EVALUATION OF NEMATICIDES AND NEEM CAKE FOR MANAGING ROOT-KNOT NEMATODES IN POINTED GOURD, *TRICHOSANTHES DIOICA*

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Summary. Experiments were conducted, during two growing seasons, to control the root-knot nematodes, *Meloidogne incognita* and *M. javanica*, in pointed gourd (*Trichosanthes dioica* Rb.), using carbosulfan, carbofuran, monocrotophos and neem cake applied in various ways. Dipping vines in carbosulfan 25 EC at 500 ppm for 6 hours + carbofuran 3G at 2.5 g/pit 45 days after planting was the best treatment as it produced the highest yield of 20,216 kg/ha and the greatest reduction of root-knot nematode gall index in both growing seasons. All other treatments increased yield and reduced nematode population density in the 2002-03 season but not in the 2003-04 season. The largest yield gain was achieved with the above-mentioned best treatment, but the largest gain/treatment cost ratio was obtained by dipping vines in monocrotophos.

Key words: Carbofuran, carbosulfan, control, *Meloidogyne incognita*, *M. javanica*, monocrotophos.

Developing countries are facing problems of food crisis and malnutrition thus making the increase in productivity of high value crops a priority goal. Pointed gourd, *Trichosanthes dioica* Roxb., is a perennial and dioecious cash crop, commonly known as "king of gourds" because its nutritive, digestible, diuretic, laxative and medicinal properties are greater than those of other cucurbits (Singh, 1989). For instance, it possesses the ability to lower total cholesterol and blood sugar (Chandrasekar *et al.*, 1988; Sharma and Pant, 1988). It is a very popular crop in the Indian subcontinent as it produces for almost eight months per year. Nowadays it is also cultivated in the USA and Australia (Lamberts, 1992; Singh and Whitehead, 1999; Fletcher, 1999).

Unfortunately, nematode infestation is a major constraint to pointed gourd production. Among the nematode parasites of the crop the root-knot nematodes, *Meloidogyne incognita* (Kofoid *et* White) Chitw. and *M. javanica* (Treub) Chitw., are predominant in the Indian subcontinent. Eradication of these nematodes from infested field is generally out of the question so prophylactic measures have to be taken. Therefore, the efficacy and economics of treatments with nematicides and neem cake were investigated in a field severely infested with root-knot nematodes and planted to pointed gourd.

MATERIALS AND METHODS

The trials were conducted in a field uniformly infested with *M. incognita* and *M. javanica* (232 eggs and second stage juveniles/200 cm^3 soil in 2002-03 and 268/200 cm^3 soil in 2003-04) at Nadia, West Bengal, India, during November-July in 2002-03 and 2003-04. The field was located at 23^0N latitude, 89^0E longitude and 9.75 m above sea level, and was planted with pointed gourd cv. Kajli in both seasons. Environmental conditions during the experiment were from 11.9-34.6 °C, 42.8-98.8% relative humidity and 3.4-362.8 mm monthly rainfall in 2002-03, and 12.5-34.1 °C, 43.3-98.5% relative humidity and 3.5-320.2 mm monthly rainfall in 2003-04. The soil of the experimental field was a typical alluvial soil (Entisol) having a sandy clay loam texture with good drainage, slightly acidic pH and moderate fertility.

To estimate the initial population of the nematodes, three composite samples, each consisting of nine subsamples covering the entire field, were collected just before land preparation and processed according to Cobb's decanting and sieving technique combined with a modified Baermann's funnel method (Christie and Perry, 1951). Nitrogen, phosphorus and potash fertilizers were applied at the rate of 150 : 60 : 40 kg/ha. The entire amounts of phosphorus and potash were applied before planting whereas nitrogen was split and applied at planting and flowering. Plots were raised by up to 6 cm with soil removed from the irrigation channel and each was of 6 m^2 (4 m × 1.5 m). Mature vine cuttings, each having three nodes, were collected from the farmer's field early in the morning of the planting day (the day after land preparation). A total of sixteen vine cuttings per plot were planted in 3.5 cm deep pits at a spacing of 75 cm × 50 cm, with a female: male ratio of 8 : 1.

There were eight treatments and an untreated check (Tables I-III), each replicated four times according to a randomized complete block design. The methods of application of the nematicides were bare vine dipping, pit application and broadcasting. The field was irrigated lightly after pit application and broadcasting. Treat-

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Table I. Effect of treatments on the growth of pointed gourd in a field infested with *Meloidogyne incognita* and *M. javanica* in 2002-03 and 2003-04 (Average of four replications).

Treatment	Plant stand/plot		Fresh root weight (g)		Dry root weight (g)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
T_1: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs	7.3 cd*	8.3 c	117.7	140.6 c	18.4	32.9 b
T_2: Vines dipped in monocrotophos 36EC at 500 ppm for 6 hrs	7.3 cd	9.0 abc	82.6	150.4 c	11.4	26.9 c
T_3: Carbofuran 3G, 2 kg a.i./ha at planting (broadcasting)	6.8 d	10.8 ab	83.4	155.9 c	12.9	18.2 de
T_4: Carbofuran 3G, 2.5 g/pit at planting	7.8 cd	8.8 abc	139.8	161.3 bc	18.5	15.4 e
T_5: Neem cake, 1500 kg/ha at planting (broadcasting)	8.0 bcd	8.8bc	137.0	203.8 a	18.7	34.4 ab
T_6: Neem cake, 50 g/pit at planting	9.3 b	8.8 bc	171.5	153.1 c	27.6	36.9 ab
T_7: Neem cake, 50 g/pit at planting + carbofuran 3G at 2.5 g/pit 45 DAP	8.5 bc	9.5 abc	160.6	105.4 d	22.9	21.8 d
T_8: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs + carbofuran 3G 2.5 g/pit 45 DAP	10.5 a	11.0 a	171.5	183.1 ab	28.2	38.9 a
T_9: Untreated control	6.8 d	7.8 c	101.3	107.1 d	9.3	14.5 e
S.Em ±	0.5	0.7	26.7	7.6	5.7	1.7
C.D. $_{at\ 0.05}$	1.43	2.01	NS	22.13	NS	4.98

* Figures marked by a common letter are not significantly different according to Duncan's Multiple Range Test at $P < 0.05$.

Table II. Effect of treatments on the yield of pointed gourd in a field infested with *M. incognita* and *M. javanica* in 2002-03 and 2003-04 (Average of four replications).

Treatment	Fruits/plot		Fruit girth/plot (cm)		Fruit length/plot (cm)		Yield/plot (kg)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
T_1: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs	283.0 ab*	274.3 bc	11.0	11.6 ab	7.3	9.0	12.0 bc	11.6 bc
T_2: Vines dipped in monocrotophos 36EC at 500 ppm for 6 hrs	285.5 ab	305.3 bc	11.0	12.1 ab	7.2	9.3	11.8 c	12.7 bc
T_3: Carbofuran 3G, 2 kg a.i./ha at planting (broadcasting)	279.0 ab	327.3 ab	10.8	12.8 a	7.3	9.3	11.8 c	13.9 ab
T_4: Carbofuran 3G, 2.5 g/pit at planting	265.3 ab	289.8 bc	11.0	11.8 ab	7.3	9.0	12.1 bc	12.0 bc
T_5: Neem cake, 1500 kg/ha at planting (broadcasting)	294.0 a	290.0 bc	10.8	11.7 ab	7.3	9.1	12.4 ab	12.2 bc
T_6: Neem cake, 50 g/pit at planting	298.0 a	290.5 bc	11.1	11.8 ab	7.4	9.3	12.6 a	12.3 bc
T_7: Neem cake, 50 g/pit at planting + carbofuran 3G 2.5 g/pit 45 DAP	292.0 ab	305.5 bc	11.2	12.3 ab	7.4	9.4	12.5 a	13.1abc
T_8: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs + carbofuran 3G 2.5 g/pit 45 DAP	296.0 a	369.0 a	11.4	12.5 ab	7.8	10.0	12.7 a	15.9 a
T_9: Untreated control	254.3 b	242.3 c	10.8	11.2 b	7.1	8.5	10.7 d	10.2 c
S.Em ±	11.8	19.9	0.2	0.5	0.2	0.5	0.1	0.9
C.D. $_{at\ 0.05}$	34.33	58.10	NS	1.38	NS	NS	0.42	2.66

* Figures marked by a common letter are not significantly different according to Duncan's Multiple Range Test at $P < 0.05$.

ments of vine cuttings and soil were made early in the morning of the planting dates (08.11.2002 and 12.11.2003).

The crops were raised following recommended practices in both years. Fruits were picked between 22.03.2003 and 31.07.2003 and between 14.03.2004 and 28.07.2004. Yields were recorded as picking proceeded but data related to roots were collected at the time of the last picking. To evaluate the effects of the treatments on the nematode, three root and related rhizosphere soil samples were collected randomly from each plot. The soil was mixed and an aliquot of 200 cm^3 was processed as mentioned earlier. The roots were washed free of soil and root gall index was rated according to a 1-5 scale (1 = no galls and/or egg masses, 2 = 1-10, 3 = 11-30, 4 = 31-100 and 5 >100 galls and/or egg masses per plant). Data were statistically analyzed and means compared according to Duncan's Multiple Range Test at the 5% level of probability. The pooled data for the two years were also subjected to correlation and regression analysis.

An economic analysis was also made. The value of the yield increase over the control and the cost of the treatments were estimated based on prices in the local market. From this information, the yield gain/treatment cost ratios were calculated.

RESULTS AND DISCUSSION

Dipping vines in carbosulfan 25 EC at 500 ppm for 6 hrs + carbofuran 3G at 2.5 g/pit 45 days after planting (DAP) (T_8) resulted in the greatest plant survival in both years, some 55.6 and 41.9% greater than the untreated check in the two years respectively (Table I). Significantly more plants also survived when neem cake at 50 g/pit was applied at planting alone (T_6) or combined with 2.5 g/pit of carbofuran 45 DAP (T_7), but only in the first year. These results differ from those of Verma *et al.* (1998), who found neem cake at 250 g/m^2 to be the best treatment. Fresh root weight was not affected by any of the treatments in 2002-2003, but it was increased by most of the treatments in 2003-2004. A similar trend occurred with dry root weight, with T_8 giving the greatest root weight. All treatments significantly increased the yield of pointed gourd in the first year but only dipping of vines in carbosulfan followed by application of carbofuran 45 DAP (T_8) increased yield in the second year; this treatment resulted in the greatest yield increase in both years, mainly due to an increase in the number of fruit per plot (Table II). In general, no treatment affected girth and length of fruits except for the broadcast application of carbofuran at

Table III. Effect of treatments on root gall index of pointed gourd and soil population density of *M. incognita* and *M. javanica* at the last harvest in 2002-03 and 2003-04 (Average of four replications).

Treatment	Gall index*		Nematode juveniles /200 cm^3 soil**	
	2002-03	2003-04	2002-03	2003-04
T_1: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs	4.2 ab***	3.3 c	66 e	232
T_2: Vines dipped in monocrotophos 36EC at 500 ppm for 6 hrs	3.6 abc	4.8 a	108 d	247
T_3: Carbofuran 3G, 2 kg a.i./ha at planting (broadcasting)	4.4 a	4.4 ab	138 bc	192
T_4: Carbofuran 3G, 2.5 g/pit at planting	3.4 bc	4.6 a	190 a	182
T_5: Neem cake, 1500 kg/ha at planting (broadcasting)	3.3 bc	4.8 a	155 b	237
T_6: Neem cake, 50 g/pit at planting	3.2 c	3.4 c	117 cd	139
T_7: Neem cake, 50 g/pit at planting + carbofuran 3G 2.5 g/pit 45 DAP	4.2 ab	3.5 bc	162 b	134
T_8: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs + carbofuran 3G 2.5 g/pit 45 DAP	2.2 d	3.3 c	107 d	113
T_9: Untreated control	3.3 bc	4.8 a	160 b	257
S.Em ±	0.3	0.3	9.4	94.6
$C.D_{\text{ at 0.05}}$	0.85	0.92	27.4	NS

* Gall Index: 1 = no galls/egg masses, 2 = 1-10, 3 = 11-30, 4 = 31-100 and 5 = >100 galls/egg masses.
** Initial nematode population was 232/200 cm^3 of soil in 2002-03 and 268/200 cm^3 of soil in 2003-04.
*** Figures marked by a common letter are not significantly different according to Duncan's Multiple Range Test at $P < 0.05$.

planting (T_3) in the second year (Table II). Verma and Anwar (1999) observed that application of carbofuran 3G at 2 kg a.i./ha at planting increased fruit yield by 22.7% over the control. In contrast, in our experiment, dipping vine cuttings in carbosulfan 25 EC at 500 ppm for six hours plus addition of carbofuran 3G at 2.5 g/pit at 45 DAP was the most effective treatment as it increased yield by 36.81% (pooled results) over the untreated control. The performance of neem was equal to that of T_8 in the first year but it did not increase yield in the second year.

The root gall index was significantly reduced by treatment T_8 in both years and only in the second year by application of neem cake at 50 g/pit at planting alone (T_6) or combined with carbofuran 45 DAP (T_7) and by dipping vines in carbosulfan (T_1) (Table III). Mahapatra *et al.* (1999) found that bare root dipping in carbosulfan at 0.05% for six hours was the most effective treatment. Moreover, Verma and Anwar (1997) reported that neem cake was as effective as carbofuran 3G at two kg a.i/ha in reducing root galling. Our trial agrees with the findings of the mentioned authors and in addition shows that dipping vines in carbosulfan followed by soil application of carbofuran (T_8) is even more effective for managing root-knot nematodes in pointed gourd. Most of the treatments significantly suppressed nematode population density in the first year, while a general suppression of nematode population density was observed in the second year with no difference between treatments (Table III). However, the method we used to extract nematodes from the soil does not extract eggs, which may represent a large proportion of the soil nematode population at harvest of the crop. Therefore, the actual nematode population could have been much larger than that reported in Table III.

A correlation matrix and multiple regression analysis (Table IV) showed that the correlation coefficients between the variables measured were significant. It is noteworthy that correlation coefficients between root-knot nematode gall index and all growth and yield parameters recorded, except fruit girth, were significantly negative, thus suggesting that the observed yield increases were due to nematode control by the treatments.

The economic analysis, made on pooled yield data of the two years, clearly shows that all treatments gave yield gain over control. However, the largest gain was obtained with treatment T_8, while the ratio between the additional benefit and the additional treatment cost was largest for treatment T_2, followed by the treatments T_1 and T_8 (Table V).

Table IV. Correlation between plant stand, fruit number, root gall index and yield of pointed gourd[a].

Correlation coefficient (r)						
Variable	Plant stand/ plot (X_1)	Fruit number/ plot (X_2)	Fruit girth (X_3)	Fruit length (X_4)	Gall index/ plot (X_5)	Yield/plot (X_6)
X_1	1.00					
X_2	0.894389*	1.00				
X_3	0.806099*	0.910726*	1.00			
X_4	0.967088*	0.961267*	0.866468*	1.00		
X_5	-0.88889*	-0.74144*	-0.59508^{NS}	-0.87529*	1.00	
X_6	0.92479*	0.986611*	0.930413*	0.971593*	-0.76293*	1.00
Regression equation						
**Y = -9.41 + 0.18X_1 + 0.02 X_2 + 0.59X_3 + 0.77X_4 + 0.13X_5						
R^2 (Coefficient of Determination)	0.99					
Adjusted R^2	0.97					
Standard Error	0.17					

[a] Calculation based on pooled data of 2002-03 and 2003-04; * Significant at $P < 0.05$; **Y = Yield/plot; NS = Not significant

Table V. Economics of the treatments tested for the control of *M. incognita* and *M. javanica* in pointed gourd*.

Treatment	Fruit yield (q/ha)	Gain in yield over control (q/ha)	Value of additional yield (Rs./ha)	Cost of treatment (Rs./ha)	Additional gain for treatment** (Rs./ha)	Additional benefit/ Additional cost
T_1: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs	166.6	18.8	11,305	1,348	9,957	8.4
T_2: Vines dipped in monocrotophos 36EC at 500 ppm for 6 hrs	173.5	25.8	15,470	1,298	14,172	11.9
T_3: Carbofuran 3G, 2 kg a.i./ha at planting (broadcasting)	181.9	34.1	20,485	4,411	16,074	4.6
T_4: Carbofuran 3G, 2.5 g/pit at planting	170.7	23.0	13,770	4,597	9,173	3.0
T_5: Neem cake, 1500 kg/ha at planting (broadcasting)	174.1	26.4	15,810	14,998	812	1.0
T_6: Neem cake, 50 g/pit at planting	176.0	28.2	16,915	13,600	3,315	1.2
T_7: Neem cake, 50 g/pit at planting + carbofuran 3G 2.5 g/pit 45 DAP	181.8	34.0	20,400	17,449	2,951	1.2
T_8: Vines dipped in carbosulfan 25EC at 500 ppm for 6 hrs + carbofuran 3G 2.5 g/pit 45 DAP	202.2	54.4	32,640	5,021	27,619	6.5
T_9: Untreated control	147.8	-	-	-	-	-

* Calculation based on pooled yield data of 2002-03 and 2003-04 presented in Table II.
* Cost of labour @ Rs. 62/- per man-day and price of pointed gourd @ Rs. 600/- per quintal in local market.
N.B.: 1 INR = 0.022650 US$ or 0.019059 € as on 15.02.2006.

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