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# Management of Root-Knot Nematode (*Meloidogyne incognita*) in Poly House on Tomato (*Solanum esculentum*) as Soil Fumigation through Chemicals

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**ABSTRACT**
*The experiment was conducted during 2017 at the Horticulture Farm in poly-house, Department of Nematology, Rajasthan College of Agriculture, Udaipur to find out the effect of two chemicals as soil fumigation on plant growth characters and reproduction of M. incognita on tomato. In this experiment two chemicals viz. STTC and Metham Sodium were used @ 25ml, 35ml, 45ml/m² respectively and control was also maintained. Observations on plant growth characters (shoot and root length, shoot and root weight) and nematode reproduction (number of galls per plant, number of egg masses per plant, number of eggs per egg mass, nematode population/100cc soil, final nematode population) were recorded. Among soil fumigants Metham sodium @ 45 ml/m² was recorded most effective fumigant followed by Metham sodium @ 35 ml/m² and STTC @ 45 ml/m² over control to reduce nematode reproduction and enhance plant growth characters.*
***KEY WORDS:*** *Chemicals, Meloidogyne incognita, Poly house, Soil Fumigation, Treatment Tomato.*

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## INTRODUCTION

Tomato (*Solanum esculentum*) is one of the most important vegetable crop in the world. It belongs to family *Solanaceae* have diploid chromosome number 24 and a self-pollinated crop. Tomato has originated from Peru, Ecuador and Bolivia on the basis of availability of numerous wild and cultivated relatives exist in these area. It is cultivated in both temperate and tropical regions of the world. It is consumed in a various ways like salad, sandwiches, cooked or processed in ketchup, sauce, juice and dried powder. Tomato plays an important role in human nutrition by providing essential amino acids, vitamins and minerals. It also contains lycopene, which is very important antioxidant and can prevent cancer [1].
The major tomato growing countries are China, India, USA, Turkey, Egypt and Italy. In entire world vegetables are grown in area of 59.16 million hectare with production of 1159.88 MT and productivity of 19.6 MT per hectare and same time in India vegetables are grown in area of 9.39 million hectare with production of 162.89 MT and productivity of 17.3 MT per hectare which contribute about 14.0% of their world production [2].
India is a second largest producer (11.5 %) of tomato in the world. During 2014-15, in the world tomato was grown in area of 4.81 million hectares with production of 163.02 MT and productivity was 33.9 MT per hectare while in India tomato is grown in at 0.88 million hectare with production 18.73 MT and productivity 21.2 MT per hectare. [3].
In India, root-knot nematode was first reported by Barber [4] on tea roots from Devala territory of Kerala. In Rajasthan, Arya [3] reported root-knot nematode on tomato from Jodhpur. Globally, a frequency estimate of sample from 75 countries showed that *M. incognita* is most widespread with 53% occurrence, *M. javanica*50%, *M. areneria* 8%, *M. hapla*8%, and other spp. 2% [8]. In India, over 350 plants are known as a host of *Meloidogyne* spp. [14]. *M. incognita* alone infecting about 250 and *M. javanica* infecting about 150 genera of plants [9] that's why the *M. incognita*is economically most important than other nematodes

of vegetable crops. It is often severely attacked by root-knot nematode, *M. incognita*, a predominant and widely prevalent species inflicting serious loss in tomato [12]. A yield loss of 35 - 39.7% has been reported due to root-knot nematode infestation [12]. Bhatti and Jain [5] estimated the crop losses up to 46.0% in Haryana state only. Reddy [12] estimated percentage of loss of 39.77 at 20 larvae /g soil in tomato field in Karnataka.

Root-knot nematode cause histopathological changes in root tissue of tomato. The results of these changes are the formation of giant cells and galls in the root system. This abnormality can upset normal physiological activities of vascular tissue of the root system and finally causes wilting, stunting, leaf chlorosis and poor growth of plants.

The protected vegetable cultivation technology can be utilize for year round production of high quality vegetable crops, with high yield and one or more of these factors are control such as temperature, $Co_2$ concentration, relative humidity, access to insect and pest etc. In poly-house, growing of tomato increased productivity efficiency and greater yields due to congenial atmosphere at 20 to 25$^0$C temperature and high relative humidity. The more incidences of root-knot nematode and soil borne pathogen found in poly-house due to favorable environmental conditions for host, pest and parasite. In these condition more infection of root-knot nematode occur which resulted in yield losses. Hence there is urgent need to the management of root-knot nematode for high production of tomato in poly-house.

## MATERIAL AND METHODS

### General procedures:-

The present investigation entitled "Management of Root-Knot Nematode, *Meloidogyne incognita* on Tomato in Poly-house" was conducted at the Horticulture Farm in poly-house, Department of Nematology, Rajasthan College of Agriculture, Udaipur (Rajasthan). The details of the materials used, experimental procedure employed and methodology implemented for assessment of treatment effects during the entire course of investigation are described in this chapter.

### Experimental site and Climatic Conditions:

The experiments were conducted during 2017 at the Horticulture Farm in poly-house, Department of Nematology, Rajasthan College of Agriculture, Udaipur, The size of the poly-house was 28 m × 32 m (896 m$^2$) covered with aluminate sheet and stabilized low density polyethylene sheet having 200 micron thickness. Udaipur is situated at 24°34'N latitude and 73°42'E Longitude at an elevation of 582.17 meters above mean sea level. The region falls under agro climatic zone IV a (Sub Humid Southern Plain and Aravali Hills) of Rajasthan. It has a typical sub-tropical climate, characterized by mild winter and summer.

### Bed Preparation:

The raised beds were prepared having length 28 meter, width 1 meter and height of 45 cm above the ground level for the experimental purpose.

### Soil Sampling From Beds:

The soil sampling was done before transplanting of the crop in poly-house to determine initial nematode population. Soil samples were collected from poly-house beds with the help of *khurpi* from 4-5 places at the depth of 6-9 inch randomly. Soil collected from poly-house was homogenized, filled in a polythene bag, labeled, tied and brought to the laboratory and stored at low temperature. The soil samples were washed within 2-3 days to avoid nematode desiccation.

### Estimation of Soil Population:

Initially 100 cc soil of each sample was processed using Cobb's sieving and decanting technique [7], followed by Baermann's funnel technique [6]. After 24 hours, suspension was drawn in a beaker from funnel and kept for some time to allow the nematode to settle down at the bottom. Upper water layer from the beaker was gently removed in order to have a concentrated nematode population. The volume of the suspension was maintained to 100 ml, from this maintained suspension 10 ml nematode suspension was drawn with the help of a pipette and poured over a counting dish. The root-knot nematode larvae were identified and counted under stereoscopic binocular microscope. Dilution count method was used for estimation of number of *Meloidogyne* juveniles.

### Identification of Root-knot Nematode:

Root-knot nematode infested roots were washed thoroughly and stained with 0.1 per cent acid fuchsin lacto phenol at 80$^o$C for 2-3 minutes [10]. After a gentle wash in tap water, roots were kept in clear lacto phenol for at least 24 hours and then examined under stereoscopic binocular microscope. After staining the females were teased out from the roots and perineal pattern were prepared [15], compared with the 'key' given by Tayler *et al*. [16] and identified as *M. incognita*.

### CROP RAISING:

### Raising of the Nursery:

For greenhouse cultivation of tomato the seedlings were raised on soil-less media in plastic portrays having cells of 2" in size at which place. A mixture of coco-peat, vermiculture and perlite at 3:1:1 was used as a nutrient media for raising seedling. One seed was sown in each cell. Regular watering as per requirement and plant protection measures were given. Nutrients were applied in the form of N:P:K (1:1:1) @ 140 ppm once in a week through the fine sprinkler to maintain uniformity in application of nutrients. The seedlings were ready for transplanting after 35 days from date of sowing.

**Transplanting:**

After five weeks seedling become ready for transplanting and attained a height of 10-12 cm, healthy seedling has transplanted according to recommended spacing of row to row and plant to plant (60 x 45 cm). Transplanted seedling in the evening followed by light irrigation.

**INTERCULTURAL OPERATIONS:**

Timely hoeing and weeding operation were performed as and when it was required to keep experimental field weed free and good aeration for better plant development.

**Stacking and Training**

Tomato plants were trained after 35 days of transplanting with synthetic plastic ropes fixed on hanging wire at the top of plants and growing tomato stem was tied at 30 cm intervals above ground level to keep single stem.

**Soil Fumigation:**

The experiment was carried out to test the efficacy of Sodium Tetra Thio Carbamate (STTC) @ 25, 35, 45 ml/m$^2$ and Metham Sodium @ 25, 35, 45 ml/m$^2$for the management of root-knot nematode, *Meloidogyne incognita* on tomato (US-3812) as soil fumigation. Untreated check was maintained for the comparison. STTC and Metham Sodium were mixed in soil with vermicompost at 15cm depth. After fumigation, the soil was covered with 25 micron transparent polythene film and the edges were sealed with the half of soil. After 15 days, polythene sheet was removed and soil was pulverized to let the residual fumes escape. After one week of removal of polythene sheet, the tomato seedlings were transplanted in poly-house.

**Statistical Analysis:**

After completion of experiments, data were statistically analyzed for interpretation of findings [11]. The critical difference was found for comparison of treatments where 'F' test was found significant at 5 per cent level of significance. Summary tables along with SEm ± and CD were worked out and presented in the text of the chapter entitled "Experimental Results" and analysis of variance for different parameters were appended in "Appendices".

## RESULTS AND DISCUSSION

Investigation conducted to find out the effect of two chemicals as soil fumigation on plant growth characters and reproduction of *M. incognita* on tomato. In this experiment two chemicals *viz*. STTC & Metham Sodium were used @ 25ml, 35ml, 45ml/m$^2$ dose respectively and control was also maintained. Observations on plant growth characters (shoot and root length, shoot and root weight) and nematode reproduction (number of galls per plant, number of egg masses per plant, number of eggs and larvae per egg mass, nematode population/100cc soil, final nematode population) were recorded and presented in table.

**Plant Growth parameters**

**i) Shoot length (cm):** Data recorded on shoot length revealed that both fumigants significantly increased the shoot length as compared to control. The maximum shoot length was recorded with Metham Sodium @ 45ml/m$^2$ (184.00 cm) followed by Metham Sodium @ 35ml/m$^2$ (168.60 cm) and STTC @ 45ml/m$^2$ (158.45 cm).While minimum shoot length (117.00 cm) was observed in control. Results exhibited that maximum increase in shoot length (57.16%) was with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (44.10%) and STTC @ 45ml/m$^2$(35.43%)over control.

**ii) Shoot weight (g):** Data revealed that all fumigants significantly increased the shoot weight as compared to control. The maximum shoot weight was recorded with Metham Sodium @ 45ml/m$^2$ (830.70 g) followed by Metham Sodium @ 35ml/m$^2$ (807.00g) and STTC @ 45 ml/m$^2$ (782.00g).These treatments were found at par each other. However, minimum shoot weight (592.01g) was observed in control. Results showed that maximum increase in shoot weight (40.24%) was with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (38.24%) and STTC @ 45ml/m$^2$(32.02%)over control.

**iii) Root length (cm):** Results showed that all fumigants significantly increased the root length as compared to untreated check. The maximum root length was recorded with Metham Sodium @ 45ml/m$^2$ (31.10cm) followed by Metham Sodium @ 35ml/m$^2$ (28.75 cm) and STTC @ 45 ml/m$^2$ (26.86 cm). However, minimum root length (10.55cm) was observed in untreated check. Data revealed that highest increase in root length (194.78%) was with the application of soil fumigation by Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (172.51%) and STTC @ 45ml/m$^2$ (154.59%) over untreated check.

**iv) Root weight (g):** Data revealed that all fumigants significantly increased the root weight as compared to control minimum (12.33 g) root weight. The maximum root weight was recorded with Metham Sodium @ 45 ml/m$^2$ (29.40 g) followed by Metham Sodium @ 35ml/m$^2$ (27.80 g) and STTC @ 45 ml/m$^2$ (26.20 g). Results pertaining that highest increase in root weight (138.44%) was with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (125.46%) and STTC @ 45ml/m$^2$(112.49%) over control.

**Nematode Reproduction**

**v) Number of galls per plant:** Results revealed that the number of galls produced by *M. incognita* on tomato reduced significantly as compared to control where no. of galls produced maximum (129.66) when chemical was applied as soil fumigation. Among different chemicals, minimum number of galls per plant was observed with Metham Sodium @ 45ml/m$^2$ (59.60) and Metham Sodium @ 35ml/m$^2$ (64.33) both treatment were found at par each other. (On the basis CD 1%). Data showed that, maximum reduction (53.98%) in no of galls per plant was recorded with the application of soil fumigation Metham Sodium @ 45ml/m$^2$followed by Metham Sodium @ 35ml/m$^2$ (50.39%) and STTC @ 45ml/m$^2$(43.70%)over control.

**vi) Number of egg masses per plant:** Data pertained that the number of egg masses per plant produced by *M. incognita* on tomato reduced significantly as compared to control with maximum egg masses per plant (145.33) when chemicals was applied as soil fumigation. Among different chemicals, minimum number of egg masses per plant was observed with Metham Sodium @ 45ml/m$^2$ (65.00) followed by Metham Sodium @ 35ml/m$^2$ (71.45) and STTC @ 45ml/m$^2$ (78.50). Results revealed that, maximum reduction (55.27%) in no of egg masses per plant was recorded with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (50.84%) and STTC @ 45ml/m$^2$(35.99%) over untreated check.

**vii) Number of eggs & larvae per egg mass:** Data showed that the number of eggs per egg mass produced by *M. incognita* on tomato reduced significantly as compared to control with maximum eggs and larvae per egg mass (285.00) when chemicals was applied as soil fumigation. Among different chemicals, minimum number of eggs per egg mass was observed with Metham Sodium @ 45ml/m$^2$ (237.67) followed by Metham Sodium @ 35ml/m$^2$ (243.50) and STTC @ 45ml/m$^2$ (248.40). These treatments were found at par each other. Results showed that, maximum reduction (16.61%) in no of eggs & larvae per egg mass was recorded with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (14.56%) and STTC @ 45ml/m$^2$ (12.84%) over control.

**viii) Nematode population per 100cc soil:** Results presented in table- 4.3 revealed that the nematode population per 100cc soil reduced significantly as compared to control with maximum (905.40) $J_2$/100cc soil when chemicals was applied as soil fumigation. Among different chemicals, minimum number of nematode population per 100cc soil was observed with Metham Sodium @ 45ml/m$^2$ (552.70) followed by Metham Sodium @ 35ml/m$^2$ (572.45) and STTC @ 45ml/m$^2$ (592.20).These treatments were found at par each other. Data showed that, maximum reduction (38.96%) in Nematode population per 100cc soil was recorded with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (36.77%) and STTC @ 45ml/m$^2$ (34.59%) over control.

**ix) Final Nematode population:** Data presented in table- 4.3 revealed that the final nematode population reduced significantly as compared to control with maximum (42453) when chemicals were applied as soil fumigation. Among different chemicals, minimum number of nematode population was observed with Metham Sodium @ 45ml/m$^2$ (16060) followed by Metham Sodium @ 35ml/m$^2$ (18075) and STTC @ 45ml/m$^2$ (20214). Results illustrated that, maximum reduction (62.17%) in final nematode population was recorded with the application of soil fumigation Metham Sodium @ 45ml/m$^2$ followed by Metham Sodium @ 35ml/m$^2$ (57.42%) and STTC @ 45ml/m$^2$(52.38%) over untreated check.

 

**Table 1: Efficacy of fumigants for the management of root-knot nematode, *M. incognita* on tomato:**

| S. No | Detail of Treatment | Shoot length(cm)* | Root length (cm)* | Shoot weight (g)* | Root weight (g)* | No. of galls/ Plant** | No. of egg masses/ Plant** | No. of eggs & larvae/ egg mass** | Nematode population/ 100 cc soil** | Final nematode population* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | STTC at 25ml/m² | 126.80 (8.37) | 15.90 (50.71) | 671.45 (13.35) | 18.00 (45.98) | 96.33 (25.71) | 102.20 (29.68) | 276.30 (3.05) | 705.00 (22.13) | 29166.05 (31.29) |
| 2. | STTC at 35ml/m² | 131.20 (12.14) | 18.30 (73.46) | 697.50 (17.75) | 22.10 (79.23) | 87.00 (32.90) | 95.33 (34.41) | 268.00 (5.97) | 680.90 (24.80) | 26315.43 (38.01) |
| 3. | STTC at 45ml/m² | 158.45 (35.43) | 26.86 (154.59) | 782.00 (32.02) | 26.20 (112.49) | 73.00 (43.70) | 78.50 (35.99) | 248.40 (12.84) | 592.20 (34.59) | 20214.49 (52.38) |
| 4. | Metham Sodium at 25ml/m² | 136.32 (16.51) | 22.80 (116.11) | 735.20 (24.12) | 23.00 (86.54) | 82.67 (36.24) | 89.67 (38.30) | 260.20 (8.70) | 643.00 (28.98) | 24039.87 (43.37) |
| 5. | Metham Sodium at 35ml/m² | 168.60 (44.10) | 28.75 (172.51) | 807.00 (38.24) | 27.80 (125.46) | 64.33 (50.39) | 71.45 (50.84) | 243.50 (14.56) | 572.45 (36.77) | 18075.79 (57.42) |
| 6. | Metham Sodium at 45ml/m² | 184.00 (57.16) | 31.10 (194.78) | 830.70 (40.24) | 29.40 (138.44) | 59.60 (53.98) | 65.00 (55.27) | 237.67 (16.61) | 552.70 (38.96) | 16060.22 (62.17) |
| 7. | Control | 117.00 | 10.55 | 592.35 | 12.33 | 129.66 | 145.33 | 285.00 | 905.40 | 42453.71 |
| | **SEm±** | **1.78** | **0.40** | **9.20** | **0.29** | **1.19** | **1.31** | **3.43** | **10.75** | **146.01** |
| | **CD 1%** | **7.14** | **1.61** | **36.84** | **1.17** | **4.77** | **5.26** | **13.76** | **43.05** | **575.43** |

Initial Nematode Population **294** larvae/ 100 cc Soil
*Increased Plant Parameter over Control (%), ** Reduction Nematode Reproduction over Control (%)

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