EFFECTS OF SELECTED VOLATILE, ORGANOPHOSPHATE AND CARBAMATE NEMATICIDES ON HATCHING, INFECTIVITY AND DEVELOPMENT OF *MELOIDOGYNE JAVANICA* [EFECTOS DE NEMATICIDAS ORGANOFOSFATOS Y CARBAMATOS SELECTOS SOBRE LA ECLOSION, INFECTIVIDAD Y DESARROLLO DE *MELOIDOGYNE JAVANICA*]

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ABSTRACT

Hatchability of *Meloidogyne javanica* Chitwood 1949 eggs was completely suppressed by 12.5 and 25 ppm aldicarb, whereas these two concentrations of miral inhibited hatch by 98 and 99%, respectively. *M. javanica* egg hatch was reduced by 87% and 90% with 12.5 and 25 ppm DBCP. Aldicarb, miral and DBCP at 6.3 ppm inhibited egg hatch by 52, 96 and 68%, respectively; some eggs hatched after they were removed from the nematicides and placed in distilled water. A permanent irreversible suppression of hatching by as great as 91% was obtained with the lowest dosage of miral after eggs were transferred to distilled water. Pretreatment with DBCP and aldicarb appeared less suppressive and the latter nematicide was the least effective. Infectivity and development of newly-hatched larvae were reduced by 98 and 100% as a result of treatment with 6.3 ppm aldicarb. Substantial suppression of infectivity and development were also obtained with all miral concentrations; those effects were only slightly less pronounced than those for DBCP. Larvae hatched from eggs preexposed to the three dosages of miral were non-infective even after removal of eggs from chemicals, whereas those from eggs treated with DBCP or aldicarb were capable of infection.

Key Words: systemic nematicides, phosphorothioates, root knot nematodes, fumigants, Temik®.

INTRODUCTION

Numerous reports confirm the efficacy of several volatile, organophosphate and carbamate nematicides against a wide range of nematode pests (2, 4, 7, 14, 17, 18). The effectiveness of these nematicides has been shown to be due in part to their interference with nematode biology/behavioral processes and consequently the impairment of their development/parasitism (1, 8, 12, 13, 25). Some behavioral studies have, however, utilized excessive concentrations of toxicants to reveal these subtle inhibitory effects. Since no information was available on the effects of sublethal concentrations of these nematicides on nematode biology and behavior, we studied the effects of low concentration of representative volatile, organophosphate and carbamte nematicides on hatching, infectivity and development of the root-knot nematode, *Meloidogyne javanica.* This paper presents results obtained from these studies.

MATERIALS AND METHODS

Uniform egg masses were obtained from tomato *(Lycopersicon esculentum* Mill.)

cv. Commune roots heavily infected with *M. javanica* and transferred singly into syracuse watch glasses containing 5 ml aqueous preparations of the following nematicides: 2-methyl-2-(methylthio)-propionaldehyde *0*-(methylcarbamoyl)-oxime, aldicarb 10 G (Temik®) as a carbamate; 0-(5-chloro-1-(1-methylethyl)-1 H-1,2,4-triazol-3-yl) *0,0*-diethyl phosphorothioate), miral 10 G (Formerly CGA 12223) as an organophosphate and 1,2 dibromo-3-chloropropane, DBCP (Fumazone® 75 EC) as a volatile nematicide. Nematicides were evaluated at 6.3, 12.5 and 25 ppm a.i. by mixing the formulated compound with 500 ml distilled water and held overnight before filtration and application to egg masses. The filtered extractions were held in an incubator at 25°C with five egg masses replicates per treatment including those retained in distilled water to serve as controls.

The effect of nematicides on hatchability of eggs was assessed by counting the hatched larvae with a stereoscope (X16) during a 10-day immersion period at 48-hr intervals. After this period, egg masses were rinsed gently with water and transferred singly into 5 ml distilled water and an estimation of hatching was continued every 48-hr for an additional 10 days in order to determine the residual effectiveness of the nematicides.

The influence of nematicides on nematode infectivity and development was made by inoculating the counted hatched larvae onto fifteen-day-old pea seedlings *(Pisum sativum* L.) cv. Little Marvel. Seedlings were obtained from seeds grown in sterilized sand and were transplanted individually into 10-cm clay pots containing sterilized sand and kept at 20 + 2°C. Ten days after the last inoculation, plant roots were examined for nematode infection and development by fragmentation in a Waring Blendor (9,24).

Percentage of inhibition of hatching, infectivity and development was determined according to: % inhibition = 100-(100Hs/Hw) where Hw was the degree of activity in water and Hs that in the test materials (18). Data were subjected to statistical treatment when appropriate.

RESULTS

HATCHABILITY: Data in Fig. 1 show that the nematicides reduced the hatchability of *M. javanica* eggs. This reduction in hatch corresponded with an increase in the nematicide dosage. Aldicarb and miral caused a drastic reduction in hatch. No eggs hatched in 25 ppm aldicarb. Miral and DBCP at 25 ppm caused a 99 and 90% inhibition of hatching, respectively. Numerically, aldicarb, miral and DBCP suppressed emergence by 52, 96 and 68% at 6.3 ppm, respectively; and by 100, 98 and 87% at 12.5 ppm.

Transfer of egg masses previously immeresed in the nematicide preparations into distilled water enhanced hatching (Fig. 1). However, pretreatment with 12.5 and 25 ppm miral and DBCP remained significantly suppressive, in contrast to aldicarb, which had a reversible inhibitory effect and reduced hatchability insignificantly. Egg masses previously exposed to the nematicides at 6.3 ppm revealed that miral was the only significantly effective compound for permanent depression of hatching, whereas DBCP and aldicarb were less effective in inhibiting egg hatch. These three nematicides at 6.3 ppm inhibited hatching by 91, 10 and 2%, respectively.

INFECTIVITY AND DEVELOPMENT: Infectivity and development of *M. javanica* larvae that emerged while in the test compounds were affected by the toxicity from the bioassayed materials (Fig. 1). Since aldicarb caused a complete inhibition of hatch at 12.5 and 25 ppm, there obviously were no larvae available for infectivity or

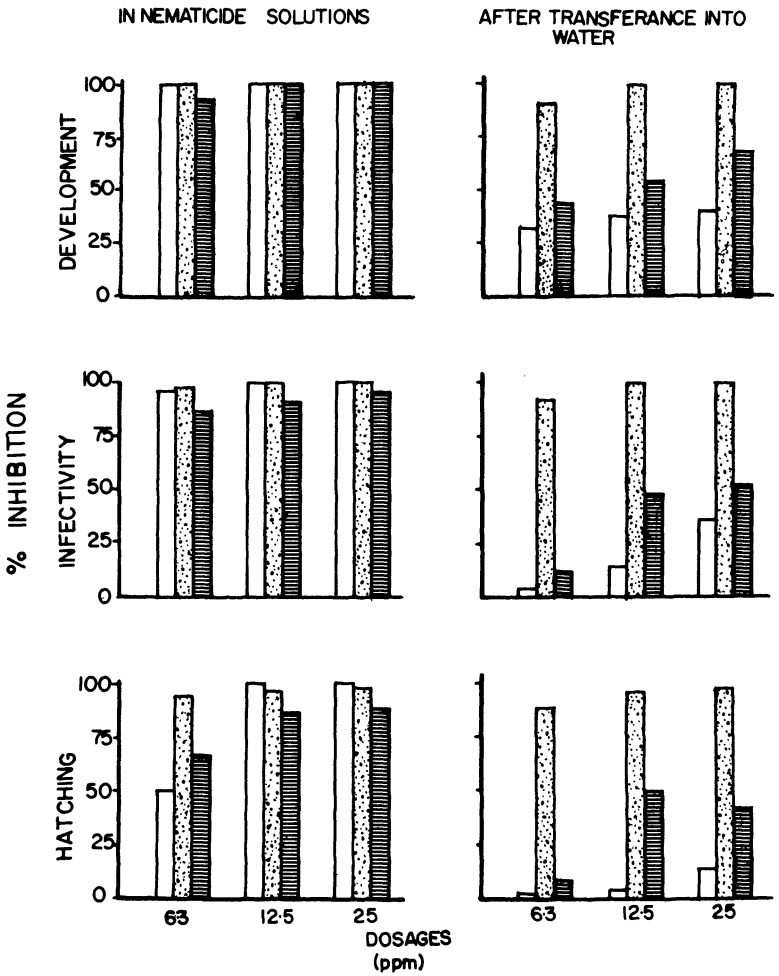

Fig. 1. Comparative effects of three nematicides on hatching, infectivity and development of *Meloidogyne javanica.*

development studies. The small number of larvae that hatched after exposure to 6.3 ppm of aldicarb were weakly infective (2%) and failed to develop within host tissue. Almost none of the very few larvae hatched in the three successive dosages of miral succeeded in infecting or developing in host tissue; DBCP was slightly less suppressive. Larvae that emerged in the three concentrations of this volatile nematicide had a low infectivity rate-13, 7 and 3% in relation to increasing concentration of DBCP. None of the larvae developed wihtin host tissue after treatment with the higher dosages, and 92% failed to develop after treatment with the lowest concentration.

The numbers of treated larvae that infected and developed within host tissue increased after the eggs were removed from the aqueous solutions of nematicides and placed into distilled water (Fig. 1). The inhibitory effect of aldicarb seemed to be less

persistant than that of DBCP and miral. As a result of pre-exposure to the three increasing dosages of aldicarb, infectivity was inhibited by 4, 15 and 36%; and development by 31, 38 and 40%. DBCP suppressed infectivity by 12, 47 and 52%; and development by 43, 53 and 67%. Miral produced an irreversible residual effect which remained highly inhibitory and allowed for only 6% infectivity and 9% development after exposure to the lowest dilution. No infection or development occurred after treatment with the highest concentrations of miral.

DISCUSSION

Past information showed that prevention of egg hatch from *M. arenaria* occurred with 50 ppm aldicarb (5), and that a concentration of 200 ppm aldicarb did not influence nematode development (6). Our findings indicate that concentrations of 6.3, 12.5 and 25 ppm of aldicarb, miral and DBCP were capable of inhibiting egg hatching, larval infectivity and development of *M. javanica* which findings agree with other reports that low concentrations of these nematicides could affect behavioral processes of nematodes (11,21). Results also support the concept that activity of nematicides is not due solely to nematotoxic effects but also involves nematistatic activities (8, 13, 15, 16). A possible explanation for suppression in the behavioral processes of *Meloidogyne javanica* is the inhibition of acetylcholinesterases and cholinesterases (20) which result in impairment of function by the nervous system and of the vital processes of nematode hatching, infection and development (22).

The relative recovery in hatching, infectivity and development after transfer of egg masses from toxic solutions, explains the inhibitory effects exercised by the lower concentrations of the compounds studied. It also reveals that miral causes irreversible effects even with the lowest concentration, in contrast with DBCP and aldicarb which had slight residual effects. The outstanding performance of miral observed in these studies could account for the superior nematode control recorded earlier as a result of treatments with this material (3, 10, 22, 23).

RESUMEN

La capacidad de eclosión de huevos de *Meloidogyne javanica* Chitwood 1949 fue totalmente eliminada con dosis de 12.5 y 25 ppm de aldicarb mientras que las mismas dosis de miral redujeron la capacidad de eclosión en un 98 y 99%, respectivamente y iguales concentrationes de DBCP redujeron la capacidad en un 87 y 90%. Aldicarb, miral y DBCP en dosis de 6.3 ppm restrijieron la eclosión en un 52, 96 y 68% respectivamente aunque algunos huevos eclosionaron cuando se traspasaron de las soluciones con nematicidas a agua destilada. El tratamiento de huevos con DBCP y aldicarb previo al traspaso fue menos satisfactorio con respecto a la reducción del grado de eclosión y aldicarb fue menos efectivo que DBCP. La infectividad y el desarrollo de larvas recién nacidas fueron reducidos en un 98 y 100% con dosis de 6.3 ppm de aldicarb. También se observó una represión substancial en la infectividad y desarrollo de las larvas con todas las concentraciones de miral; estos efectos fueron un poco menos acentuados que los obtenidos con DBCP. Larvas de huevos tratados con las tres dosis de miral no fueron infectivas aún cuando se separaron los huevos del compuesto nematicida; las procendentes de huevos tratados con DBCP o aldicarb retuvieron su infectividad.

Claves: nematicidas sistémicos, fosforotioatos, nematodos noduladores, fumigantes, Temik®

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