INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

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QUANTITATIVE AND QUALITATIVE YIELD LOSS DUE TO ROOT KNOT NEMATODE, *MELOIDOGYNE INCOGNITA* IN TURMERIC (*CURCUMA LONGA* L.)

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ABSTRACT
The root knot nematodes *Meloidogyne incognita* belongs to important polyphagous group of highly adapted obligate plant pathogens which are distributed worldwide and parasitize nearly every species of higher plants. Due to their endoparasitic way of living and feeding, root knot nematodes disrupt the physiology and reduce crop yield both quantitative and qualitatively. Therefore, experiments were conducted under glasshouse and field conditions to determine yield loss of turmeric (Local: Erode) due to natural infestation by *M. incognita* using carbofuran 3G at 1kg a.i. /ha and untreated as check. The yield of turmeric was found to be higher with the application of carbofuran 3G at 1kg a.i. /ha. The percentage increase over control were quantitative and qualitatively under glasshouse (26.13 & 5.70), conventional method (11.19 & 25.00) and drip irrigation (8.16 &13.65). A significant reduction in the yield of turmeric in untreated plots was mainly attributed to direct damage of the root system by the feeding of root knot nematode, *M. incognita.* Higher nematode population in the untreated check decreased plant growth and consequently reduced the number of rhizomes and other agronomic parameters.

KEY WORDS: Curcumin content, Drip irrigation, Quantitative and Qualitative loss, Root knot nematode, Turmeric.

INTRODUCTION

Turmeric *(Curcuma longa* L.) is being cultivated both under conventional and drip irrigated systems. Several biotic and abiotic stresses hamper the sustainable cultivation of turmeric. Among the biotic stresses, plant parasitic nematodes play an important role in affecting the crop growth and causes subsequent yield loss of turmeric. The nematodes associated with turmeric includes root knot nematode (*Meloidogyne* spp.), burrowing nematode (*Radopholus similis*) and other species belonging to the genera *Rotylenchulus, Helicotylenchus, Longidorus, Xiphinema, Hoplolaimus, Pratylenchus, Tylenchus, Tylenchorhynchus, Caloosia* and *Aphelenchs* (Nair, 1980). Of all the nematodes the root knot nematode *Meloidogyne* spp. is considered as a key nematode pest of turmeric grown in Tamil Nadu (Gunasekaran *et al.,* 1987) and caused in rhizome yield loss to an extent of 45.3 per cent (Bai *et al.,* 1995). The first record of root knot nematode infestation on turmeric was made by Ayyar in South India (1926). In general, the crop yields were reduced and products were of poor quality. An initial inoculum level of *M. incognita* at 1,00,000 nematodes/plant caused 76.6 per cent reduction in rhizome weight under pot conditions. Avoidable yield loss under field conditions was 45.3 per cent in turmeric and ginger (Ray *et al.,* 1995). Similarly, in turmeric the level of protein, carbohydrate, chlorophyll a and b and curcumin was lower in plants infected with *M. incognita* (Poornima and Sivagami Vadivelu, 1998). Infected rhizomes lose their bright yellow colour and as a result it lost its consumer preference in the market. Nematode often caused shrinking under storage in export oriented crop like ginger rhizomes thereby reducing storage life and its quality of these produce (Gowen *et al.,* 2008).

MATERIALS A& METHODS

Maintenance of pure culture

The root knot nematode *M. incognita* collected from the infected turmeric plants was used for pure culturing of nematodes. Turmeric roots with conspicuous galls were selected and washed thoroughly in water and examined for the presence of eggmass under microscope. The eggmass were picked out and kept in a beaker half filled with sterile water and incubated at room temperature with frequent aeration. After a week, the hatched out J_2 were used for pure culturing of *M. incognita* on coleus. Coleus (var. Local) cuttings were planted in seedling pan (5 kg) filled with sterilized pot mixture prepared with sand, red soil and FYM in 2:1:1 ratio. After the establishment of plants, the freshly hatched out juveniles (J_2) were inoculated at 21 DAP. The plants were gently uprooted at 35 days after inoculation (DAI) and washed with water. The egg masses were picked out from root galls under the stereozoom microscope and kept in water for a week with frequent aeration. The freshly hatched out J_2 were used as inoculum for the present study.

Glasshouse conditions

An experiment was conducted under controlled glasshouse conditions (28 $\pm 2^0$C). Sterilized soil mixture prepared with sand: red soil and FYM in 2:1:1 ratio were filled in mud pots (10 kg) and planted with turmeric (Local: Erode) rhizome sterilized with mercuric chloride at 0.5 %. On

establishment of turmeric plants freshly hatched out RKN juveniles collected from pure culture and inoculated at the rate of 1 J_2/g soil at 21 days after planting (DAP). In the two sets of pots with each 13 nos, one set of pots were treated with carbofuran 3G at the rate 1 kg a.i/ha on soil volume basis as nematode protectant. Other set of (13 nos) untreated pots were served as control to compute quantitative and qualitative yield loss.

Field experiments

Field experiments conducted to assess the quantitative and qualitative yield loss due to *M. incognita* on turmeric grown under conventional and drip irrigated method separately. A nematode sick field having initial root knot nematode population of >1 juvenile/g was selected and planted with turmeric local 'Erode' grown under conventional and drip irrigated method in Coimbatore district. The selected field to an extent of 0.5 ha was divided into two halves and 13 plots with 10 m^2 area were marked as replication in each half of the field. In one half of the field chemical pesticide carbofuran 3G was applied as nematode protectant at the rate of 1kg a.i/ha and another half of the untreated field was served as control. Observations on plant growth parameters including rhizome weight and nematode population/ incidence were made at the time of termination of the experiment made at 300 DAP. The observations made on plant growth parameters including rhizome yield and curcumin content were analyzed using paired't' test to assess quantitative and qualitative yield loss due to root knot nematode in turmeric.

Quantitative yield loss

On maturity of crop at 300 DAP observations on yield attributes *viz.*, length and weight of shoot and root and rhizome yield were made to quantify the yield loss due to root knot nematode in turmeric.

Plant growth parameters

Shoot and root length

The length of plant was measured from the ground level to the tip of the youngest unfurled leaf in shoot and from base of the stem to the tip of the root the values were expressed in cm.

Shoot and root weight

The plants were cut at collar region, separated, weighed and expressed in g $plant^{-1}$.

Rhizome weight

Fresh weight of mother rhizomes/plant was recorded immediately after harvest by separating the mother rhizomes followed by cleaning of soil and adhering roots and expressed in g.

Nematode population /Incidence in soil and root

A composite soil sample of 250 g was drawn from each replication from the rhizosphere region at 15cm depth at monthly interval and at the time of concluding the experiment. The collected samples were analyzed for nematode population using standard procedure (Cobb, 1918 and Schindler, 1961). Similarly, root sample (10 g) collected replication wise were assayed for nematode population using standard procedure (Mc Beth *et al.*, 1941).

Qualitative yield loss

Rhizome samples collected at the termination of the experiment meant for the assessment of qualitative yield loss due to root knot nematode under controlled and field conditions were referred to the Department of Post-Harvest Technology Centre, Agricultural Engineering College and Research Institute. The procedure described by Manjunath *et al.* (1991) for the analysis of curcumin content.

Analysis for curcumin content

A sample of 200 g of cured rhizome was ground in a Wiley Mill and sieved the powdered sample through 40 mesh sieve. One hundred milligram of turmeric powder was taken in the extraction flask and 30 ml of alcohol was added and refluxed for two and half hr. The extract was cooled and filtered quantitatively into a 100 ml volumetric flask. Then the extracted residue was transferred to the filter, washed thoroughly and diluted to the mark with 95 % alcohol and 20 ml of filtered extract was pipetted into a 250 ml volumetric flask and diluted to the volume with 25 per cent alcohol. The absorbance of extract and standard solution was measured at 425 nm against an alcohol blank (ASTA 1997).

Standard curcumin (25 mg) was weighed into 100 ml volumetric flask and dissolved and diluted to the mark with alcohol. One ml of the solution was transferred to 100 ml volumetric flask and made upto 100 ml with 95 % alcohol. This standard solution contained 0.0025 g of curcumin per litre with absorbance of 0.42 at 425 nm. The curcumin content present in the taken sample was worked out as follows.

$$\text{Curcumin \% (g)} = \frac{\text{Absorbance at 425 nm x 125}}{\text{Cell length (cm) x A x Sample weight}}$$

$$\text{Absorbity nm of Curcumin (A)} = \frac{\text{Absorbance of standred solution at 425 nm x 125}}{\text{Cell length (cm)x concentration (g} - 1)}$$

$$= \frac{\text{OD value x 125 x 0.0025}}{\text{0.42 x 0.1 x 1}}$$

RESULTS & DISCUSSION

Glasshouse conditions

The results of the experiment conducted to quantify the yield loss quantitatively and qualitatively due to *M. incognita* in turmeric under glasshouse conditions are furnished (Table. 1). It is evident that the plants protected from nematodes by treating carbofuran 3G @ 1kg a.i/ha showed increase in plant biomass in terms of shoot length (12.49%) and weight (16.26%); root length (13.38%) and weight (19.66%) accompanied with increase in rhizome weight (98.23 g/plant) compared to untreated control. The improvement in plant growth was resulted through checking in nematode population in soil (71.61%) and root (81.20%) following the treatment with carbofuran. Hence

it is concluded that the root knot nematode *M. incognita* was responsible for the quantitative loss of 26.13 per cent in turmeric rhizome yield. Similarly, the qualitative yield loss in terms of percentage of curcumin content was computed as 5.70 due to *M. incognita* in turmeric.

TABLE 1. Quantitative and qualitative yield loss due to *M. incognita* in turmeric under glasshouse condition

Treatments	Shoot		Root		Nematode population		Yield/ Plant (g)	Curcumin Content (%)
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Soil (250 g)	Root (10 g)		
Carbofuran 3G @1kg a.i/ha	75.18 (12.49)	81.18 (16.26)	12.41 (13.38)	17.40 (19.66)	91.38 (71.61)	31.92 (81.20)	98.23 (26.13)	3.75 (5.70)
Untreated control	65.79	73.56	10.75	13.98	321.92	57.84	72.56	3.68
't' value	2.56	2.42	2.36	2.87	2.96	2.67	2.32	2.19

Figures in parentheses are per cent increase (+) or decrease (-) over control

Field conditions

Conventional method

The root knot nematode *M. incognita* caused quantitative yield loss of 11.19 % in rhizome weight and qualitative yield loss of 25.00 per cent in terms of curcumin content of turmeric subsequent to improvement in plant growth parameters *viz.,* shoot length (12.17%) and weight (14.79%); root length (12.29%) and weight (14.80%) by the suppression of nematode population in soil (60.75%) and root (53.67%) in plants treated with carbofuran compared to untreated plants grown under conventional method of flood irrigation (Table 2).

TABLE 2. Quantitative and qualitative yield loss due to *M. incognita* in turmeric grown under conventional method

Treatments	Shoot		Root		Nematode population		Yield (t/ha)	Curcumin Content (%)
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Soil (250 g)	Root (10 g)		
Carbofuran 3G @ 1kg a.i/ha	129.77 (12.17)	143.88 (14.79)	7.89 (12.29)	8.31 (14.80)	174.85 (60.75)	22.73 (53.67)	31.09 (11.19)	4.20 (25.00)
Untreated control	104.08	120.60	5.95	6.53	281.07	42.93	27.96	3.15
't' value	2.67	2.81	2.38	2.21	2.53	2.26	2.65	2.73

Figures in parentheses are per cent increase (+) or decrease (-) over control

Drip irrigation

There was significant reduction in turmeric rhizome yield (8.16 %) quantitatively and curcumin content (13.65%) qualitatively due to *M. incognita* as observed in drip irrigated method following the suppression in nematode population both in soil (56.06%) and root (50.72%) and subsequent improvement in plant biomass in terms of shoot length (17.17%) and weight (16.12%); root length (20.73%) and weight (14.37%) in plants treated with carbofuran 3G @ 1 kg a.i/ha compared to untreated control (Table. 3). Hence the quantitative and qualitative yield loss due to *M. incognita* was worked out as 8.16 and 13.65 % respectively. However the yield loss caused by *M. incognita* was comparatively lesser in drip irrigated turmeric than conventional method of flood irrigated turmeric. The quantitative yield loss due to *M. incognita* in turmeric was estimated as 26.13; 11.19 and 8.16 %; 5.70, 25.00 and 13.65 % under qualitatively under controlled glasshouse, conventional and drip irrigated method respectively. Similar yield loss of 15.02 to 25.6 % in pulse crop, 41.02 to 79.0 % in root crops; 74.02 % in vegetables, 26.30 % in ginger and 33.6 % in turmeric due to *M. incognita* was reported earlier by Ahuja and Mukhapadadhyaya (1992); Ali (1992) and Ray *et al.* (1995) support the present finding.

The extent of yield loss in turmeric was higher under controlled conditions (26.13%) compared to field condition with conventional (11.19 %) and drip irrigated method (8.16%) in the present study. Further the qualitative yield loss observed in the present study with curcumin content of turmeric infected by *M. incognita* was in accordance with the report of reduction in leucine content in soybean (Rebois *et al.,* 1973), protein content in black gram (Sharma and Khan, 1993), sucrose content in sugar beet (Sanjeva Gandhi, 2006), and alkaloid content in medicinal crops (Haseeb *et al.,* 1990) due to root knot nematodes. Hence it is opined controlled glasshouse conditions is the most reliable method for the assessment of yield loss due to nematodes.

Root knot nematode caused quantitative and qualitative yield loss in terms of curcumin content under controlled glasshouse, conventional and drip irrigated method respectively in turmeric. The yield loss caused by *M. incognita* was found to be higher under controlled glasshouse conditions compared to field conditions either with conventional or drip irrigated method. It is viewed that controlled conditions experiment was more reliable for assessing acute yield loss due to nematodes.

TABLE 3. Quantitative and qualitative yield loss due to *M. incognita* in turmeric grown under drip irrigated method

Treatments	Shoot		Root		Nematode population		Yield (t/ha)	Curcumin Content (%)
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Soil (250 g)	Root (10 g)		
Carbofuran 3G @	115.00	137.58	6.61	7.03	169.46	18.08	34.43	6.08
1kg a.i/ha	(17.17)	(16.12)	(20.73)	(14.37)	(56.06)	(50.72)	(8.16)	(13.65)
Untreated control	119.83	126.55	6.92	7.58	264.46	36.69	31.83	5.25
't' value	2.93	2.85	2.81	2.33	2.52	2.75	2.47	2.26

Figures in parentheses are per cent increase (+) or decrease (-) over control.

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