Phytoprotection

Plant bed treatment with 1,3-dichloropropene for *Meloidogyne hapla* control in carrots grown in organic soil
Traitement de la planche de semis au 1,3-dichloropropène pour la lutte contre le *Meloidogyne hapla* en culture de carottes en sol organique

G. Bélair and Y. Fournier

Volume 78, Number 1, 1997

URI: https://id.erudit.org/iderudit/706117ar
DOI: https://doi.org/10.7202/706117ar

See table of contents

Publisher(s)

Société de protection des plantes du Québec (SPPQ)l

ISSN

0031-9511 (print)
1710-1603 (digital)

Explore this journal

Cite this article

Bélair, G. & Fournier, Y. (1997). Plant bed treatment with 1,3-dichloropropene for *Meloidogyne hapla* control in carrots grown in organic soil. *Phytoprotection*, *78*(1), 35–39. https://doi.org/10.7202/706117ar

Article abstract

The efficacy of plant bed treatment with the fumigant 1,3-dichloropropene (1,3-D) to control *Meloidogyne hapla* and improve carrot yields was determined in an organic soil under commercial field conditions. The soil was treated with 1,3-D at 56 and 112 L ha^{-1} either mixed with a rototiller in a 15-cm width band over the row or injected 20 cm deep with a single shank behind the rototiller at a rate of 56 L ha^{-1}. The single injection treatment at the 56 L ha^{-1} rate provided the best nematode control with the lowest galling indices and the highest yield of marketable carrot roots (66.7 t ha^{-1} vs. 5 t ha^{-1} for untreated control). The mixed application method was less effective than the soil injection method, even at twice the rate. In a second field trial, the fumigant was injected at 40 L ha^{-1} rate through a single shank at 20 cm deep. Soil treatment suppressed galling and significantly increased the number of marketable carrot roots (68.71 ha^{-1} vs. 11.81 ha^{-1} control). Plant bed treatment with 1,3-D is an effective alternative to traditional broadcast treatment for control of root-knot nematodes in carrot production on organic soil.

Communication brève / Short Communication

Plant bed treatment with 1,3-dichloropropene for *Meloidogyne hapla* control in carrots grown in organic soil

Guy Bélair and Yvon Fournier[1]

Received 1996-08-29; accepted 1997-02-03

PHYTOPROTECTION 78 : 35-39.

The efficacy of plant bed treatment with the fumigant 1,3-dichloropropene (1,3-D) to control *Meloidogyne hapla* and improve carrot yields was determined in an organic soil under commercial field conditions. The soil was treated with 1,3-D at 56 and 112 L ha^{-1} either mixed with a rototiller in a 15-cm width band over the row or injected 20 cm deep with a single shank behind the rototiller at a rate of 56 L ha^{-1}. The single injection treatment at the 56 L ha^{-1} rate provided the best nematode control with the lowest galling indices and the highest yield of marketable carrot roots (66.7 t ha^{-1} vs. 5 t ha^{-1} for untreated control). The mixed application method was less effective than the soil injection method, even at twice the rate. In a second field trial, the fumigant was injected at 40 L ha^{-1} rate through a single shank at 20 cm deep. Soil treatment suppressed galling and significantly increased the number of marketable carrot roots (68.7 t ha^{-1} vs. 11.8 t ha^{-1} control). Plant bed treatment with 1,3-D is an effective alternative to traditional broadcast treatment for control of root-knot nematodes in carrot production on organic soil.

[Traitement de la planche de semis au 1,3-dichloropropène pour la lutte contre le *Meloidogyne hapla* en culture de carottes en sol organique]

L'efficacité d'un traitement de la planche de semis avec le fumigant 1,3-dichloropropène (1,3-D) pour la lutte contre le *Meloidogyne hapla* et l'accroissement des rendements de carotte a été évaluée en sol organique dans des champs commerciaux. Le sol a été traité avec le 1,3-D à la dose de 56 et 112 L ha^{-1}, soit incorporé avec un motoculteur sur une bande de 15 cm sur le rang ou injecté sous la planche de semis à 20 cm de profondeur à la dose de 56 L ha^{-1} à l'aide d'une jambe derrière le motoculteur. L'injection à 56 L ha^{-1} a fourni le plus haut niveau de lutte contre le nématode avec le plus faible indice de nodosité et les meilleurs rendements en carottes vendables (66,7 t ha^{-1} vs. 5 t ha^{-1} pour le témoin non traité). La méthode d'application par incorporation a été moins efficace que la méthode par injection, même avec le double de la dose. Dans un deuxième essai au champ, le fumigant a été injecté à la dose de 40 L ha^{-1} avec un injecteur simple à 20 cm de profondeur. Le traitement

1. Horticultural Research and Development Centre, Agriculture and Agri-Food Canada, 430 Gouin Blvd., Saint-Jean-sur-Richelieu, Quebec, Canada J3B 3E6. Contribution no. 335/97.02.01R

de sol a augmenté le nombre de carottes vendables (68,7 t ha^{-1} vs. 11,8 t ha^{-1} pour le témoin non traité) et a réduit la nodulation. Un traitement de la planche de semis avec le 1,3-D est une méthode alternative et efficace au traitement traditionnel à la volée pour la lutte contre le nématode des nodosités en culture de carottes en sol organique.

The northern root-knot nematode, *Meloidogyne hapla* Chitwood, is a major pest of carrot (*Daucus carota* L.) in the northern United States and eastern Canada (Berney and Bird 1992; Vrain 1978). The infective second-stage juveniles disrupt the normal formation of the taproot and induce symptoms such as root forking and plant stunting (Vrain 1982). This nematode is a recurrent problem in southwestern Quebec's organic soils and losses are important in many carrot fields. Because of the sensitivity of carrot to *M. hapla* injury, high rates of fumigant nematicides are required (Vrain *et al.* 1981). Broadcast soil fumigation with 1,3-dichloropropene (1,3-D) at 300 L ha^{-1} (twice the normal rate) is the standard chemical treatment used for nematode control. This method is very expensive and gives acceptable economic control only 50% of the time (G. Bélair and Y. Fournier, unpublished data).

Row or band treatment with soil fumigant can be a cost-effective method for nematode control in annual crops (Lembright 1990). Savings for the growers result from reducing the treated area while maintaining equal or superior efficacy compared to a broadcast treatment. A localized application of metam-sodium delivered through a drip irrigation system effectively protected carrot roots from injury by *Meloidogyne incognita* (Kofoid and White) Chitwood in sandy loam (Roberts *et al.* 1988). However, the efficacy of localized application of fumigant nematicides has not yet been investigated in carrot production in organic soil.

The objective of this study was to evaluate the efficacy of plant bed treatment with 1,3-D at sowing time for control of *M. hapla* and the effect of row treatment with this nematicide on carrot yields under commercial field conditions in organic soil.

Field trial #1 : The trial was conducted in organic soil in Sainte-Clotilde (lat. 45°25' N, long. 73°41' W), Quebec, in 1987. A carrot field with a severe *M. hapla* root-knot nematode infestation (100% yield loss in carrot the year previous to the trial) was used to evaluate the efficacy of row soil treatment for root-knot nematode control in carrot production. The soil was a fibrosol with a pH of 4.8-5.5 and >80% organic matter. The fumigant (92% 1,3-dichloropropene, formulated as Telone II-B®) was released from a modified band fertilizer applicator designed to deliver material in a 15-cm width band and incorporate to a 25-cm depth with a one-wheel rototiller. On 17 June 1987, the following treatments were applied : 1) fumigant dripped at the 56 L ha^{-1} rate onto the soil in front of the rototiller and incorporated; 2) similar to treatment 1 but at the rate of 112 L ha^{-1}; 3) fumigant injected 20 cm deep with a single shank behind the rototiller at the rate of 56 L ha^{-1}; 4) rototilled and untreated control. The soil surface was immediately sealed with a trailing roller over the band. On application day, the soil had a 175-200% moisture content (approximately 0.3 bar) and a temperature of 11°C. Each plot, 1.4 m x 10 m, consisted of four rows, 45 cm apart. Treatments were replicated five times in a complete randomized block design. Five days after fumigation, the carrots were sown over the treated areas without harrowing the treated soil. On 31 August, carrots were harvested from 3 m of rows (3 x 1 m) in each plot, graded for marketability, weighed, and rated on a root-gall index (Bélair and Boivin 1988) according to the following 0-5 scale : 0 = no galling, no forking, no stunting, marketable; 1 = 1-10 galls on secondary roots, taproot not affected, marketable; 2 = 11-50 galls, none coalesced, taproots with light forking, no stunting, unmarketable; 3 = 51-100 galls with some coalesced, forking, no stunting, unmarketable; 4 = more than 100 galls with some coalesced, severe forking and moderate stunting, unmarketable; 5 = more than 100 galls, mostly coalesced, severe stunting, unmarketable. After harvest, each plot was sampled for nematodes by removing 15 soil cores (5 cm diam x 20 cm deep), 5 per meter of harvested row, which were then bulked and mixed. *M. hapla* second-stage juveniles (J_2) were extracted from 100-cm^3 subsamples for 1 wk using the pan method (Townshend 1963).

Field trial #2 : In 1995, a second trial was conducted in Sainte-Clotilde, Quebec, on a commercial carrot farm with a history of root-knot nematode problems. In this study, the efficacy of row fumigation for root-knot nematode control in carrot was evaluated by applying the fumigant underneath the seed bed at planting time. The soil was a fibrosol with a pH of 4.8-5.5 and >80% organic matter. On 25 May 1995, the fumigant (92% 1,3-dichloropropene, Telone II-B®) was released from a commercial carrot seeder coupled with a fumigant applicator. The fumigant was injected at a 40 L ha^{-1} rate through a single shank 20 cm deep along each row. Behind the seeder, the soil surface was immediately sealed using a trailing roller over the band. On application day, the soil had a 135-180% moisture content (approximately 3 bar) and a temperature of 13°C. Each plot was 5 m x 10 m long and consisted of 10 carrot rows 45 cm apart. The treatment and an untreated control were replicated six times in a randomized complete block design. On 12 September, carrots were harvested from 2 m of rows in each plot to estimate control efficacy. Total number of plants, total weight, marketable weight, percentage marketable roots, and galling indices (0-5) were recorded. In each plot, soil samples for nematode assays were collected at 0, 15, and 30 cm from the center of the row. Each soil sample consisted of five soil cores (5 cm diam x 20 cm deep) from the harvested 2-m zone. *M. hapla* J_2 densities in each soil sample were determined as previously mentioned.

Nematode counts were transformed using ($\log_{10}$ [x + 1]) before statistical analysis. Data were analyzed by the analysis of variance and general linear model (GLM) procedures (SAS Institute Inc. 1988). Duncan's multiple-range test was used to compare treatments when the analysis of variance showed significant differences among means.

Field trial #1: All treatments significantly increased marketable carrot yields compared to the untreated control (Table 1). At the 56 L ha^{-1} rate, the single injection treatment provided the best nematode control with the lowest galling index and the highest percentage of marketable carrot roots. At this same rate, incorporating the soil treatment by mixing was less effective than the single injec-

Table 1. Effect of plant bed treatment with 1,3-dichloropropene on *M. hapla* and carrot yield response in organic soil in 1987

Treatment	Rate (L ha^{-1})	Total yield (t ha^{-1})	Marketable roots (t ha^{-1})	Marketable roots (%)	Gall index[1] (0-5)	*M. hapla* (J_2 100 cm^{-3})[2]
Mixing	56	52.8 b[3]	36.7 b	70.6 b	1.5 b	24 ab
Mixing	112	70.5 a	53.4 a	73.1 ab	0.5 b	2 b
Injection (20 cm deep)	56	73.8 a	66.7 a	91.9 a	0.1 c	3 b
Control	–	47.4 b	5.0 c	8.7 c	3.9 a	174 a

[1] Gall index (0-5) : 0 = no galling, no forking, no stunting, marketable; 1 = 1-10 galls on secondary roots, taproot not affected, marketable; 2 = 11-50 galls, none coalesced, taproots with light forking, no stunting, unmarketable; 3 = 51-100 galls with some coalesced, forking, no stunting, unmarketable; 4 = more than 100 galls with some coalesced, severe forking and moderate stunting, unmarketable; 5 = more than 100 galls, mostly coalesced, severe stunting, unmarketable.

[2] Measured in the plant row (0 cm distance).

[3] Values followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

Table 2. **Effect of plant bed treatment with 1,3-dichloropropene on *M. hapla* and carrot yield response in organic soil in 1995**

Treatment	Rate (L ha^{-1})	Total yield (t ha^{-1})	Marketable roots (t ha^{-1})	Marketable roots (%)	Gall index[1] (0-5)	*M. hapla* (J_2 100 cm^{-3}) 0 cm[2]	15 cm	30 cm
Injection (20 cm deep)	40	68.8 a[3]	48.6 a	65.4 a	0.4 b	238 b	865 a	406 a
Control	–	52.2 a	11.8 b	14.4 b	3.6 a	1646 a	1115 a	606 a

[1] Gall index (0-5): 0 = no galling, no forking, no stunting, marketable; 1 = 1-10 galls on secondary roots, taproot not affected, marketable; 2 = 11-50 galls, none coalesced, taproots with light forking, no stunting, unmarketable; 3 = 51-100 galls with some coalesced, forking, no stunting, unmarketable; 4 = more than 100 galls with some coalesced, severe forking and moderate stunting, unmarketable; 5 = more than 100 galls, mostly coalesced, severe stunting, unmarketable.

[2] Distance from plant row.

[3] Values followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

tion treatment. No phytotoxicity was observed on the carrot tops in any treated plots.

Field trial #2: Soil treatment significantly increased the number of marketable carrots and suppressed galling in organic soil (Table 2). Total carrot growth was not significantly affected by the treatment. When compared to the untreated plots, the final *M. hapla* J_2 density was significantly reduced in treated plots in the center of the carrot row (0 cm) but was not reduced 15 or 30 cm from the center of the carrot row. No phytotoxicity was observed in the treated plots.

From these field experiments, it appears that plant bed treatment with 1,3-D at or prior to sowing time can be an effective method to control root-knot nematode in carrot in organic soil. Carrot yield increase associated with root-knot nematode control by this method compared favorably with results from broadcast treatment in organic soil (Vrain *et al.* 1981). With row treatment, fumigation costs are 6-7 times less than with broadcast application. Additional savings may occur when growers are able to plant and fumigate in a single operation and when delays in the sowing date are eliminated. However, the success of the treatment depends on environmental conditions (Lembright 1990), because under high soil moisture and low temperature, the fumigant may remain trapped in the soil, causing damage to plants.

Plant bed treatment with 1,3-D at sowing time is a useful alternative to traditional broadcast treatment for control of root-knot nematodes in carrot. However, our results also indicate that high residual nematode populations occur in the year of treatment, at just a short distance from the plant row. Following the standard broadcast application, acceptable marketable carrots could be obtained for two or more years, depending on the initial nematode population densities and the soil fumigant performance (Vrain *et al.* 1981). To avoid the high cost of broadcast treatment and to minimize potential damage from high population densities of *M. hapla* near and between plant rows, an integrated management approach for root-knot nematode populations in carrot production should be considered, combining plant bed fumigation with other control tactics such as cultural practices and crop rotation, which are effective in this cropping system (Bélair 1992; Bélair and Parent 1996).

REFERENCES

Bélair, G. 1992. Effects of cropping sequences on population densities of *Meloidogyne hapla* and carrot yield in organic soil. J. Nematol. 24 : 450-456.

Bélair, G., and G. Boivin. 1988. Spatial pattern and sequential sampling plan for *Meloidogyne hapla* in muck-grown carrots. Phytopathology 78 : 604-607.

Bélair, G., and L.E. Parent. 1996. Using crop rotation to control *Meloidogyne hapla* Chitwood and improve marketable carrot yield. HortScience 31 : 106-108.

Berney, M.F., and G.W. Bird. 1992. Distribution of *Heterodera carotae* and *Meloidogyne hapla* in Michigan carrot production. J. Nematol. 24 : 776-778.

Lembright, H.W. 1990. Soil fumigation: principles and application technology. J. Nematol. 22 : 632-644.

Roberts, P.A., A.C. Magyarosy, W.C. Matthews, and D.M. May. 1988. Effects of metam-sodium applied by drip irrigation on root-knot nematodes, *Pythium ultimum*, and *Fusarium* sp. in soil and on carrot and tomato roots. Plant Dis. 72 : 213-217.

SAS Institute Inc. 1988. SAS/STAT, user's guide: release 6.03 ed. SAS Institute Inc., Cary, North Carolina. 1028 pp.

Townshend, J.L. 1963. A modification and evaluation of the apparatus for the Oostenbrink direct cotton-wool filter extraction method. Nematologica 9 : 106-110.

Vrain, T.C. 1978. Dissémination et importance des nématodes phytoparasites dans les sols organiques du Québec. Phytoprotection 59 : 186 (Abstract).

Vrain, T.C. 1982. Relationship between *Meloidogyne hapla* density and damage to carrots in organic soils. J. Nematol. 14 : 50-57.

Vrain, T.C., Y. Fournier, and R. Crête. 1981. Carrot yield increases after chemical control of root-knot nematode in organic soil. Can. J. Plant Sci. 61 : 677-682.