J. King Saud Univ., Vol. **4**, *Agric. Sci.* (1), pp. 69-77, Riyadh (A.H. 1412 / 1992).

Effect of Controlled Release Formulations of Carbofuran Soil Fertilizers and Their Mixtures on Root-Knot Nematode on Tomato Plants

M.Y. El-Shoura, S.T. Badr, S.A. El-Khishen and **M.M. Abu Elamayem**
Plant Protection Department, Faculty of Agriculture, University of Alexandria, Alexandria, Egypt

Abstract. Efficacy of different controlled-release formulations of carbofuran (RN-302-1, RN-302-2, RN-302-3, currater 5% and currater 10% G) at two rates (5 and 10 ppm) for controlling *Meloidogyne javanica* on tomato plants was investigated separately or in combinations with some soil fertilizers (thiourea, ureaformaldehyde and urea) under greenhouse conditions. Results indicated that the smallest numbers of root galls and developmental stages of nematode were recorded with RN-302-2 formulation. Carbofuran formulations were more effective in reducing egg-masses than ureaformaldehyde and urea. The addition of soil fertilizers to carbofuran formulations resulted in a greater reduction of root-knot nematodes than the use of carbofuran formulations alone. Thiourea was the most effective in enhancing the efficacy of carbofuran formulations, followed by urea formaldehyde and then by urea. The controlled-release formulations of carbofuran improved the growth of tomato plants than the use of traditional formulations of carbofuran. With respect to mixtures the addition of soil fertilizers (especially thiourea and urea) to the tested formulations resulted in a greater increase in tomato growth than the use of carbofuran formulations separately.

Introduction

A Controlled-release formulation can either maintain equivalent control to a conventional formulation with far less active ingredient or maintain control longer with an equivalent of pesticides. In both cases, the environmental impact of pesticide treatment is likely to be reduced [1]. Various controlled-release formulations of organophosphate and carbamate insecticides have been tested against soil nematodes. Batterby *et al.* [2] and Birtle and Wright [3] have examined the usefulness of controlled-release formulations of aldicarb and vydate against the sugar beet cyst nematode, *Heterodera schachtii* Schmitt. They have found that such formulations might be most useful on soils of low organic content. El-Shoura *et al.* [4] have also studied the efficacy of different controlled-release formulations of carbofuran for controlling citrus nematode *Tylenchulus semipenetrans* Cobb. They found that

carbofuran in the formulation of RN-302-2 at 10 ppm was apparently the most effective in reducing nematode juveniles and females among the other tested formulations and this was followed by RN-302-3. The aim of this investigation was to determine the efficiency of different controlled-release formulations of carbofuran separately and in mixtures with some soil fertilizers namely, thiourea, ureaformaldehyde and urea against root-knot nematode *Meloidogyne javanica* (Trub) infection and reproduction on tomato plants *Lycopersicum esculentum* var common, cultivar Ace under greenhouse conditions.

Materials and Methods

Five different formulations of carbofuran (2,3 dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) were used. Three of which are controlled-release formulations namely RN-302-1; RN-302-2; and RN-302-3 (each 5% G) and were supplied by ICI company. The other two are traditional formulations, currater 5% G. and currater 10% G. The three different controlled-release formulations of carbofuran have different rates of release of carbofuran (5).

Urea, ureaformaldehyde and thiourea were used as soil fertilizers. The characteristics and constituents of the tested fertilizers are shown in the Table 1.

Table 1. Constituents and characteristics of the three soil fertilizers used*

Material	Formula	Solubility	Shape	%N	Rate Kg/fed.
Urea	H_2NCONH_2	Very soluble	Granule	46.5	100
Ureaform-aldehyde	CH_2NCONH_2	Soluble	Granule	46.5	100
Thiourea	H_2NCSNH_2	Soluble	Crystal	36.0	120

* Supplied by Abu Qir fertilizers and Chemical Company, Alexandria, Egypt.

Clay pots (12 cm diam.) containing one kg of sterilized-sandy clay loam soil (using autoclave) were used. One tomato seedlings of 4 weeks old was transplanted in each pot and then inoculated with 4600 second juvenile stage of *M. javanica*. Each of the carbofuran five formulations was used at two rates, 5 and 10 ppm. The soil fertilizers, thiourea, ureaformaldehyde and urea were used at the rates of 120, 100 and 100 kg/fed.; respectively. Each nematicide formulation, fertilizer and their mixtures were applied, at the time of nematode inoculation, to the soil in pots at depth of 3-5 cm. The treated plants were then watered daily. Treatments (Table 2) were arranged in a complete randomized block design in a greenhouse at 25±5C and 65±5 R.H and

Table 2. Effect of different controlled-release formulations of carbofuran singly or combined with some soil fertilizers on infection and reproduction of *Meloidogyne Javanica* stages on tomato seedlings var-comman cultivar Ace.

Treatment*	Rate PPm	No. of galls/root system	Average No. of nematode stages/gm root larvae females	egg-masses	Effectiveness % galls	larvae females	egg-masses
Currater 5 %	5	259	107	23	36	32	56
Curr. + Thiourea		200	80	20	51	49	62
Curr. + Ureaformaldehyde		210	84	22	48	47	59
Curr + Urea		229	89	38	43	44	28
Currater 5 %	10	203	69	14	50	56	73
Curr. + Thiourea		149	51	13	63	68	76
Curr. + Ureaformaldehyde		151	55	11	63	65	79
Curr. Urea		188	62	17	54	61	67
Currater 10 %	5	213	102	24	48	35	55
Curr. + Thiourea		142	70	15	65	56	72
Curr. + Ureaformaldehyde		173	78	14	57	51	73
Curr + Urea		190	80	22	53	49	59
Currater 10 %	183	59	15	55	63	71	
Curr. + Thiourea		120	43	9	70	73	83
Curr. + Ureaformaldehyde		147	39	11	64	75	79
Curr + Urea		160	57	17	61	64	68
RN - 302 - 1	5	209	79	15	48	50	71
RN - 302 - + Thiourea		139	51	13	66	68	76
RN - 302 - 1 + Ureaform		150	58	11	63	63	79
RN - 302 - 1 + Urea		172	68	17	58	57	67
RN - 302 - 1	10	147	63	8	64	60	84
RN - 302 - 1 + Thiourea		91	44	10	77	72	82
RN - 302 - 1 + Ureaform		102	39	11	75	75	79
RN - 302 - 1 + Urea		111	49	15	73	69	72
RN - 302 - 2	5	124	43	24	69	73	73
RN - 302 - 2 + Thiourea		73	30	8	82	81	86
RN - 302 - 2 + Ureaform		90	48	8	78	70	84
RN - 302 - 2 + Urea		100	50	17	75	68	67
RN - 302 - 2	10	100	43	9	75	73	84
RN - 302 - 2 + Thiourea		60	21	6	85	87	88
RN - 302 - 2 + Ureaform		72	50	6	82	68	89
RN - 302 - 2 + Urea		83	41	16	80	74	70
RN - 302 - 3	10	150	47	12	63	70	78
RN - 302 - 3 + Thiourea		99	41	9	75	74	82
RN - 302 - 3 + Ureaform		120	50	14	70	68	74

Table 2. Cont.

Treatment*	Rate PPm	No. of galls/root system	Average No. of nematode stages/gm root larvae females	egg-masses	Effectiveness % galls	larvae females	egg-masses
RN-302-3 + Urea kg/fedd.		122	22	16	70	86	70
Thiourea	120	271	115	39	33	27	27
Ureaformaldehyde	100	305	127	41	25	20	22
Urea	100	366	149	47	10	6	12
Check (nematode inoculum only)	–	405	158	53	0.00	0.00	0.00
Untreated	0.00	–	–	–	–	–	
L.S.D.O.05		35.31	5.49	0.00	–	–	–

* All treatments except the last one, included nematode inoculation.

were replicated three times. At the end of the experiment (7 weeks) plants were gently removed from pots. Roots were washed, stained with acid fuchsin in lactophenol for egg-masses counting. The number of galls per root system and the number of juveniles, and females per one gm root were counted. Plants growth was also recorded.

Results

Effects on number of galls and nematode development

The greatest number of galls, juveniles, females and egg-masses were found with the treatment (nematode inoculation only), while the smallest numbers were generally found in the mixtures treatments of RN-302-2 (at 10 ppm) with all fertilizers (Table 2). All treatments gave lower number of galls, juveniles, females and egg-masses than the check.

All formulations of carbofuran significantly reduced the number of galls, juveniles, females and egg-masses when compared with check. Their high rates were more effective than low rates. At both rates, the formulation RN-302-2 was apparently the most effective among the other formulations in reducing the number of galls (75.41%), followed by RN-302-1 (63.81%) and RN-302-3 (62.99%). Currater 5% G, on the other hand was the lowest (50%) (Table, 2).

With respect to the combined number of juveniles and females, the formulation RN-302-2 gave the highest effectiveness (78.78%) followed by RN-302-2 (70.17%), RN-302-1 (66.34%), currater 10% (62.61%) and currater 5% (56.94%). Carbofuran formulations were more effective against egg-masses than juveniles and females.

The combination of soil fertilizers with carbofuran formulations resulted in more reduction in galls, juveniles, females and egg-masses than the use of carbofuran formulations alone (Table 2). Thiourea fertilizer was the most effective in enhancing the efficiency of carbofuran formulations against development of *M. javanica*, followed by urea formaldehyde and then urea. The effect of thiourea was more apparent on RN-302-2, RN-302-3 and RN-302-1 than on the traditional formulations (currator 5% G and 10% G.). The soil fertilizer, thiourea was more effective in reducing the number of galls, larvae, females and egg-masses, than urea formaldehyde and urea, compared with control.

Effects on the growth of tomato plants

Inoculation with *M. javanica* reduced the growth weights of shoots (13.57%) and roots (32%) of tomato seedlings (Table 3). Application of fertilizers has increased tomato weights (shoots + roots) to as much as 26.75–43.02% compared with untreated control. All carbofuran formulations either alone or in combination with the soil fertilizers, significantly increased root weight and shoot weight. However the low rates of all the tested carbofuran formulations stimulated the growth of tomato plants than the high-rates. The formulation RN-302-2 gave the greatest growth (205.35%) followed by RN-302-1 (186.91%) and then by currater 10% (155.75%). The combinations of soil fertilizers (especially thiourea and urea) and the carbofuran formulations resulted in more increase in tomato growth than the use of carbofuran formulations separately. The combination of RN-302-1 with ureaformaldehyde gave the highest increase in tomato growth (244.03%) while the least increase occured with RN-302-1-Urea (203.64%) mixtures (Table 3).

Discussion

The present results are in harmony with those obtained by Weight and El-Shoura [5] who found that the carbofuran formulation RN-302-2 was the most effective against root-knot nematode. It also increased the fresh weight of the root system. The other formulations were either phytotoxic or uneffective. They suggested that the inert material of these formulations holds a moderate concentration of the active ingredient of carbofuran for the time required for nematode control without a phytotoxic effect on the root system. In conformation with these results, El-Shoura *et al.* [4], reported that the carbofuran formulation RN-302-2 was the most effective in citrus nematode control.

It can be concluded therefore, that the controlled-release formulations of carbofuran were more efficient in controlling *M. javanica* and improving the growth of tomato plants, than its traditional formulations. The addition of soil fertilizers to car-

Table 3. Effect of different controlled-release formulations of carbofuran, fertilizers and their mixtures on growth of tomato seedlings

Treatments	Rate ppm	Shoot weight (gm)	Root weight (gm)	Plant growth response %	
				Shoot	Root
Currater 5%	5	11.99	5.71	107.72	92.09
Currater + Thiourea		16.32	7.62	146.63	122.90
Currater + Ureaform		14.43	7.16	129.64	115.48
Currater + Ureaform		17.50	9.30	157.23	150.00
Currater 5%	10	10.36	4.73	93.08	76.29
Currater + Thiourea		13.77	6.1	123.71	98.38
Currater + Ureaform		11.93	5.36	107.18	86.45
Currater + Urea		14.12	7.01	126.12	113.06
Currater + 10%	5	14.83	6.71	133.24	108.22
Currater + Thiourea		20.67	9.74	185.71	92.58
Currater + Ureaform		17.50	7.50	157.23	120.96
Currater + Urea		20.93	10.03	188.05	161.77
Currater + 10%	10	12.20	5.90	109.61	95.16
Currater + Thiourea		14.33	6.32	128.75	101.93
Currater + Ureaform		14.10	7.05	126.68	113.70
Currater + Urea		16.73	9.50	150.31	153.22
RN–302–1	5	16.51	9.34	148.33	150.64
RN–302–1+Thiourea		19.32	11.61	173.58	187.25
RN–302–1+ Ureaform		22.03	11.72	197.93	189.03
RN–302–1	10	11.72	6.53	105.30	105.32
RN–302–1+Thiourea		15.98	7.10	143.57	114.51
RN–302–1+Ureaform		15.71	6.11	141.15	98.54
RN–302–1+Urea		13.35	7.91	119.94	127.58
RN–302–2	5	17.76	10.64	159.56	171.61
RN–302–2+Thiourea		20.31	11.63	182.47	187.58
RN–302–2+Ureaform		16.26	10.31	146.09	166.29
RN–302–2+Urea		18.77	11.33	168.64	182.74
RN–302–2	10	12.90	6.40	115.90	103.22
RN–302–2+Thiourea		14.82	7.95	133.15	128.22
RN–302–2+Ureaform		15.10	7.13	135.66	115.00
RN–302–2+Urea		15.33	8.93	137.73	144.03

Table 3. Cont.

Treatments	Rate ppm	Shoot weight (gm)	Root weight (gm)	Plant growth response %	
				Shoot	Root
RN-302-3	5	14.76	10.00	132.61	161.29
RN-302-3+Thiourea		18.72	12.02	168.19	193.87
RN-302-3+Ureaform		15.21	9.85	136.65	158.87
RN-302-3+Urea		18.10	9.13	162.62	150.0
RN-302-3	10	11.50	7.50	103.32	127.62
RN-302-3+Thiourea		14.51	8.37	130.36	135.0
RN-302-3+Ureaform		13.03	5.50	117.07	95.16
RN-302-3+Urea		15.31	6.78	137.55	109.36
kg/fedd					
Thiourea	120	11.47	8.31	103.05	134.03
Urea formaldehyde	100	11.35	6.18	101.97	99.67
Urea	100	12.73	6.50	114.37	111.29
Check (nematode inoculum only)		9.63	4.20	86.52	67.74
Untreated		11.13	6.20	100	100
L.S.D. 0.05		6.12	3.30	0	0

bofuran formulations resulted in reducing more, the root-knot nematode populations and increasing tomato growth.

References

[1] Cramer, R.D. "Control Release Pesticides-Making the Most of the Benefits." Part 1. *Inter. Pest. Cont.*, 18 (1976), 1-3.

[2] Batterby, S.G.N, Patourel, J. LE. and Wright, D.J. "Effect of Aldicarb Persistence on Field Population of *Heterodera schactii.*" *Appl. Biology,* 95 (1980), 105-13.

[3] Birtle, A.J. and Wright, D.J. "Prospects for Improving the Efficiency of Pesticides with Slow Release Formulations." *Aspects Applied Biology,* 2 (1983), 65-73.

[4] El-Shoura, M.Y. Rabie, R.S. Ibrahim, I.K. and Khattab, M. "The Efficiency of Slow Release Formulations of Carbofuran on the Citrus Nematode". *J. Agric. Res. Tanta Univ.,* 11 No. 4 (1985), 995-1001.

[5] Wright, D.J. and El-Shoura, M.Y. "Efficacy and Rate Release of Four Control Release Formulations of Carbofuran Against Root-knot Nematode." (*Unpublished Report*).

تأثير تجهيزات مُتحكم في تحررها من مبيد الكربوفيوران، الأسمدة الأرضية ومخاليطهما على نيماتودا تعقد الجذور على نباتات الطماطم

محمود الشورى، سهير بدر، شفيق الخشن، ومحمود أبو العمايم

قسم وقاية النبات، كلية الزراعة، جامعة الأسكندرية، الأسكندرية، مصر

ملخص البحث. تمت دراسة تأثير تجهيزات مختلفة في تحررها للمادة الفعالة من مبيد الكربوفيوران وهي رن ـ٣٠٢ ـ١، رن ـ٣٠٢ـ٢، رن ـ٣٠٢ـ٣) إضافة إلى التجهيزتين التقليديتين كوراتير ٥٪ محبب، كوراتير ١٠٪ محبب، وذلك بمعدلين، سواءً بمفردها أو في خلائط مع الأسمدة الأرضية: ثيوريا، يوريا فورمالدهيد واليوريا على نيماتودا تعقد الجذور على شتلات الطماطم. ولقد أظهرت الدراسة أن أفضل هذه التجهيزات هي التجهيزة رن ـ٣٠٢ـ٢ أو عند خلطها مع سماد الثيوريا حيث أدى تطبيق أي من المعاملتين إلى خفض عدد اليرقات والأناث وكتل البيض داخل الجذور كما أدت إلى زيادة في نمو المجموع الجذري والخضري للطماطم.