Single and double combinations of nematicides against *Rotylenchulus reniformis* and *Tylenchulus semipenetrans* infecting cowpea and citrus

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SUMMARY

Application of aldicarb, oxamyl and fensulfothion nematicides gave an increase in growth of cowpea and citrus and a reduction in the populations of *Rotylenchulus reniformis* and *Tylenchulus semipenetrans*. Growth of plants grown in soil treated with DBCP and miral was not increased even though the nematode populations were reduced. Plant growth was unthrifty in the ethoprop and phenamiphos applications and nematode control was intermediate. Of the nematicide combinations tested, oxamyl + DBCP combination was the best effective mixture for host growth followed by miral + DBCP and fensulfothion + DBCP. All combinations produced maximum nematode kill.

RÉSUMÉ

Effets des nématicides, seuls ou en combinaisons par deux, contre Rotylenchulus reniformis *et* Tylenchulus semipenetrans, *parasites de* Vigna sinensis *et des citrus*

Sept nematicides, fumigants, de contact et systémiques, ont été testés, en pots, aux doses de 24 et 36 kg/ha contre *Rotylenchulus reniformis* et *Tylenchulus semipenetrans* parasitant respectivement *Vigna sinensis* et les citrus. Ils comprenaient deux carbamates : l'aldicarb et l'oxamyl, quatre organophosphorés : l'ethoprop, le fensulfothion, le miral et le phenamiphos et un fumigant : le DBCP. Dans une autre expérience, des pots contenant des pieds de *Vigna* ou de citrus ont été traités avec des combinaisons de deux nématicides à la dose totale de 36 kg/ha. Les résultats ont montré que l'aldicarb, l'oxamyl et le fensulfothion provoquaient une réponse hautement significative de la plante allant de pair avec un remarquable contrôle des deux parasites. Avec le miral et le DBCP l'augmentation de croissance de la plante était moindre bien que leur action nématicide sur *R. reniformis* et *T. semipenetrans* fût très forte. A l'inverse, l'éthotrop et le phenamiphos n'ont eu que peu d'action sur la croissance des plantes et n'ont que modérément éliminé les nématodes. Parmi les combinaisons de deux produits, l'oxamyl associé au DBCP a été la plus active pour stimuler la croissance des plantes, suivie de près par le fensulfothion associé au DBCP, la moins active étant le miral associé au DBCP. Les trois combinaisons ont réduit sérieusement les populations de *R. reniformis* et *T. semipenetrans* permettant la propagation du plus faible nombre de nématodes sur les plantes traitées.

The application of fumigant, non fumigant and systemic nematicides can be a successful management tool in controlling nematode pests. Fumigants have proved to be effective in eradication of *Belonolaimus*, *Heterodera*, *Meloidogyne*, *Paratylenchus*, *Pratylenchus*, *Radopholus*, *Trichodorus*, *Tylenchorhynchus*, *Tylenchulus* and *Xiphinema* (Baines, 1964 ; Figueroa, 1975 ; Guérout, 1972 ; Maggenti & Hart, 1975 ; Miller, Edgington & Hawkins, 1967 ; Raski *et al.*, 1975 ; Reynolds & O'Bannon, 1963 ; Rhoades, 1972; Sasser, Nelson & Barker, 1972; Tarjan

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& O'Bannon, 1974 ; Van Gundy *et al.*, 1960 ; Weingartner & Dickson, 1970 and Whitehead *et al.*, 1972). Also, oximacarbamate and organophosphate nematicides have been efficient against plant parasite nematodes infecting crops, e.g., deciduous fruits, potatoes, citrus, cotton, carnations, banana, tomatoes and beets (Abawi & Mai, 1971 ; Abdel-Rahman *et al.*, 1974 ; Baines & Small, 1969, 1974 & 1976 ; Birchfield, 1971 ; Cuany *et al.*, 1974 ; Gowen, 1977 ; Jones & Overman, 1976 ; Scotto La Massese & Roussel, 1975 ; Moss, Crump & Whitehead, 1976 ; Oteifa, Elgindi & Eleraqi, 1971 ; Radewald *et al.*, 1973 and Steudel, 1976). This study was intended to evaluate the nematicidal efficacy and degree of host response due to single and double combinations of some nematicides.

Materials and Methods

Cowpea, *Vigna sinensis* Endl. cv. Azmerely and 6-month-old lime seedlings, *Citrus aurantifolia* Swingle were raised in 15 cm clay pots filled with 1 kg steam-sterilized clay loam soil. Cowpea were thinned to two plants/pot, while the citrus seedlings were maintained at one seedling/pot. Two weeks after planting, the cowpea and citrus seedlings were infected with the nematodes, *Rotylenchulus reniformis* Linford & Oliveira, 1940 and *Tylenchulus semipenetrans* Cobb, 1913, respectively. *Rotylenchulus* was introduced into the soil around cowpeas at approximately 3,000 nematodes/pot, while *Tylenchulus* was added to lime at 8,000 nematodes/pot. Ten days after infesting the soil, seven nematicides were introduced into soil around the two hosts. These were : methyl N'N' dimethyl-N-((methylcarbamoyl)oxy)-l-thiooxamimidate = oxamyl 10% G (Vydate®) ; 2-methyl-2-(methylthio)-propionaldehyde 0-(methylcarbamoyl)-oxime = aldicarb 10% G (Temik®) ; 0-(5-chloro-1-(1-methylethyl)-1 H-1,2,4-trizol-3-yl) 0,0-diethylphosphorothioate) = miral 10% G (formerly CGA 12223) ; 0-ethyl S,S-dipropylphosphorodithioate = ethoprop 10% G (Mocap®) ; 0,0-diethyl 0-[p-(methylsulfinyl) phenyl] phosphorothioate = fensulfothion 10% G (Terracur P®) ; ethyl 4-(methylthio)-m-tolylisopropylphosphoramidate = phenamiphos 5% G (Nemacur®) and 1,2 dibromo-3-chloropropane = DBCP (Fumazone® 75% EC). Single nematicides were applied at two rates : 24 and 36 kg/ha (2.4 and 3.6 kg a.i./ha) while combinations of nematicides were applied at 36 kg/ha composed of 18 kg of each nematicide. There were three replications per treatment. Plants were left untreated to serve as controls. Experiments were conducted in a greenhouse at 30 ± 5 °C for 60 days and then terminated. At harvest, plants were removed and plant growth was recorded as shoot and root weights. Soil nematodes were extracted by means of Oostenbrink's technique (1960) on replicated 250 g samples, while nematodes populations in roots were determined on 3 g representative root sample/treatment using the blending technique of Fallis (1943) as modified by Taylor and Loegering (1953).

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Results

Results of nematicides application on populations of *R. reniformis* and *T. semipenetrans* as well as on the growth of cowpea and citrus are given in Tables 1 and 2. All nematicides reduced nematode numbers associated with both hosts as compared to untreated controls. Data also revealed that control of *R. reniformis* and *T. semipenetrans* was not necessarily correlated with increased nematicide concentration. Nematode control was only improved with the higher rates of fensulfothion and miral. Data of soil populations were analyzed ; all chemicals and rates significantly depressed *T. semipenetrans* and *R. reniformis* at 0.01 level in Duncan's multiple range test except for ethoprop and phenamiphos.

The application of nematicides was beneficial in controlling nematodes and improved growth of both hosts (Tabl. 1 and 2). Visually, plants treated with aldicarb and fensulfothion were larger and greener than those either treated with other materials or left untreated. No symptoms of phytotoxicity were evident in any of

Table 1

Effectiveness of several fumigant, contact and systemic nematicides on growth of cowpea plants and associated *Rotylenchulus reniformis*

Treatment	*Total plant weight (g)*	*Soil populations / 250 g soil*				*Root infection/ 3 g tissues*
		Larvae	*Males*	*Females*	*Total*	
Aldicarb 10% G I	23.91 b	189	119	51	359 b	58
Aldicarb 10% G II	25.83 b	147	162	399	708 b	163
DBCP 75% EC I	18.00	232	182	57	471 b	71
DBCP 75% EC II	20.34 a	255	246	42	543 b	104
Ethoprop 10% G I	18.33	4788	526	1299	6613 a	332
Ethoprop 10% G II	20.58 a	3483	383	945	4811 b	378
Fensulfothion 10% G I	22.33 a	917	151	302	1370 b	67
Fensulfothion 10% G II	25.00 b	194	17	55	266 b	30
Miral 10% G I	20.59 a	1019	357	506	1882 b	84
Miral 10% G II	21.75 a	659	215	120	994 b	41
Oxamyl 10% G I	21.00 a	187	71	122	380 b	24
Oxamyl 10% G II	25.66 b	175	25	25	225 b	19
Phenamiphos 5% G I	18.59	5667	967	1100	7734	360
Phenamiphos 5% G II	21.00 a	467	160	162	789 b	92
Fensulfothion + DBCP	21.40 a	0	0	0	0	9
Miral + DBCP	16.24	0	0	0	0	7
Oxamyl + DBCP	21.50 a	0	0	0	0	15
Untreated	12.67	7712	848	2093	10,653	587

I and II = 2.4 and 3.6 kg a.i./ha. a & b statistically significant from control at 5 and 1% probability, respectively using Duncan's multiple range test.

Table 2

Effectiveness of several fumigant, contact and systemic nematicides on growth of lime plants and associated *Tylenchulus semipenetrans*

Treatment	*Total plant weight (g)*	*Soil populations/ 250 g soil*	*Root infection/ 3 g tissues*
Aldicarb 10% G I	12.26 b	303 b	107
Aldicarb 10% G II	13.51 b	556 b	84
DBCP 75% EC I	9.27 a	129 b	41
DBCP 75% EC II	11.55 b	75 b	13
Ethoprop 10% G I	10.72 b	1810 b	114
Ethoprop 10% G II	11.38 b	1317 b	62
Fensulfothion 10% G I	11.68 b	719 b	170
Fensulfothion 10% G II	13.71 b	470 b	45
Miral 10% G I	9.57 a	369 b	37
Miral 10% G II	10.88 b	195 b	9
Oxamyl 10% G I	11.45 b	122 b	72
Oxamyl 10% G II	12.60 b	200 b	18
Phenamiphos 5% G I	7.69	803 b	194
Phenamiphos 5% G II	8.19	930 b	211
Fensulfothion + DBCP	12.27 b	161 b	23
Miral + DBCP	9.53 a	53 b	0
Oxamyl + DBCP	13.35 b	25 b	0
Untreated	6.39	2658	413

I and II = 2.4 and 3.6 kg a.i./ha. a & b statistically significant from control at 5 and 1% probability, respectively using Duncan's multiple range test.

the treatments. Aldicarb induced highly significant growth increases in both hosts, while the other nematicides gave variable effects (Tabl. 1 and 2).

Data on nematicide combinations are summarized in Tables 1 and 2. No soil populations of *R. reniformis* were recovered from any combination treatments and similarly T. *semipenetrans* failed to appear in citrus tissues after the incorporation of miral or oxamyl with DBCP.

As regards growth of treated cowpea and citrus, it was revealed that best response to these combinations was reported by fensulfothion or oxamyl plus DBCP, while plants receiving miral+DBCP were relatively unthrifty (Tabl. 1 and 2).

Discussion

Some nematicides controlled nematodes and increased the growth of cowpea and citrus. The results obtained with aldicarb, oxamyl and fensulforthion were always statistically significant. Another group of materials were highly effective against nematodes but gave intermediate increases in growth of treated hosts. These materials were DBCP, miral and ethoprop. Phenamiphos gave the least satisfactory growth of both treated hosts.

Combinations of nematicides suggested that this area must be very promising for nematode control and plant growth stimulation.

References

Abawi, G. S. & Mai, W. F. (1971). Root diseases of fruit trees in New York State. III. Control of *Pratylenchus penetrans* in roots of apple, peach, pear and cherry by foliar spray with a nematicide-insecticide. *Pl. Dis. Reptr*, 55 : 617-620.

Adbel-Rahman, T. B., Elgindi, D. M. & Oteifa, B. A. (1974). Efficacy of certain systemic pesticides in the control of root-knot and reniform nematodes of potato. *Pl. Dis. Reptr*, 58 : 517-520.

Baines, R. C. (1964). Controlling citrus nematode with DBCP increases yields. *Calif. Citrogr.*, 49 : 222, 233.

Baines, R. C. & Small, R. H. (1969). Efficacy of some new compounds for control of citrus nematode, *Tylenchulus semipenetrans* on established trees. *Proc. 1st. Internat. Citrus Symp.*, 2 : 973-977.

Baines, R. C. & Small, R. H. (1974). Evidence of modes of action of oxamyl nematicide on *Tylenchulus semipenetrans*. *J. Nematol.*, 6 : 135.

Baines, R. C. & Small, R. H. (1976). Effects of oxamyl on the citrus nematode, *Tylenchulus semipenetrans*, and on the infection of sweet orange. *J. Nematol.*, 8 : 122-130.

Birchfield, W. (1971). Systemic nematicides control *Rotylenchulus reniformis* of cotton. *Pl. Dis. Reptr*, 55 : 362-365.

Cuany, A., Bergé, J. B., Scotto La Massese, C. & Ritter, M. (1974). Considérations sur les utilisations de l'aldicarbe et de l'oxamyl, substances nématicides endothérapiques. *Phytiat.-Phytopharm.*, 23 : 199-210.

Fallis, A. M. (1943). Use of the waring blendor to separate small parasites from tissues. *Can. J. publ. Hlth*, 34 : 44.

Figueroa, A. (1975). Studies of five nematicides in the control of *Radopholus similis* (Cobb) Thorne in the banana zone of Guapiles. *Fitopatologia*, 10 : 67.

Gowen, S. R. (1977). Nematicidal effects of oxamyl applied to leaves of banana seedlings. *J. Nematol.*, 9 : 158-161.

Guérout, R. (1972). Relation entre les populations de *Radopholus similis* Cobb et la croissance du bananier. *Fruits*, 27 : 331-337.

Jones, J.-P. & Overman, A. J. (1976). Tomato wilts, nematodes and yields as affected by soil reaction, and persistent contact nematicides. *Pl. Dis. Reptr*, 60 : 913-917.

Maggenti, A. R. & Hart, W. H. (1975). Carbamate and phosphate nematicidal granules, drenches and dips for the control of *Ditylenchus destructor* on bulbous iris, variety Wedgewood. *Pl. Dis. Reptr*, 59 : 233-235.

Miller, P. M., Edgington, L. V. & Hawkins, A. (1967). Effects of soil fumigation on Verticillium wilt, nematodes and other diseases of potato roots and tubers. *Am. Potato J.*, 44 : 316-323.

Moss, S. R., Crump, D. & Whitehead, A. G. (1976). Control of potato cyst nematodes, *Globodera rostochiensis* and *G. pallida*, in different soils by small amounts of oxamyl or aldicarb. *Ann. appl. Biol.*, 84 : 335-359.

Oostenbrink, M. (1960). Estimating nematode populations by some selected methods. In : Sasser, J. N. & Jenkins, W. R. (Eds) *Nematology*, Univ. N. Carolina Press, Chapel Hill : 85-102.

Oteifa, B. A., Elgindi, D. M. & Eleraqi, M. S. (1971). Evaluation of some granular systemic nematicides for the control of *Rotylenchulus reniformis* on Egyptian cotton. *Res. Bull. 514, Fac. Agric., Ain-Shams Univ.*, 1-13.

Radewald, J. D., Rosedale, D., Shibuya, F. & Nelson, J. (1973). Control of the citrus nematode,

Tylenchulus semipenetrans with foliar Vydate sprays on Valencia oranges in Southern California. *Phytopathology*, 63 : 1217.

RASKI, D. J., JONES, N. O., KISSLER, J. J. & LUVISI, D. A. (1975). Further results from deep-placement fumigation for control of nematodes in vineyards. *Pl. Dis. Reptr*, 59 : 345-349.

REYNOLDS, H. W. & O'BANNON, J. H. (1963). Decline of grapefruit trees in relation to citrus nematode populations and tree recovery after chemical treatment. *Phytopathology*, 53 : 1011-1015.

RHOADES, H. D. (1972). Pathogenicity and control of a Florida population of the sugar beet nematode, *Heterodera schachtii* on cabbage. *Proc. Fla St. hort. Soc.* (1971), 84 : 139-142.

SASSER, J. N., NELSON, L. A. & BARKER, K. R. (1972). Effects of *Trichodorus christiei* and *Belonolaimus longicaudatus* on growth and yield of soybean following chemical soil treatment. *J. Nematol.*, 4 : 233-234.

SCOTTO LA MASSESE, C. & ROUSSEL, P. (1975). Action du Furadan et du phenamiphos sur le taux de multiplication d'*Heterodera rostochiensis* et sur les rendements d'une culture précoce de pomme de terre. *Phytiat.-Phytopharm.*, 24 : 25-36.

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STEUDEL, W. (1976). Schaden durch Rübennematoden. Und wie man sie verhüten kann. *Mitt. Deutsch. Landwirtges.*, 91 : 325.

TARJAN, A. C. & O'BANNON, J. H. (1974). Postplant fumigation with DBCP for citrus nematode control in Florida. *J. Nematol.*, 6 : 41-48.

TAYLOR, A. L. & LOEGERING, W. Q. (1953). Nematodes associated with lesions in Abaca. *Turrialba*, 31 : 8-13.

VAN GUNDY, S. D., FOOTE, F. J., RACKHAM, R. L. & RINKOV, A. (1960). Studies on methods of application of emulsifiable DBCP around living citrus trees. *Pl. Dis. Reptr*, 44 : 830-833.

WEINGARTNER, D. P. & DICKSON, D. W. (1971). Nematode control on potatoes by soil fumigants, band and in-furrow applications of contact nematicides. *Proc. Fla. St. hort. Soc.* (1970), 27-29.

WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. M. (1972). Control of potato cyst-nematode, *Heterodera rostochiensis*, in peaty loam soil by D-D, aldicarb and a resistant variety of potato. *Ann. appl. Biol.*, 72 : 307-312.