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Nematicidal Potential of Extracts from Some Selected Plants against the Root-Knot Nematode, Meloidogyne incognita.

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Abstract: *The use of botanical extracts for controlling plant-parasitic nematodes is becoming more popular because of the problem of environmental pollution arising from the use of persistent pesticides. Some nematicides have been banned, yet the farmers still use them. This poses danger to human, the environment, beneficial microbes in the soil as well as underground body water. This emphases the need for new methods of control such as the use of environmentally-friendly plant extracts. Therefore, effects of water extracts of leaves of Tagetes erecta (Marigold), Tithonia diversifolia (Mexican sunflower), Chromolaena odorata (Siam weed) and Occimum gratissimun (Tree basil) each at 3.3, 5.0, 6,6, 8.3 and 10% w/v, on eggs and second stage juveniles of Meloidogyne incognita were investigated in vitro. The efficacy of dry milled leaves of these plants at 1 t/ha and 2 t/ha and carbofuran at 1.5kg a.i./ha and 2.5kg a.i./ha were also evaluated against M. incognita in a screen house. Fifty M. incognita eggs per 1ml in water suspension were pipette and dispensed into glass blocks and 1ml of each extract at different concentrations were added. Fifty freshly hatched juveniles per 1ml were also dispensed into a glass blocks and 1 ml of each plant extracts at different concentrations were also added. Distilled water served as control. Hatched eggs were counted every 24 hours for 10 days while juveniles were observed for mortality every 24 hours for five days. In the screen house, 48 pots were filled with sterilized soil. Treatments were carbofuran (1.5 and 2.5 kg a.i./ha), milled dried leaves of marigold, siam weed, mexican sunflower and tree basil at 1t/ha and 2t/ha each and untreated control. Two days later four seeds of cucumber were sown in each of the 48 pots. One week after germination, the seedlings were each inoculated with 10,000 M incognita eggs. The treatments were arranged in a completely randomised designed with four replicates. Data were collected on Vegetative Growth (VG), Gall Index (GI), nematode reproduction and yield (g). LC_{50} was also determined. All data were analysed using ANOVA (p=0.05) and means were separated using Duncan multiple range test at 5% probability. Water extracts of T. erecta inhibited egg hatch by 90.5% at the highest concentration and was significantly higher than egg hatch observed in O. gratissimum which produced the lowest egg hatch inhibition of 70.7%. T. erecta also caused 100% juvenile mortality within 24 hours of exposure followed by T. diversifolia (59%), C. odorata (50%) and O. gratissimum 26.5% at the lowest concentration. Targetes erecta extract was the most potent among the plant extracts used with LC_{50} of 1.321mg/ml^{-1}. In the pot experiment, T. erecta, C. odorata, Carbofuran and O. gratissimun reduced GI by 62.5%, 65%, 75% and 75.5%, respectively. Similarly, RKN population was reduced by 85.4% in T. erecta-treated pots; C. odorata caused 87.6% reduction and Carbofuran 93.1%. The results of this study suggest that application of these plants as botanical pesticides in the management of RKN is highly promising, especially as they are readily available in Nigeria.*

Keywords: *Eggs, Juvenile mortality, Root-Knot nematode, Tagetes erecta, Tithonia diversifolia.*

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I. Introduction

Tagetes erecta (marigold) is commonly used as an ornamental plant; it has been used for nematode and insect pest management (Khann, 1971). Hethelyi *et al*. (1986) reported that the essential oil of marigold had a 100% inhibitory effect against fungi and gram-positive bacteria. Also ∞-terthienyl a chemical released by marigold roots has drawn much attention for its nematicidal properties. Siam weed, *Chromolaena odorata* (L.) King *et* Robinson, is a fast growing perennial shrub native to Central and South America. It is a major weed in plantations and croplands. Atu and Ogbuji (1982) found it to be highly resistant to the root-knot nematode *Meloidogyne incognita* race 2. Water extracts of dried *C. odorata* plant material on *M. incognita* juveniles has nematicidal effects (Subramaniyan 1985). The root exudates of *C. odorata* is also reported to inhibit M. Incognita egg hatch *in vitro* (Amosu 1981).

Tree basil (*Ocimum gratissimum)* belongs to the family Lamiaceae. Its potential for nematicidal activity of indigenous plants and their products as an alternative for traditional nematicides has been studied by several workers (Haseeb *et al*., 1984; Pracer *et al*,. 1987; Osman and Viglierchio, 1988).

The genus *Meloidogyne* are called root-knot nematodes because their feeding activity gives rise to irregular, knotty enlargement of the roots (Scurrah *et al.,* 2005). As a result of this irregularity of roots there is a blockage of water and nutrients to the upper part of the plants for food production therefore the plants show patchiness in the field, yellowing of leaves (chlorosis), stunting, wilting especially in hot weather and death of plants in severe cases. Globally, the crop loss as a result of infection by root-knot nematodes is approximately 5% and about 2000 plants are susceptible to infection (Sasser and Carter 1985). Therefore, the challenge is to identify plants that have nematicidal potential as an alternative to the soil fumigant methyl bromide, which is being phased out due to its ozone depleting effect (Annonymous, 1992).

However, information on the nematicidal potential of *Tithonia diversifolia* is scanty. It is commonly called Mexican sunflower and it belongs to the family Asteraceae. It is a bushy, many-branched, annual weed that grows up to 2.5m high. It reproduces from seeds and from vegetative re-growth of basal stem when plant is cut. Moreso, the use of chemical for the control of M. incognita is expensive and economically viable for high value crops which also create a potential hazard to environment and human health (Tsay *et al*., 2004). Therefore, the aim of the study was to investigate the potential of *T. diversifolia* as a nematicide in comparism with other three selected plants to eggs and second stage juveniles of root-knot nematode and to investigate the efficacy of these selected plants as alternative nematicides for root-knot nematode control in comparison with carbofuran, as a standard synethetic nematicide in cucumber.

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II. Methodology

Extraction of root-knot nematode eggs

a) *Meloidogyne incognita* eggs used for this study were cultured on *Celosia argentea* plants for three months in pots. The galled roots were harvested and thoroughly washed under running water in order to remove soil particles. They were then chopped into 2-3cm pieces and placed into a 2 L conical flask. Sodium hypochlorite solution of 0.5% concentration was prepared and added into the conical flask and shaken for four minutes extracted (Hussey and Barker, 1973). The content in the conical flask was poured onto a stack of sieves. The upper sieve No 1 mm was used for collecting the plant debris, followed by a 2 mm mesh for fines while the 28 mm was used to collect the eggs. The 28 mm sieve with the eggs was then quickly placed under a stream of cold water to remove residual NaOCl, and collected in a beaker. The egg suspension in the beaker was thoroughly mixed using a magnetic stirrer. The number of eggs in 1ml of suspension was counted under the dissecting microscope. The average of three counts was taken to estimate the egg population per ml of egg suspension.

Preparation of leaf extracts: The extracts were prepared using the method of Bharadway and Sharma (2007). Five concentrations (w/v) i.e 6.6, 10.0, 13.3, 16.6 and 20% of hot water leaf extracts were prepared by boiling 50, 75, 100, 125 and 150 g chopped fresh leaves of T. *erecta, C. odorata, T. diversifolia* and *O. gratissimum.* for 15 minutes in 750 ml of distilled water. After cooling the liquid was filtered through No 1 Waltham filter paper twice to get a clean filtrate.

The plant extracts on egg hatch: Aliquots of one ml of nematode egg suspension that contained 50 fresh *M. incognita* eggs were dispensed in transparent glass blocks arranged on the laboratory work bench. One ml each of the water extracts of each plant (6.6, 10.0. 13.3, 16.6 and 20%) and distilled water were added into the egg suspension already contained in the glass blocks. This brought the effective concentration of water extracts to 3.3, 5.0, 6.6, 8.3 and 10% respectively. The treatments and control were incubated at average temperature of 27^{o}C and relative humidity of 85%. The experimental design was completely randomized with 21 treatments and four replicates. Juveniles hatched were counted every 24 hour for 10 days. A second trial was conducted as described above without any modification.

Mortality of 2nd stage juveniles of M. incognita exposed to plant extracts

Freshly extracted eggs of *M. incognita* were incubated in the laboratory at 27^{o}C for 5 days. Mobile 2nd stage juveniles were collected. Three 1 ml aliquots of the extract was dispensed in a counting dish and counted under dissecting microscope. Aliquots of one ml of juvenile suspension containing second-stage juveniles of *M. incognitata* were dispensed into transparent glass blocks that were arranged on the laboratory bench. One ml each of the water extracts of each plant (6.6, 10.0. 13.3, 16.6 and 20%) were added into the glass blocks containing second stage juveniles and distilled water act as control. The experimental design was completely randomized with 21 treatments replicated four times. Nematodes were observed daily for 5 days and juveniles

were considered dead if they did not respond when touched with inoculating needle. This trial was repeated as described above without any modification.

Greenhouse studies

Greenhouse studies were conducted in two separate trials with carbofuran and milled air-dried leaves of marigold (*Tagetes erecta*), siam weed (*Chromolaena odorata)*, Mexican sunflower *(Tithonia diversifolia)* and tree basil *(Occimum gratissimum).* In all 48 pots filled with steam-pasteurized soil were used. Fourty (40) out of the 48 pots were treated as follows with carbofuran (1.5 and 2.5 kg a.i./ha), milled dried leaves of marigold (*Tagetes erecta*), siam weed (*Chromolaena odorata)*, Mexican sunflower *(Tithonia diversifolia)* and tree basil *(Occimum gratissimum)* at 2 rates of 1t/ha and 2t/ha. Two days later 4 seeds of cucumber (Marketmore) were sown in each of the 48 pots. One week after germination, the seedlings were thinned to one seedling per pot and were each inoculated with 10,000 *M incognita* eggs one week later. The experimental design was completely randomized with 4 replicates.

Data Collection

Data were collected on Vegetative Growth (VG), Gall Index (GI), nematode reproduction and yield (g). LC_{50} values were determined by using probit analysis (Finney, 1971). All data were analysed using ANOVA (p=0.05) and means were separated using Duncan multiple range test at 5% probability.

III. Results

In vitro assessments of effects of extracts of Mexican sunflower, basil, Siam weed and marigold leaves on eggs of M. incognita

Egg-hatch of *M. incognita* in extracts of *Tithonia diversifolia, Occimum gratissimum Chromolaena odorata* and *Tagetes erecta* leaves is presented in Table I. Marigold water extract of leaves at 3.3, 5.0, 6.6, 8.3, and 10% concentrations, completely inhibited nematode egg-hatch (100% inhibition) compared to other plant extracts. Siam weed at 10% also provided 100% inhibition of egg hatch. This was followed by Mexican sunflower extract at 10% level of concentration which gave 97.79% inhibition. Of all the plant extracts tested, basil extract at 3.3% gave the least inhibition in egg-hatch (40.33% inhibition). However, control (distilled water medium) all the eggs were hatched at 10days. The results of the second trial followed the same trend as in the first trial (Table 2).

Table I: Egg-hatch of *M. incognita* in extracts of Mexican sunflower, basil, Siam weed and Marigold leaves (1^{st} Trial)

Treatment	Concentration (w/v) %	% Egg hatch in 10 days	% Egg-hatch inhibition in 10days
Mexican sunflower	3.3	46c	49.17
	5.0	9.5f	89.50
	6.6	9.5f	89.50
	8.3	11.5f	87.29
	10	2.0fg	97.79
Basil	3.3	54.0b	40.33
	5.0	36.0d	60.22
	6.6	40.5	55.25
	8.3	29.0e	67.96
	10	26.5e	70.72
Siam weed	3.3	24.0e	73.48
	5.0	6.0f	93.37
	6.6	5.0f	94.48
	8.3	2.5fg	97.24
	10	0.0fg	100
Marigold	3.3	0.0fg	100
	5.0	0.0fg	100
	6.6	0.0fg	100
	8.3	0.0fg	100
	10	0.0fg	100
Water (Control)		90.5a	0

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

Table 2: Egg-hatch of *M. incognita* in extracts of Mexican sunflower, basil, Siam weed and Marigold leaves (2nd Trial)

Treatment	Concentration (w/v) %	% Egg hatch in 10 days	% Egg-hatch inhibition in 10days
Mexican sunflower	3.3	43.0c	53.26b
	5.0	9.5g	89.67a
	6.6	9.5g	89.67a
	8.3	11.0g	88.04a
	10	2.0gh	97.82a
Basil	3.3	54.0b	41.30b
	5.0	35.5cd	61.41b
	6.6	40.5c	55.98b
	8.3	29.0e	68.48b
	10	23.0f	75.00ab
Siam weed	3.3	20.5f	77.72ab
	5.0	6.0g	93.48a
	6.6	5.0gh	94.57a
	8.3	2.5gh	97.28a
	10	0.0gh	100a
Marigold	3.3	0.0gh	100a
	5.0	0.0gh	100a
	6.6	0.0gh	100a
	8.3	0.0gh	100a
	10	0.0gh	100a
Water (control)		92.0a	0c

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

In vitro assessments of effects of extracts of Mexican sunflower, basil, Siam weed and marigold leaves on Mortality of Meloidogyne incognita second-stage juveniles (J2)

Table 3 shows the effects of extracts of Mexican sunflower, basil, Siam weed and marigold leaves on mortality of second-stage juveniles of Meloidogyne incognita (first Trial). Marigold extract at 10% level of concentration was the most potent of all the plant extracts as all the juveniles in the extract were killed within 24 hours of exposure. At all levels of concentration of marigold, all the juveniles were killed after two days of exposure. This was closely followed by Mexican sunflower at 10% level of concentration in which all the juveniles were killed within two days. The least effective of the plant extracts in terms of juvenile mortality was basil leaf extract in which all the nematode juveniles were killed over a period of 8 days. However, the juveniles in distilled water control had 86% and 90% of the juveniles that were still living at 8 days of incubation for 1st and 2nd trials respectively. The results of the second trial followed the same trend as in the first trial (Table 4)

Table 3: Effects of extracts of Mexican sunflower, Basil, Siam weed and Marigold leaves on Mortality of 2nd Stage Juveniles of *Meloidogyne incognita* (1st Trial)

Treatment	Concentration W/v (%)	% Cumulative J_2 Mortality							
		Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8
Mexican Sunflower	3.3	25.5j	59cd	100a	100a	100a	100a	100a	100a
	5.0	30i	70c	100a	100a	100a	100a	100a	100a
	6.6	35h	75b	100a	100a	100a	100a	100a	100a
	8.3	45f	100a	100a	100a	100a	100a	100a	100a
	10	55d	100a	100a	100a	100a	100a	100a	100a
Basil	3.3	12k	27.5f	47.5g	63b	77a	89.5a	100a	100a
	5.0	14.5k	29f	52.5f	61c	73.5b	85.5b	100a	100a
	6.6	40g	70c	100a	100a	100a	100a	100a	100a
	8.3	50e	75b	100a	100a	100a	100a	100a	100a
	10	43f	67.5c	100a	100a	100a	100a	100a	100a
Siam weed	3.3	25j	50e	76.5e	100a	100a	100a	100a	100a
	5.0	38.5g	63c	86.5b	100a	100a	100a	100a	100a
	6.6	34.5h	64c	84c	100a	100a	100a	100a	100a
	8.3	30i	56d	81d	100a	100a	100a	100a	100a
	10	35h	57.8d	85bc	100a	100a	100a	100a	100a
Marigold	3.3	93c	100a	100a	100a	100a	100a	100a	100a
	5.0	90.5c	100a	100a	100a	100a	100a	100a	100a
	6.6	94bc	100a	100a	100a	100a	100a	100a	100a
	8.3	96.5b	100a	100a	100a	100a	100a	100a	100a
	10	100a	100a	100a	100a	100a	100a	100a	100a
Water (Control)		5l	7g	12h	20.5d	29c	43.5c	66b	86b

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

Table 4: Effects of extracts of Mexican sunflower, Basil, Siam weed and Marigold leaves on Mortality of 2nd stage Juveniles of *Meloidogyne incognita* (2nd Trial)

Treatment	Concentration W/v (%)	% Cumulative J_2 Mortality							
		Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8
Mexican Sunflower	3.3	25.5j	59h	100a	100a	100a	100a	100a	100a
	5.0	30i	70f	100a	100a	100a	100a	100a	100a
	6.6	35g	75e	100a	100a	100a	100a	100a	100a
	8.3	45e	100a	100a	100a	100a	100a	100a	100a
	10	55d	100a	100a	100a	100a	100a	100a	100a
Basil	3.3	12k	26.5j	50d	70.5b	83a	99b	100a	100a
	5.0	12k	25.5j	46e	64c	80b	100a	100a	100a
	6.6	42.5ef	70f	100a	100a	100a	100a	100a	100a
	8.3	45e	75e	100a	100a	100a	100a	100a	100a
	10	40f	65g	100a	100a	100a	100a	100a	100a
Siam weed	3.3	25j	50i	77.5c	100a	100a	100a	100a	100a
	5.0	38.5f	63g	83.5b	100a	100a	100a	100a	100a
	6.6	34.5h	64g	84b	100a	100a	100a	100a	100a
	8.3	30i	56h	81b	100a	100a	100a	100a	100a
	10	35g	57.5h	85b	100a	100a	100a	100a	100a
Marigold	3.3	93bc	100a	100a	100a	100a	100a	100a	100a
	5.0	90.5c	100a	100a	100a	100a	100a	100a	100a
	6.6	94b	100a	100a	100a	100a	100a	100a	100a
	8.3	97.5a	100a	100a	100a	100a	100a	100a	100a
	10	100a	100a	100a	100a	100a	100a	100a	100a
Water (Control)	0	81	12.5k	22f	25.5d	34c	55c	67.5	90

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

Table 5 shows the lethal concentration of the water extracts of leaves of Mexican sunflower, basil, Siam weed and Marigold to juveniles of root-knot nematode after 24 hours of exposure. The highest value LC50 was recorded for Siam weed (119.12mg/ml), this was followed by values calculated for Local basil and Mexican sunflower that is 11.43 and 10.57mg/ml respectively while the least value was calculated for Marigold 1.32mg/ml

Table-5: Results of the lethal Concentration of the four plant water extracts for the determination of LD50 after 24hours of exposure of 2nd stage Juveniles of Root-Knot nematode (n=50)

Plant Extract	Concentration	Log dose	% Mortality	Corrected Mortality	Probit values	LC_{50}
Mexican	**3.3**	**0.52**	**25.5**	**21.58**	**4.23**	
Sunflower	**5.0**	**0.70**	**30.0**	**26.32**	**4.36**	
	6.6	**0.82**	**35.0**	**31.58**	**4.53**	
	8.3	**0.92**	**45.0**	**42.11**	**4.80**	
	10.0	**1.00**	**55.0**	**52.63**	**5.08**	**10.57mg/ml**
Local Basil	**3.3**	**0.52**	**12.0**	**7.37**	**3.52**	
	5.0	**0.70**	**14.5**	**10.00**	**3.72**	
	6.6	**0.82**	**40.0**	**36.84**	**4.07**	
	8.3	**0.92**	**50.0**	**47.37**	**4.92**	
	10.0	**1.00**	**43.0**	**40.00**	**4.75**	**11.43mg/ml**
Siam weed	**3.3**	**0.52**	**25.0**	**21.05**	**4.19**	
	5.0	**0.70**	**38.5**	**35.26**	**4.61**	
	6.6	**0.82**	**34.5**	**31.05**	**4.50**	
	8.3	**0.92**	**30.0**	**26.32**	**4.36**	
	10.0	**1.00**	**35.0**	**31.58**	**4.53**	**119.12mg/ml**
Marigold	**3.3**	**0.52**	**93**	**92.63**	**6.45**	
	5.0	**0.70**	**90.5**	**90.00**	**6.28**	
	6.6	**0.82**	**94**	**93.68**	**6.55**	
	8.3	**0.92**	**96.5**	**96.32**	**6.75**	
	10.0	**1.00**	**100**	**100**	**8.09**	**1.32mg/ml**
Water Control	**0**		**5**			

Effect of extracts on gall formation and nematode population

The effects of the treatments on number of galls, nematode population in soil and root are shown on Table 6. All the treatments dried milled powder of marigold, Siam weed, Mexican sunflower and local basil significantly reduced the number of galls compared to control. Similarly, the number of nematodes extracted from the treated plants in soil and root were lower when compared with the untreated plants.

Table 6: Effects of carbofuran, Mexican sunflower, Basil, Siam weed and Marigold on plant root damage and nematode reproduction on cucumber infected with *Meloidogyne incognita* (1st and 2nd Trials)

Treatment	Gall Index		Root Population		Soil Population		Final Nematode Pop		Reproductive Factor (RF)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Marigold (1t/ha)	2.00bc	1.75bc	2325c	2100b	750ab	555.00b	32,325ab	24,300b	3.23bc	2.43b
Marigold (2t/ha)	2.00bc	1.90bc	5050bc	4125b	650ab	512.50b	31050ab	24,625b	3.11bc	2.46b
Siam weed (1t/ha)	1.75bc	1.75bc	2375c	1750b	450bc	387.50bc	20,375c	17250bc	2.04c	1.73b
Siam weed (2t/ha)	2.52b	2.50b	4750bc	4500b	525bc	350.00bc	25,750bc	18,500bc	2.58bc	1.85b
Mexican sun (1t/ha)	2.75b	2.68b	4050bc	4000b	550bc	312.50bc	26,050bc	16500bc	2.61bc	1.65b
Mexican sun (2t/ha)	2.00bc	1.75bc	4025bc	1925b	250bc	112.50bc	14,025bc	6,425de	1.40bc	0.64c
Basil (1t/ha)	2.50b	2.00b	8500b	4475b	400bc	312.50bc	24,500bc	16975bc	2.45b	1.70b
Basil (2t/ha)	1.25c	1.20c	5150bc	1435b	550abc	212.50bc	27,150abc	9,935d	2.72bc	0.99c
Carbofuran (1.5kg a. i/ha	1.25c	1.25c	1475c	1525b	225bc	175.00bc	10,475bc	8,525d	1.05c	0.85c
Carbofuran (2.5kg a. i/ha	1.25c	1.25c	1525c	975b	125bc	100.00bc	6,525c	4,975e	0.65c	0.50c
Inoculated control	5.00a	5.00a	18550a	17900a	1150a	1575.00a	64,550a	80,900a	64.55a	8.09a
Uninoculated control	0.00d	0.00d	0.00d	0.00c	0.00d	0.00d	0.00d	0.00f	0.00d	0.00b

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

Effect of treatment on the yield of Cucumber

The dried milled powder of Mexican sunflower at the two rates significantly increased the cucumber fresh shoot weight and dry shoot weight over control and other treatments. The number of fruits harvested from Mexican sunflower treated plant at 2 t/ha was significantly higher than other treatments, there was no significant different from the plants treated with carbofuran at 2.5kg a.i /ha. The least cucumber fruits were harvested from the plants treated with Mexican sunflower at 1t/ha which was not significantly different from control and other treatments.

Table 7: : Effects of carbofuran, Mexican sunflower, Basil, Siam weed and Marigold on fresh shoot weight, number of fruits and fruits weight of cucumber infected with *Meloidogyne incognita* (1st and 2nd Trials)

	1st Trial				2nd Trial			
Trt	FShwt (g)	DShwt (g)	NFruit	FruitWt (g)	FShwt (g)	DShwt (g)	NFruit	FruitWt (g)
Marigold (1t/ha)	212.50c*	28.63d	1.00ab	93.75b	181.25c	23.69c	0.75ab	80.00cd
Marigold (2t/ha)	228.75bc	30.63d	1.25ab	87.50b	211.50bc	29.41bc	0.75ab	90.00cd
Siam weed (1t/ha)	220.00bc	31.55cd	1.00ab	118.75ab	201.25bc	27.17bc	0.75ab	68.75d
Siam weed (2t/ha)	192.50cd	35.03c	1.00ab	112.50ab	188.75cd	23.28c	1.00ab	87.50d
Mexican sun (1t/ha)	281.25a	24.84e	0.50b	128.00ab	258.75a	26.15bc	0.50b	120.00bc
Mexican sun (2t/ha)	298.75a	43.05a	2.25a	346.00a	281.50a	33.82a	1.75ab	205.00a
Basil (1t/ha)	243.75b	33.82c	0.75ab	207.00ab	223.75b	28.45bc	0.75ab	87.50d
Basil (2t/ha)	228.75bc	33.58c	1.00ab	250.00ab	211.25bc	27.95bc	1.00ab	118.75bc
Carbofuran (1.5kg a. i/ha	142.50e	23.50e	2.00ab	165.00ab	127.50d	21.04d	1.75ab	140.00ab
Carbofuran (2.5kg a. i/ha	200.00c	31.63cd	2.25a	328.00a	206.25c	28.57bc	2.00a	188.75ab
Inoculated control	197.50cd	33.05cd	0.75ab	181.25ab	172.50cd	24.15cd	0.75ab	106.25bc
Uninoculated control	175.00d	27.23d	1.25ab	287.50ab	171.25cd	20.50d	1.75ab	185.00ab

*Means followed by the same letter in the same column are not significantly different by Duncan's Multiple Range Test (P≤0.05)

FShwt = fresh shoot weight DShwt=Dry shoot weight Nfruit =number of fruits

IV. Discussion

The extracts of all the plant tested were effective in inhibiting egg-hatch of *M. incognita* and survival of second-stage juveniles of the nematode at all the concentrations tested. Extract of marigold leaves was the most effective than any other plant extracts tested. Marigold extract at 10% level of concentration was the most effective of all the plant extracts as all the juveniles in the extract were killed within 24 hours of exposure. At all levels of concentration of marigold, all the juveniles were killed within two days of incubation. This was closely followed by Mexican sunflower at 10% level of concentration in which all the juveniles were killed within two days. The least effective of the plant extract in term of juveniles mortality was basil leaf extract in which all the nematodes juveniles were killed over a period of 8 days. However, the juveniles in distilled water control some were still living at 8 days of incubation. Ali *et al*. (2001) reported that aqueous and methanolic extracts of *Lantana camara* were found to be excellent inhibitors of eggs-hatch and killed juveniles of *Meloidogyne javanica.* Also Upadhyay *et al*. (2003) reported that water extract of some plants like leaves of *Allium cepa* L. and *Solanum nigrum* L. and seeds of *Azadirachta indica* A. Juss killed juveniles of *M. incognita* and *Heterodera cajani* up to 100% mortality and suppressed egg-hatch of both species at 1:5 dilution.

The results also corroborated with the findings of Fatoki and Fawole (2000) who reported that extracts of neem, Siam weed, cassava peels effectively reduced hatching of *M. incognita* eggs and caused the death of juveniles after they have hatched. The toxicity of extracts increased with increase in concentration as well as the exposure time. Akhtar and Farzana (1990) tested root and shoot extracts of some plants of family Lamiaceae on eggs and second stage juveniles of root-knot nematode. All tested plant extracts exhibited high nematode toxicity.

V. Conclusions

Mexican sunflower, Basil, Siam weed and Marigold extracts and dried milled powdered can be used to management root-knot nematode in cucumber field as an alternative to chemicals which are detrimental to our health and environment

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