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# Efficacy of Three Nematicides and Two Oil Cakes for Control of Root-Knot Nematode (*Meloidogyne* incognita) on Potato Seedlings

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The efficacy of three synthetic nematicides namely, D-D (mixture of 1, 2-dichloropropane and 1, 3-dichloropropene), carbofuran and sodium azide, and oil cakes of mustard (*Brassica campestris*) and cotton seeds (*Gossypium hirsutum*) for controlling root-knot nematode (*Meloidogyne* ***incognita)*** on potato (*Solanum* ***tuberosum)*** seedlings raised from true potato seeds (TPS) were evaluated with pot experiments. Nematode infested soil was treated with D-D at 0, 0.05, 0.10 and 0.15 ml/kg, and sodium azide at 0, 25, 50, and 75 mg/kg soil 2 weeks before sowing. Carbofuran was applied at 0, 0.0450, 0.0675 and 0.0900 mg/kg soil 2 hr before sowing. Oil cakes of mustard and cotton seeds were mixed with the soil at 0, 0.25, 0.50 and 1.0% (w/w) and allowed to decompose for 2 weeks before sowing. Twenty five TPS were sown in each pot under all experiments. Seven days after germination seedlings were thinned and 10 plants/pot were allowed to grow for 6 weeks. Data on plant growth and severity of root-knot were recorded. It was found that treatment of soil with the nematicides and oil cakes gave significant reduction in gall indices and in numbers of galls and females in roots. Higher dosage corresponded to better control of the disease. Complete elimination of root-knot was achieved with only the treatment with highest dosage of sodium azide. Except sodium azide all treatments with other two chemicals and oil cakes improved plant growth in terms of shoot and root weight significantly.

## INTRODUCTION

Though potato (*Solanum tuberosum*) is a profitable crop in Bangladesh, its cultivation by means of seed tubers is expensive (Ahmad, 1977). In recent years, use of seedlings raised from true potato seeds (TPS) as planting materials has been shown to be a great potential in the country. Cost of production can be reduced appreciably by the use of TPS seedlings (Ahmad and Sikka, 1981). In Bangladesh, root-knot nematodes (*Meloidogyne* incognita and *M. javanica*) are widely distributed throughout the potato growing areas and they attack potato plants causing considerable yield loss. With a pot experiment it has been shown that the loss may be up to 27% (Mian, 1987). Seedlings may be infested with the root-knot nematodes from seedbed soil and the loss may be higher if infested seedlings are planted. Therefore, before advocating use of potato seedlings suitable method to grow nematode-free-seedling needs to be developed. Presently, treatment of soil with synthetic nematicide is considered to be one of the reliable method to control the pests. Effective control of root-knot nematodes with

D-D (Hemeng, 1977 ; Minton and Parker, 1979), carbofuran (Overman, 1974 ; Johnson *et al.*, 1979) and sodium azide (Rodriguez-Kabana *et al.*, 1975 ; Kelley and Rodriguez-Kabana, 1978) has been reported. Oil cakes of mustard and cotton seeds are also recorded as effective soil treating amendments against them (Mishra and Prosad, 1974 ; Trivedi *et al.*, 1978 ; Mian and Rodriguez-Kabana, 1982). Use of those materials to treat the seedbed soil for growing nematode-free-seedlings from TPS may be acceptable to the growers because only the seedbed soil is enough to be treated and also because seedlings can reduce the cost of cultivation to a substantial amount. Oil cakes, particularly, mustard and cotton seed cakes are available in the country. However, their nematicidal values against root-knot nematodes has not yet been evaluated.

The present study was undertaken to evaluate the efficacy of three synthetic nematicides namely D-D (mixture of 1, 2-dichloropropane and 1, 3-dichloropropene), carbofuran and sodium azide and oil cakes of mustard (*Brassica campestris*) and cotton seeds (*Gossypium hirsutum*) for controlling root-knot nematode (*M.* incognita) on potato (*Solanum tuberosum*) seedlings raised from true potato seeds.

## MATERIALS AND METHODS

Five independent experiments were conducted with a silty loam soil having pH 6.5, organic matter content less than 1% and infested with a population of *M. **incognita*** from tomato. Cylindrical plastic pots having 4.5 kg capacity were used in all experiments. The soil was mixed with sand (40% v/v), dried and ground cowdung (5% w/w), and ash (5% w/w). The mixed soil was screened through a sieve having 2 mm pore size, apportioned to 4 kg amount and put in 10 kg capacity polyethylene bags. To treat the soil D-D at the rate of 0, 0.05, 0.10 and 0.15 ml/kg and sodium azide at 0, 25, 50 and 75 mg/kg soil were added to polyethylene bags and thoroughly mixed with the soils. The treated soils were transferred to the pots, covered with polyethylene sheets and incubated at 22-25 C for 2 weeks before sowing. Carbofuran was applied at the rate of 0, 0.045, 0.0675 and 0.0900 mg/kg, mixed with soil in polyethylene bags and transferred to the pots 2 hr before sowing.

Dried and ground (2 mm of particle size) oil cakes of mustard and cotton seeds were mixed thoroughly with soils in polyethylene bags at the rate of 0, 0.25, 0.50 and 1.0% (w/w). The amended soil was transferred to the experimental pots and incubated for 2 weeks for decomposition before sowing.

Pots under all experiments were planted with 25 TPS cultivar, Dohazarilal. After germination, seedlings were thinned and 10 plants/pot were allowed to grow for 6 weeks providing necessary water and fertilizer.

Each treatment under all experiments was represented by 7 relicated pots and they were arranged at the pot yard following a completely randomized design. At the end of growing period, the potato seedlings were collected from soils, and the roots were washed with tap water to estimate the degree of galling on the basis of a scale of 0–10, where 0 represented roots free from gall and 10 severely galled root systems (Zeck, 1971). Numbers of galls and females per gram of roots were estimated. To increase the visibility of females, root tissues were stained with lactophenol cotton blue (Daykin and Hussey, 1985). Shoot height and fresh weight of shoots and roots were recorded. All data were analyzed for analysis of variance, and correlation coefficients and

regression equations were calculated. Differences between means were evaluated following Duncan's multiple range test.

## RESULTS

Efficacy of D-D (1, **2-dichloropropane+1, 3-dichloropropene)**

The results of the experiment are shown in Table 1. Root-knot severity was significantly ($P=0.05$) lower in D-D treated soil than in untreated soil. The relation ($r=-0.984$) between gall index and dosage of D-D was inverse and linear as expressed by the equation Yi= 4.23-23.18 Xd, where Yi represented gall index values and Xd represented dosage of D-D in mg/kg soil. The numbers of galls and females in roots were reduced significantly by the chemical as compared with control treatment. The gall number (Yg) was also inversely correlated (r= -0.955) with the dosage (Xd) ; the equation relating two variables was Yg = 245.3− 151.6 Xd. Similarly, a linear function could be used to describe the relation (r= -0.970) between number of females (Yn) and dosage of D-D (Xd) ; the equation was Yn = 258.35− 1425 Xd. Number of galls was directly and significantly correlated (r = -0.990) with the number of females in roots. Shoot height and fresh weight of shoot and root increased significantly due to application of D-D at the rate of 0.05 ml/kg soil or more. The highest dosage caused significant reduction in shoot weight as compared with the lowest dosage.

**Efficacy of** carbofuran

Results of the experiment are shown in Table 2. Application of carbofuran

Table 1. Effect of D-D on growth of potato seedlings and development of *Meloidogyne incognita**

| Amount (ml/kg of Soil) | Shoot Height (cm) | Shoot Weight (g) | Root Weight (g) | Gall Index** (O-10) | Gall/g Root | Female/g Root |
|---|---|---|---|---|---|---|
| 0.00 | 7.0 A | 0.36 A | 0.038 A | 4.6 A | 273.8 A | 275.7 A |
| 0.05 | 10.0 B | 1.28 B | 0.112 B | 2.8 B | 129.9 B | 175.0 B |
| 0.10 | 12.8 CD | 1.39 BC | 0.109 B | 2.0 B | 66.2 BC | 89.8 C |
| 0.15 | 13.6 D | 0.98 c | 0.087 B | 1.0 c | 34.8 c | 65.9 C |

* Values are averages of 4 replications ; those within the same column with a common letter do not differ significantly ($P=0.05$).
** Based on a O-10 scale (Zeck, 1971).

Table 2. Effect of carbofuran on growth of potato seedlings and development of *Meloidogyne incognita**.

| Amount (mg/kg of Soil) | Shoot Height (cm) | Shoot Weight (g) | Root Weight (g) | Gall Index** (O-10) | Gall/g Root | Female/g Root |
|---|---|---|---|---|---|---|
| 0.0000 | 9.43 A | 0.42 A | 0.108 A | 2.7 A | 279.6 A | 289.6 A |
| 0.0450 | 14.12 B | 0.53 B | 0.148 A | 3.1 A | 68.9 A | 287.1 A |
| 0.0675 | 16.90 B | 0.61 B | 0.218 B | 2.4 A | 111.3 B | 138.8 B |
| 0.0900 | 14.91 B | 0.46 A | 0.111 A | 1.8 A | 90.1 B | 158.0 B |

* Values are averages of 4 replications ; those within the same column with a common letter do not differ significantly ($P=0.05$).
** Based on a O-10 scale (Zeck, 1971).

resulted in reduction of gall index values to some extent but the effect of all treatments with the nematicide on this parameter was not significant. Treatments with the dosages of 0.0675 and 0.090 mg/kg soil gave significant reduction in numbers of galls and females per gram of roots as compared with control and 0.045 mg/kg treatment. The effects of the two higher dosages on gall formation and nematode development were statistically the same. Shoot weight increased gradually with the increase of dosage up to 0.0675 mg/kg and decreased thereafter, whereas only the dosage 0.0675 mg/kg soil gave significantly heavier roots as compare to control treatment and other dosage. Significantly taller plants were achieved with all dosages but effect of all dosage on this parameter was statistically similar among themselves.

**Efficacy of sodium azide**

Results of the experiment are summarized in Table 3. Application of sodium azide resulted in significant reduction in severity of root-knot and numbers of females and galls in root systems. Complete elimination of the disease was achieved with only the dosage of 75 mg/kg soil. Gall index values and dosage of the chemical were linearly and inversely correlated (r= -0.991) and their relaton could be described by the equation Yi = − 1.92 − 0.027 Xs, where Yi represented galls indices and Xs the dosage of sodium azide. Similaly, numbers of galls and females decreased with increasing dosages of the nematicide. The relation of dosage (Xs) with gall number (Yg) and number of females (Yn) could be expressed as Yg = 432.85 − 6.67 Xs and Yn = 559.28 − 9.29 Xs, respectively. Plant growth in terms of shoot height and fresh weight of shoots and roots increased gradually with increasing dosage but no treatment showed significant effect on plant growth.

Table 3. Effect of sodium azide on growth of potato seedlings and development of ***Meloidogyne incognita****.

| Amount (mg/kg of Soil) | Shoot Height (cm) | Shoot Weight (g) | Root Weight (g) | Gall Index ** (O-10) | Gall/g Root | Female/g Root |
|---|---|---|---|---|---|---|
| 0 | 13.30 A | 0.57 A | 0.018 A | 2.0 A | 522.5 A | 759.6 A |
| 25 | 14.30 A | 0.80 A | 0.027 A | 1.1 B | 154.1 B | 63.9 B |
| 50 | 15.70 A | 1.02 A | 0.027 A | 0.5 c | 54.6 B | 20.0 B |
| 75 | 15.60 A | 1.04 A | 0.034 A | 0.0 c | 0.0 B | 0.0 B |

* Values are averages of 4 replications ; those within the same column with a common letter do not differ significantly (P=0.05).
** Based on a O-10 scale (Zeck, 1971).

**Efficacy of mustard oil cake**

Data obtained from this experiment are shown in Table 4. Gall indices decreased gradually and significantly with the increase of each level of mustard oil cake. The correlation (r = -0.996) between these two variables could be described as Yi =3.71− 5.80 Xm, where Xm was percentage of the oil cake added to soil. The amendment gave significant reduction in numbers of galls and females as compared with control but there were no significant differences among the dosages. The material had favourable effects on shoot growth. Significantly heavier shoot was achieved with the application of the oil cake but the effect of all dosages on this variable was statistically similar. Shoot height increased gradually in response to increasing dosage but differences in

plant height with and without the amendment were insignificant. Fresh weight of roots also improved significantly in the range from 0.25 to 0.50% as compared with control treatment. The treatment with 1.0% oil cake resulted in reduction of root weight as compare to other rates.

Table 4. Effect of mustard oil cake as amendment to soil on growth of potato seedlings and development of *Meloidogyne incognita**.

| Amount % (W/W) | Shoot Height (cm) | Shoot Weight (g) | Root Weight (g) | Gall Index** (O-10) | Gall/g Root | Female/g Root |
|---|---|---|---|---|---|---|
| 0.00 | 9.54 A | 0.45 A | 0.115 A | 3.8 A | 1667.8 A | 665.9 A |
| 0.25 | 10.95 A | 0.51 B | 0.159 B | 2.1 B | 523.5 B | 53.2 B |
| 0.50 | 11.50 A | 0.49 B | 0.134 B | 0.9 c | 184.8 B | 69.8 B |
| 1.00 | 11.44 A | 0.56 B | 0.093 B | 0.8 C | 268.4 B | 75.7 B |

* Values are averages of 4 replications ; those within the same column with a common letter do not differ significantly (P = 0.05).
** Based on a O-10 scale (Zeck, 1971).

### Efficacy of cotton seed oil cake

Results of the experiment are presented in Table 5. A general and significant (P = 0.05) reduction in numbers of galls and females, and gall indices occured in the pots with the amendments as compare to control but their effect on those variables was not significantly different among the treatments. The relation (r = -0.786) between gall index (Yi) and dosage of the cake (Xc) was inverse and linear as described by Yi= 3.22 – 4.96 Xc. Seedlings in amended soil were heavier than those in unamended soil but diffirences in shoot weight amended soils were not significant. Only the dosage of 0.25% gave significant increase in root weight and further increase resulted in reduction of root growth producing the lowest root weight at the highest dosage.

Table 5. Effect of cotton seed oil cake as amendment to soil on growth of potato seedlings and development of *Meloidogyne incognita**.

| Amount % (W/W) | Shoot Height (cm) | Shoot Weight (g) | Root Weight (g) | Gall Index** (O-10) | Gall/g Root | Female/g Root |
|---|---|---|---|---|---|---|
| 0.00 | 9.54 A | 0.45 A | 0.115 A | 3.8 A | 1667.8 A | 665.9 A |
| 0.25 | 11.75 A | 0.61 B | 0.216 B | 0.9 B | 111.3 B | 125.5 B |
| 0.50 | 9.80 A | 0.53 B | 0.153 A | 1.3 B | 172.9 B | 284.8 B |
| 1.00 | 9.00 A | 0.51 B | 0.109 A | 0.8 B | 267.7 B | 309.3 B |

* Values are averages of 4 replications ; those within the same column with a common letter do not differ significantly (P = 0.05).
** Based on a O-10 scale (Zeck, 1971).

## DISCUSSION

D-D was found to be an effective nematicide to control root knot and to improve growth of seedlings but no treatment gave complete elimination of the disease.

Moreover, higher dosage caused phytotoxicity. Similar resultes were also reported by Hemeng (1977) and Minton and Parker (1979) who studied with other crops. Carbofuran gave effective control of root-knot at suitable dosages but it was not found to be effective to grow nematode-free-seedlings from TPS. Koshy *et* al. (1979) also could not produce seedling of *Elettaris cardamomum* free from nematode infestation by treating seedbed soil with carbofuran. Complete elimination of root-knot from the roots of potato seedlings was achieved with sodium azide, only when it was applied at 75 mg/kg soil but the chemical did not show favourable effect on growth. Reports on effectiveness of sodium azide to control phytonematodes of other crops are also available (Overman, 1974 ; Rodriguez-Kabana et al., 1975 ; Kelley and Rodriguez-Kabana, 1978). However, it may not be advisable to recommend the chemical to treat seedbed soil to grow potato seedlings from TPS because it may cause adverse effect on environment and on the health of the users.

The results of the two experiments with oil cakes of mustard and cotton seeds indicate that the materials can reduce severity of root-knot and improve growth of potato seedlings in the range from 0.25 to 0.50%. Other investigators also reported similar results recorded from their studies with other crops (Gour and Prosad, 1970 ; Srivastava et ***al.,*** 1971; Khan et ***al.,*** 1973 ; Mishra and Prosad, 1974 ; Mian and Rodriguez-Kabana, 1982 ; Podder et al., 1988). However, no treatment with any of the oil cakes gave root-knot nematode-free-seedlings from TPS.

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