

TO DETERMINE THE POPULATION DYNAMICS OF CITRUS NEMATODES (*TYLENCHULUS SEMIPENETRANS*) AND ITS CHEMICAL CONTROL

Nazir Javed, Muhammad Azhar Iqbal, Riaz Ahmed Chohan

**Pest Warning and Quality Control of Pesticides, Department of Agriculture, Sargodha.*

** *Pakistan Science Foundation, Islamabad.*

Department of Plant Pathology, U.A. Faisalabad.

Abstract

The maximum number of *Tylenchulus semipenetrans*/500g of soil were observed at the depth of 20 cm. Above and below this depth, the nematode population was less except in the month of July, August and January when the temperature was 38°C, 39°C and 15-17°C respectively, the population of citrus nematode was high at 30cm depth. The female nematode population remained high in the month of May and November when temperature was 27°C. The lowest number of nematodes was found at the depth of 10cm. The effect of five nematicides viz; Furadon, Advantage, Rugby, Basudine and Unihypo was studied against *Tylenchulus semipenetrans* population densities on kinow mandarin yield during a two-year experiment in citrus orchard at Sargodha. The experiment was conducted in two sets, one on slightly diseased trees and other on highly diseased trees. Two applications of each nematicide, with one year between applications at the rate of 2g a.i./m² reduced nematode population to undetectable level and increased the yield of kinow mandarin. The maximum increase in yield was obtained with Rugby followed by Advantage, Furadon and Basudine, respectively. Unihypo remained the least effective.

INTRODUCTION

Citrus occupies a prominent position in fruit industry of the world. It is grown in more than 125 countries in a belt within 35° latitude north or south of the equator. Pakistan is among the leading citrus growing countries of the world and earns substantial amount of foreign exchange annually. In Pakistan, citrus is the largest group of fruits produced over an area of 194.2 thousands hectares with an annual production of 1830.3 thousands tons (Anonymous, 2003).

Numerous nematode species have been found are associated with the citrus rhizosphere (Cohn, 1972). To date, however, relatively few have been shown to be of economic importance. With the exception of *Tylenchulus semipenetrans* Cobb, most nematode species capable of damaging

mature citrus which may be due to edaphic conditions or due to the natural distribution of a particular nematode.

In citrus plantings, symptoms development progressed slowly as nematode population developed to high levels (Cohn and Minz, 1965). Characteristic symptoms associated with highly infested trees were: poor root development, smaller and chlorotic leaves. In highly saline conditions, excessive sodium may accumulate in leaves (Van Gundy & Martin 1961, Heald & O'Bannon 1987). Wilting occurring earlier during period of water stress and leaf drop was more pronounced producing exposed branch terminals. Heavily infected feeder roots are slightly thicker than healthy roots and have a dirty appearance due to soil

particles that adhere to gelatinous egg masses on the root surface.

Soil moisture and temperature favorable for growth of citrus are equally favourable for nematode development and reproduction. However, certain environmental conditions may directly or indirectly influence nematode development. The citrus nematodes occur over a wide range of soil conditions through out the world. Certain soil factors readily influence infection and reproduction. In general, citrus nematode invasion and reproduction is slower in very sandy and coarse-textured soils than in other soil types (Baines 1974, O'Bannon 1968, Van Gundy and Kirkpatrick (1964).

Citrus nematode causes heavy losses and therefore, efficient control measures are required to alleviate this effect. Among different nematode management strategies, chemical control has proved generally effective no doubt, but majority of the chemicals are highly expensive and often hazardous to use.

MATERIALS AND METHODS

To study the effect of seasonal fluctuation on the population dynamics of citrus nematodes, a 20-years old citrus orchard was selected at Sargodha. Soil and root samples were collected at 15-day intervals from March 2001 to February 2002. Soil samples were taken with the help of a trowel, weighing about 500 g of soil from a depth of 10, 20 and 30 cm and 120 cm away from the trunk.

Samples of feeder roots were taken at a distance of 120 cm from tree trunk. Soil temperature was recorded at the time of sampling. The samples were brought to the laboratory and placed in cool incubator at 15°C to keep the material fresh. The second stage juveniles were isolated from each sample by using Whitehead and Hemming (1965) tray method.

One gram of feeder roots from each sample was taken out and after careful washing in running tap water, stained in acid fuchsin lactophenol. The roots were macerated in root blender for 30 seconds. Samples were sieved at 100 and 325 mesh into a beaker. The material was centrifuged to concentrate the females in a volume of 10 ml. The suspension was placed in a counting dish and observed under a dissecting microscope. Final calculations were expressed as the number of females per gram of roots.

The experiment was designed in a citrus orchard, at Sargodha naturally infested with *T. semipenetrans* having 20-25 years old kinnow trees at Sargodha. The rootstock used was rough lemon. The experiment was started in October 2000 in two groups with five nematicides viz, Furadon, Advantage, Rugby, Basudine and Unihypo. In the first group, highly infested trees with slow decline were selected. Treatments were replicated five times and arranged in a randomized complete block design. The treated trees were alternated with untreated trees. The nematicides were distributed evenly from the drip line to the trunk of tree at the rate of 2g a.i. per m². The nematicides were hand raked in the top 2.5 cm of soil and the orchard was flooded with water. Irrigation by flooding continued at irregular intervals, as needed.

The experiment was conducted in the same manner with slightly affected trees with slow decline. Pretreatment and post treatment nematode population densities were estimated by counting the number of juveniles and females extracted from feeder roots and from soil. Soil and roots were taken from the top 30 cm of soil from the north, east, south and west sides of each tree, 30 to 60 cm inside the drip line just before and after one year of each application. The samples were brought to the laboratory and placed in cool incubator

at 15°C to keep the material fresh. The second stage juveniles were isolated from each sample by using Whitehead and Hemming (1965) tray method and counted under stereoscope as number of juveniles per 500g of soil.

One gram of feeder roots from each sample was taken out and after careful washing in running tap water, stained in acid fuchsin lactophenol. The roots were macerated in root blender for 30 seconds. Samples were sieved at 100 and 325 mesh into a beaker. The material was centrifuged to concentrate the females in a volume of 10 ml. The suspension was placed in a counting dish and observed under a dissecting microscope. Final calculations were expressed as the number of females per gram of roots.

The yield data was collected at the harvest; all the fruit from each tree was removed in a single picking in February and weighed. The experiment was repeated next year in the same manner.

RESULTS

The result reveals that nematode population differs significantly at the depth of 10 cm, 20 cm, and 30 cm. The maximum nematode population was observed at the depth of 20 cm through out the year except the months of August, September and January. The nematode population also differs significantly at different temperatures and the maximum number of nematodes was observed at 27°C. (Table-I).

The female nematode populations in most of the cases also differ significantly at different temperatures. The maximum number of female nematodes was observed at 27°C.

Evaluation of different nematicides against citrus nematode, *T. semipenetrans* on highly diseased trees

The nematode population (Table 3) reveals that all the nematicides significantly decreased the nematode population after the first application. But the difference between 2nd and 3rd year remained non-significant. Rugby showed the best control followed by Advantage, Furadon and Basudine. Unihypo remained the least effective. None of the nematicides gave 100 % control of nematodes.

The results (Table 2) revealed that all the nematicides significantly reduced the number of female nematode population after 1st and 2nd treatment. Rugby treated trees showed significantly less number of females of *T. semipenetrans* followed by Furadon, Advantage and Basudine. Unihypo remained the least effective.

The yield data of the treated trees in the 1st, 2nd and 3rd year indicates that a significant increase in yield was obtained in the 3rd year where Rugby was applied. The increase in yield due to Furadon and Basudine remained non-significant. The increase in yield from 1st to 2nd year remain non significant in all the cases (Table 6).

Effect of various nematicides against citrus nematode, *T. semipenetrans* on slightly diseased trees

All the nematicides significantly reduced the number of citrus nematodes after the 1st application, while decrease in nematode population remained non-significant after 2nd application. Rugby showed the best results followed by Advantage, furadon and Basudine. All the treatments differ significantly from the control, but did not differ significantly from each other.

The result reveals that all the nematicides significantly reduced the number of female citrus nematode/g of root after the 1st and 2nd application. Rugby

showed the best results followed by Advantage, Basudine and Furadon. Unihypo remained the least effective. None of the nematicides gave 100% control (Table 5).

The results in the Table 5 reveal that Rugby significantly increased the yield from 1st year to 3rd year. The increase in yield among the other nematicides remained non significant. The difference in average yield among all the treatments remained non significant.

DISCUSSION

The citrus nematode, *T. semipenetrans* was found through out the year in soil and roots of citrus trees. The population of *T. semipenetrans* in roots increased from March to May and significantly decreased in June with minimum in July (38.5°C) and August (37.5°C). The population again increased from September to November with highest population in November (27°C) and minimum in January (15°C) due to extremely high and low temperatures. The similar results have been reported by Hussain *et al.* (1981), Smolik (1982), Chawla & Sharma (1984), Davis (1984), Mangat & Bhatti (1988), Seghal *et al.* (1991) and Ahmed *et al.* (1992).

The population of citrus nematode in the soil at 10 cm depth was very low as compared to the population at soil depth of 20 cm and 30 cm. The population of nematodes increased with increasing the depth of soil up to 20 cm, so the population was the highest at 20 cm depth through out the year as maximum feeder roots and soil activities occur at this depth (Chawla & Sharma 1984). In June (36°C), July (38.5°C) and August (37.5°C) when temperature was maximum, the greater population of nematodes was recorded at 30 cm soil depth due to downward movement of nematodes (Chanbey & Malhotra, 1988). In January-February the activities of nematodes were again checked due to low temperature. In

citrus, feeder roots develop twice in the year, first in April, May and then in October- November and maximum population was observed in these months. The temperature suitable for root growth is also favourable for the penetration and infection of nematode (Baines, 1974). Maximum population of *T. semipenetrans* was recorded at 27°C both in soil and roots as shown in the table and progressive decrease occurred in nematode population as the temperature increased or decreased above or below 27°C.

The seasonal fluctuations seem to play an important role in the development of effective management strategies for nematode population around the citrus population.

The effect of the five nematicides, furadon, advantage, rugby, basudine and unihypo @ 2g a.i./m² was studied in field conditions on highly and slightly diseased trees. The data collected for three years starting from October 2000. One week before the treatment up to October 2002 in the same month after one year of the application of nematicides to estimate the effect on population densities of the citrus nematode. The last application was given in October 2001. All the nematicides significantly decrease the number of juveniles and males /500g of soil from the number of nematodes before treatment and also from the control. The second application further decrease the number of nematodes /500g of soil but difference of nematode population densities between first and second treatment remained non significant. This indicates that the nematodes could not maintain the population even after one year. However, none of the nematicides gave the 100% control. Novaretti *et al.* (1991) studied the effect of carbosulfan 5G and Cadusafos 10G against citrus nematode and found that all the treatments controlled *T. semipenetrans*.

These results are in conformity with those concluded by, Harris (1982), Davis (1985), Stirling and Wachtel (1987), Childers *et al.*, (1987), Martinez *et al.*, (1987), Greco *et al.*, (1993), McClure & Schmitt (1996), Le Roux *et al.*, (1998).

All the treatments significantly decreased the number of females of *T. semipenetrans* as compared to control. The second treatment also significantly decreased the female nematode population. After the first application, the effect of rugby and furadon remained statistically same. After the second application, rugby showed significantly better results than the other nematicides while furadon and advantage remained statistically at par. It indicates that all the nematicides reduced the number of females per gram of soil, even after one year the female population was less however, none of them eliminated the females from the roots of the trees. Davis and Heald (1982), Spiegel *et al.* (1989) described the effect of chitin against citrus nematode and observed a reduction of 50-90 % in *T. semipenetrans* population densities on roots of citrus rootstocks.

The three-year data before and after the application of furadon, advantage, rugby, basudine and unihypo reveal that the increase in yield after one year of application remained non-significant. After one year of second application, the increase in yield again remained non-significant except rugby which significantly increased the yield. Rabe and Sweelam (1990) showed the effect of potassium nematicide and their contributions in relation to absorption of potassium, population of citrus nematode and yield of mandarin (*Citrus reticulata*). K_2SO_4 at 1.8kg/tree/year gave the highest yield (kg/ tree) among treatments. An increase in K nutrition decreased the population of citrus nematode in the roots and soil. The combination of the nematicide and K nutrition treatment sharply

decreased the population of the nematode. Philis (1997) reported that fenamiphos and aldicarb gave the effective control of *T. semipenetrans* and significantly increased the yield of citrus. These results are in line with Stirling and Wachtel (1987), Childers *et al.* (1987).

The effect of furadon, advantage, rugby, basudine and unihypo was also studied on slightly diseased plants. All the nematicides significantly decreased the nematode population in soil after the first application but decrease after the second application remained non-significant in all the cases. A significant decrease in female nematode population was also observed in all the treatments. Rugby showed the best results, however none of the nematicides eliminated the nematodes from soil and roots. In control the decrease in nematode population after one year, both in soil and in roots was observed which might be attributed to environmental factors and there was again increase in nematode population in the second year.

The effect of nematicides was also observed on the yield. Only rugby significantly increased the yield of citrus after the second treatment, but the difference of yield between the treatments remained non-significant. These results are similar to that in which nematicides were applied on highly diseased plants. These results are in conformity to those of , Harris (1982), Davis (1985), Stirling and Wachtel (1987), Childers *et al.*, (1987), Martinez *et al.*, (1987), Greco *et al.*, (1993), McClure & Schmitt (1996), Le Roux *et al.*, (1998).

Table-I Effect of seasonal fluctuation, on population dynamics of citrus nematode, *T. semipenetrans*.

Month	Soil Temperature (°C)		Nematode population in 500 gm of soil at depth of			No. of females per gram of root
			10 cm	20 cm	30 cm	
March 01	T ₁	23	250 z[	2576 n	2257 o	1450 F
	T ₂	24	365 wxyz	3955 k	3436 l	1514 F
April 01	T ₁	25	987 s	5342 h	4265 j	1828 D
	T ₂	26	1454 q	8587 e	6384 g	1976 C
May 01	T ₁	27	3436 l	12125 a	10547 c	2479 A
	T ₂	29	3118 m	11736 b	9739 d	2408 B
June 01	T ₁	35	185 [v]	2570 n	2596 n	1502 F
	T ₂	37	67 \]^	1285 r	587 u	670 G
July 01	T ₁	38	35]^	570 u	465 uvwx	320 I
	T ₂	39	13 ^	432uvwx	474 uvwx	87 KL
August 01	T ₁	38	14 ^	43]^	469 uvwx	80 KL
	T ₂	37	17 ^	435uvwx	497 uvw	142 K
Sep. 01	T ₁	34	215 z[\	515 uvw	598 u	295 J
	T ₂	34	234 z[	520 uvw	1795 p	301 J
October 01	T ₁	31	762 t	1817 P.	1863 p	596 H
	T ₂	30	885 st	4522 I	10508 c	1470 F
Nov. 01	T ₁	27	3512 l	12130 a	7476 f	2480 A
	T ₂	26	3498 l	1187 r	3935 k	2475 A
Dec. 01	T ₁	22	1807 p	4527 I	1008 s	1626 F
	T ₂	20	546 uv	1276 r	287 yz[	470 I
January 02	T ₁	16	35]^	305 xyz[	261 z[	52 L
	T ₂	15	22]^	275 yz[	530 uvw	36 L
February 02	T ₁	17	42]^	565 u	865 st	435 I
	T ₂	19	377 vwxyz	996 s	865 st	590 H

T₁ = First day of the month. T₂ = Sixteenth day of the month P= 0.05

Means with similar letters do not differ significantly by LSD = 143.0, 56.76

Table 2. Comparison of female nematodes/g roots regarding the treatment of nematicides against *T. semipenetrans* on highly diseased trees.

Treatments	Mean no. of females in Oct.2000	Mean no. of females in Oct. 2001	% decrease over control	Mean no. of females in Oct.2002	% decrease over control
Control	1582 a	1378 b	0.00	1603 a	0.00
Furadon	1553 a	758.4 ef	51.16	543.2 g	65.02
Advantage	1538 a	790.6 e	48.59	609.6 g	60.36
Rugby	1627 a	644.4 fg	60.39	354.0 h	78.24
Basudine	1645 a	1125 c	31.61	744.8 ef	54.72
Unihypo	1578 a	1202 c	23.82	989.6 d	37.28
LSD	123.2				

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

Table 3. Comparison of mean number of nematodes/500g of soil, before and after the application of nematicides when applied on highly diseased trees.

Treatments	Mean no. of nematodes in Oct.2000	Mean no. of nematodes in Oct. 2001	% decrease over control	Mean no. of nematodes in Oct.2002	% decrease over control
Control	5714 bc	5936ab	0.00	6564 a	0.00
Furadon	5333 bc	414.6 f	92.22	233.8 f	95.61
Advantage	4437 d	207.6 f	95.32	106.2 f	97.60
Rugby	5127 cd	231.6 f	95.48	95.0 f	98.14
Basudine	6042 ab	663.0ef	89.02	369.6 f	93.88
Unihypo	5430 bc	1237 e	77.21	759.6 ef	86.01
LSD	721.7				

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

Table 4. Comparison of mean number of nematodes/500g of soil, before and after the application of nematicides on slightly diseased trees.

Treatments	Mean no. of Nematodes In Oct.2000	Mean no. of nematodes in Oct. 2001	% decrease over control	Mean no. of nematodes in Oct.2002	% decrease over control
Control	5186 b	3122 c	39.79	6214 a	-19.82
Furadon	5018 b	533.8 de	89.36	331.6 e	93.39
Advantage	5250 b	432.6 de	91.76	274.2 e	94.77
Rugby	5453 b	253.0 e	95.36	167.4 e	96.93
Basudine	5385 b	706.6 de	86.87	347.8 e	93.54
Unihypo	5011 b	996.8 d	80.10	784.8 de	84.33
LSD	557.8				

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

Table 5. Comparison of female nematodes/g of roots regarding the treatment of nematicides against *T. semipenetrans* on slightly diseased citrus trees.

Treatments	Mean no. of females in Oct.2000	Mean no. of females in Oct. 2001	% decrease over control	Mean no. of females in Oct.2002	% decrease over control	
Control	1486 a	1183 b	2.4	1530 a	-2.96	
Furadon	1541 a	752.4 de	51.17	635.2 e	58.78	
Advantage	1564 a	793.4 d	49.27	306.6 g	80.39	
Rugby	1528 a	501.4 f		67.18	167.4 h	89.04
Basudine	1532 a	1048 c	31.59	505.2 f	67.02	
Unihypo	1494 a	1182 b	20.88	930.4 c	37.72	
LSD	125.6					

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

Table 6. Mean yield of citrus in kg/tree from the year 2001-2003 in highly diseased trees

Treatment	Mean yield Feb. 2001	Mean yield Feb. 2002	% increase over Control	Mean yield Feb. 2003	% increase over control
Control	23.60 def	21.60 ef	0.00	22.80 def	0.00
Furadon	20.20 f	21.60 ef	6.93	26.00 de	28.71
Advantage	29.00ab	28.20abc	-2.75	32.60 a	12.41
Rugby	21.80 ef	23.40 def	7.33	32.60a	49.54
Basudine	23.20 def	24.40bcdef	5.17	27.40bcd	18.10
Unihypo	20.20f	20.60 ef	1.98	23.60 def	16.83
LSD	4.717				

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

Table 7. Mean yield of citrus in kg/tree from the year 2001-2003 in slightly diseased trees

Treatment	Mean yield Feb. 2001	Mean yield Feb.2002	% increase over Control	Mean yield Feb. 2003	% increase over control
Control	62.60 abcd	62.00 abcd	0.00	62.40 abcd	0.00
Furadon	64.40 abcd	66.20 abcd	-2.79	70.20 a	9.00
Advantage	61.60 abcd	62.00 abcd	0.64	70.00 a	13.63
Rugby	60.00 bcd	61.60 abcd	2.66	71.00 a	18.33
Basudine	57.60 d	58.00 cd	0.69	62.00 abcd	7.63
Unihypo	67.80 abc	68.80 a b	1.47	69.00 ab	1.76
LSD	8.630				

Data are means of five replicates.

Means with similar letters do not differ significantly by LSD test (P= 0.05).

REFERENCES

- Ahmed R., M. Z. Kayani, M. Inam-ul-Haq and N. Javed. 1992. Effect of seasonal fluctuations on the population dynamics of citrus nematode (*Tylenchulus semipenetrans* Cobb). *Second Int. workshop plant Nematol.* 22-26 November. *National Nematological Research Centre, University of Karachi, Karachi*: 33-37.
- Ahmed, R. and H. Khan., 1999. Citrus slow decline. Problems and Progress in the Punjab. *Natl. Conference of Plant Pathol.*, Sept. 27-29. *Univ. Agric. Faisalabad* : 20-23.
- Anonymous. 2002-2003. *Agricultural Statistics of Pakistan. Ministry of Food, Agric. and Coop. Govt. Pak. Food Agric. Div. Planning unit, Islamabad.* pp 89.
- Baines, R.C. 1974. The effect of soil type on the movement and infection rate of larvae of *Tylenchulus semipenetrans*. *J. Nematol.* 6(2): 61-62.
- Chanbey, A.K. and S.K. Malhotra. 1988. An account of possible role in phyto-nematodes as indicators of drought conditions. *Natl. Symp. Treated Habitates, India.* 31 Jan.-2 Feb., 1988.
- Chawla, M.L. and S.B. Sharma. 1984. Horizontal and vertical distribution of citrus nematode, *Tylenchulus semipenetrans*. *Ind. J. Nematol.* 14: 193-195.
- Childers, C.C., L.W. Duncan, T.A. Wheaton, and L.W. Timmer. 1987. Arthropod and nematode control with aldicarb on Florida citrus. *J. Eco. Entomol.* 80(5): 1064-1071.
- Cohn, E. 1972. Nematode diseases of citrus. *Eco.. Nematol. Academic Press, London*: 215-244.
- Cohn, E., and G. Minz, 1965. Application of nematicides in established orchards for controlling the citrus nematode, *Tylenchulus semipenetrans* Cobb. *Phytopath. Medit.* 4: 17-20.
- Davis, R.M. 1985. Citrus nematode control. *Am. Nematol. Soc.* 40: 112.
- Davis, R.M., and C.M. Heald .1982. Evaluation of nematicides for the control of citrus nematode in Texas grapefruit. *Am. Phytopathol. Soc.* 39: 95-96.
- Davis, R.M. 1984. Distribution of *Tylenchulus semipenetrans* in Texas grape fruit orchard. *J. Nematol.* 16: 313-317.
- Greco, N, M. Basile, T.D, Addabbo and A. Brandonisio 1993. Influence of Aldicarb and Fenamiphos on *Tylenchulus semipenetrans* population densities and orange yield. *J. Nematol.* 25(4S): 768-772.
- Hussain, S.I., H.Y. Muhammad, and A.J. Al-Zarai. 1981. Studies on the vertical distribution and seasonal fluctuation of the citrus nematode in Iraq. *Nematol. Medit.* 9: 7-19.
- Harris, A. R. 1982. Control of root-knot and citrus nematodes in nursery soil. *American Phytopathol. Soc. 39, 91 Dept. Agric. Sunraysia Hortic. Res. Inst. Irymple, Victoria.* 3498.
- Heald, C. M. and J.H. O'Bannon, 1987. Citrus declines caused by nematodes. V. Slow decline. *Florida Depart. Agric. consumer Servic. Div. plant industry, Nematol. circular.* 143:4.
- Le Roux, H.F., A.B. Ware, and M.C. Pretorius. 1998. Comparative efficacy of pre-plant fumigation and post-plant chemical treatment of replant citrus trees in an orchard infested with *Tylenchulus semipenetrans*. *Plant Disease* 82:1323-1327.
- Martinez-Beringola, M.L., A. Carceles, and M.P. Gutierrez. 1987. Nematicide trials against the nematode of citrus, *Tylenchulus semipenetrans*. *Ensayos de*

- nematicidas contra el nematodo de los agrios, *Tylenchulus semipenetrans*. *Boletín de Sanidad Vegetal, Plagas* 13(3): 261-271.
- McClure, M.A., and M.E. Schmitt .1996. Control of citrus nematode. *Tylenchulus semipenetrans*, with cadusafos. *J. Nematol.* 28(4S): 624-628.
- Mangat, B.P.S. and D.S. Bhatti .1988. Effect of temperature and soil type on the recovery of 2nd stage juveniles of citrus nematode, *T. semipenetrans* . *Int. Nematol. Network Newsl.* 5(2): 6-7.
- Novati, W.R.T., D. Tihohod, A.D. Paulo, and A.A.P. Novaretti. 1991. Carbosulfan 5G and cadusafos 10G, control of citrus nematode. *Nematologia Brasileira* 15(2): 196-198.
- O'Bannon, J.H. 1968. The influence of an organic soil amendment on infectivity and reproduction of *Tylenchulus semipenetrans* on two citrus rootstocks. *Phytopath.* 58: 597-601.
- Philis, I. 1997. Effect of citrus nematode control on the yield and fruit quality of grapefruit in Cyprus. *Nicosia : Cyprus*, No. 66: 6.
- Rabeh, M.R.M., and M.E. Sweelam, 1990. Efficacy of potassium, nematicide and their combination in relation to absorption of potassium, population of citrus nematode (*Tylenchulus semipenetrans*) and yield of mandarin (*Citrus reticulata*). *Indian Jour. Agric. Sci.* 60(1): 52-55.
- Spiegel, Y; E. Cohn and I. Chet, 1989. Use of chitin for controlling *Heterodera avenae* and *Tylenchulus semipenetrans*. *J. Nematol.* 21(3): 416-422.
- Stirling, G.R. and M.F. Wachtel. 1987. Effects of nematicides on citrus nematode (*Tylenchulus semipenetrans*) and the yield of citrus in South Australia. *Agric. Record* 12(17): 6-11.
- Seghal, M., M.L. Chawla, S. Singh, and K. Balakrishnan .1991. Studies on interactive effect of moisture and temperature on *Tylenchulus semipenetrans*. *Current Nematol.* 1: 35-36.
- Smolik, J.D. 1982. Effect of soil moisture or soil temperature on reproduction of indigenous nematode populations in a mixed prairie. *Prairie Nature List.* 14:61-67.
- Van Gundy, S. D., and J.P. Martin, 1961. Influence of *Tylenchulus semipenetrans* on the growth and chemical composition of sweet orange seedlings in soils of various exchangeable cation ratio. *Phytopathol.* 51:146-151.
- Van Gundy, S.D., and J.D. Kirkpatrick .1964. Nature of resistance in certain citrus rootstocks to citrus nematode. *Phytopath.* 54: 419-427.