal with soil borne pests; 3) assimilating existing hydrological and other ecological knowledge of the NEF flatwoods agricultural system for purposes of designing a prototype pest management region.

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