

## STUDIES ON SURVEYING NEMATODES, HOST SUITABILITY AND CONTROL OF *Meloidogyne incognita* ON GRAPEVINE BY CERTAIN COMPOUNDS WITH REFERENCE TO NEMATODE INFESTATION AND YIELD.

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### ABSTRACT

Percentage of frequency occurrence, population density and prominence value were determined for the plant parasitic nematodes associated with some grape varieties in Behira governorate. Data revealed that stunt nematodes *Tylenchorhynchus* spp. and the root knot nematode *Meloidogyne* spp. were found with highest prominence value on Flame, King-Ruby, Perlette, Superior and Thompson varieties as compared to other nematode genera. Host suitability of varieties Early Superior, Flame, King Ruby, Perlette, Superior and Thompson to infection of root-knot nematode *M. incognita* was tested under greenhouse conditions. The varieties Early Superior, Flame and Superior were rated as susceptible hosts. The relationship of grapevine yield to *M. incognita* densities was studied. Five grapevine varieties were tested to carry out the experiment in South Tahrir. Association between *M. incognita* densities and yield was variable, even when the vines were separated according to vigor of vines, varieties and yield. The highest density of *M. incognita* was associated with the medium yield while the low densities of *M. incognita* associated with the low production of all varieties except Thompson variety. The result showed that the high production trees were more infected than low production trees in the same variety as shown with King Ruby and Flame. Biological treatments i.e. Diple 2x, EM1 and mycorrhizal fungi (*Glomus* spp.) as well as certain organic soil amendments namely chopped garlic cloves, (*Allium sativum*) and dried powdered leaves and stems of liquorice (*Glycyrrhiza glabra* L.) and chamomile (*Matricaria chamomile*) were examined for controlling *M. incognita* infecting Superior variety. Results indicated that all treatments showed significant effect in reduction of galling and reproduction of *M. incognita* on grapevine as compared to untreated trees. However the application of chopped garlic cloves at the rate of 80 gm/ tree gave the highest reduction in galling and reproduction of *M. incognita* was followed by mycorrhizal fungi (*Glomus* spp.) at the rate of 1ml/ 100ml water as compared to control treatment while the least effect was recorded with dried powder of chamomile plant at the rate of 40 gm / tree . The most tested treatments significantly reduced nematode reproduction of *M. incognita* in soil and roots of grapevine cv. Superior compared to the untreated check.

**Keywords:** Grapevine, *Meloidogyne incognita*, Survey , host- suitability, infestation and yield and control.

### INTRODUCTION

Grapevine (*Vitis vinifera* L.) is considered one of the most important economic fruit crops in Egypt. Plant parasitic nematodes especially root-knot nematodes are known as pests of grapevine mainly in tropical and subtropical areas of the world. The root – knot nematode *Meloidogyne* spp. have been recognized as a potential serious problem to the grapevine productivity. The effect of *Meloidogyne* spp on the growth and yield of vine

yards was studied in Egypt (EL-Gindi *et al.*, 1976). (Anonymous, 1986) indicated that nematodes are a particular problem in grapes.

Many attempts has been conducted in most grape production areas around the world to assess the amount of damage caused by nematodes. The root-knot nematodes *M.incognita*, *M. javanica*, *Tylenchorhynchus* spp., *Tylenchulus semipentrans*, *Xiphinema americanum* and *Helicotylenchus* spp. were recorded associated with grapevine at high frequencies occurrence and population densities (Riad, 1982a; Loubser and Meyer, 1988a). Suitability of grape varieties to root - knot nematode *M. incognita* infection was studied by many investigators. The varieties King Ruby, Flame Superior and Romy Ahmer were susceptible, while Cleoptra and Thompson varieties were rated as resistant and moderately resistant respectively . (Riad *et al.*, 1982b; Melakeberhan and Ferris, 1987and Mahmoud, 2003). These studies also were oriented to determine the relation ship of grapevine yield to root knot nematode, *M. incognita* densities (Ferris and Mckenry, 1975; Quader *et al.*, 2002; and Korayem, 2006).

The use of chemicals to control phytoparasitic nematodes has always been an expensive remedy and may also reduce populations of beneficial antagonistic microorganisms in soil. However, great interest has given among nematologists to use alternative nematode management practices because of environmental and health problems associated with nematicide use. The nematicidal activity of certain plant products applied in soil as organic amendment including medicinal plant were suppressed the build up of root – knot nematode *M. incognita* (Gupta and Sharma, 1993; Ali, 1994; Ali *et al.*, 1997; Shady, 2001; Shawky and Moisa 2005). The biological treatments i.e. EM1, Diple 2x and mycorrhizal fungi were used as microbial pathogen to control root knot nematode *M. incognita* (Osman *et al.*, 1988; Carling *et al.*, 1989; Mena *et al.*, 1996; Zawam, 1999; Radwan *et al.*, 2004; and EL- Hadad, 2005).

The objective of the present study were to provide information on the occurrence and population density of the most common pathogenic nematodes associated with grapevine and to evaluate host suitability of certain varieties to the infection of *M. incognita*. The present investigation aimed also to evaluate the relations ship between the infection of root–knot nematode *M. incognita* and the yied of same grapevine varieties. The effect of certain biological compounds and some organic soil amendments to control *M. incognita* infecting grapevine in Egypt.

## **MATERIALS AND METHODS**

### **1-Survey study:**

Survey was carried out to determine the plant parsitic nemtodes associated with certain grapevine varieties at the newly reclaimed sandy soil of South Tahrir and to study the distribution and density of the root knot nematode *Meloidogyne* spp. Soil and root samples were collected from the rhizosphere of the varieties Flame, King Ruby, Perlette, Superior and Thompson. Aliquot of 250 gm soil sample was taken and soaked in tap water for nematode extraction by sieving through 60 and 325 mesh sieves.

Nematode present in the suspension were collected from the fine sieve and extracted by the modified Bermann pan technique (Goody, 1963). The final volume of extracted suspension was descend to about 20 ml. Recovered nematode genera from each sample was counted under a microscope using the eelworm counting slide. Genera identification was based on morphology of adult and juvenile forms according to (Mai & Lyon, 1975) and (Siddiqui, 1986) . Percentage of frequency occurrence (%F.O), population density per 250 gm soil (P.D) and prominence value (P.V.) of the identified genera was calculated according to (Norton, 1978) .

## **2- Host Suitability of some grapevine varieties to *M. incognita* under greenhouse conditions:**

Greenhouse test was conducted to determine the susceptibility of selected grapevine varieties to *M. incognita* .The tested varieties were Early Superior, Flame, King Ruby, Perlette, Superior and Thompson. To monthes old seedling of each grapevine variety grown in pot of 20 cm diameter and were filled with steam sterilized sandy loam soil and they were inoculated with 3000 newly hatched second stage juveniles of *M. incognita* . Eight pots were used for each variety, of which four pots were inoculated while others were left free and served as control . All pots were arranged in block design system. Four month after nematode inoculation plants were uprooted and root system were washed from adhering soil. Number of juveniles per pot, galls, egg masses, eggs per egg- mass and developmental stages per root system were counted. The nematode reproduction factor (RF) was calculated for each variety. Root gall index (R G I) were determined according to the scale given by (Taylor and Sasser, 1978) as follows: 0 = no galls, 1 = 1-2 galls, 2 = 3 – 10 galls, 3 = 11 –30 galls, 4 = 31 – 100 galls and 5 = more than 100 galls. Host suitability was measured according to the scale of (Hadisaeganda and Sasser, 1982) on the basis of root gall index as follows: RGI range of 0.0 – 1.0 = highly resistant (HR), 1.1- 3.0 = very resistant (VR), 3.1 – 3.5 = moderately resistant ( MR), 3.6 - 4 = slightly resistant (SR) and 4.1 – 5 = susceptible (S). Host suitability was also measured by using the designations based on the relation between root gall index and nematode reproduction ( R. Factor) according to (Canto – Saenz, 1983) as follows: (RGI  $\leq$  2 & R  $\leq$  1) resistant ( R) , RGI  $\leq$  2 & R > 1) tolerant (T), RGI  $\geq$  2 & R  $\leq$  1) hyper – susceptible (HS) and (RGI  $\geq$  2 & R  $\geq$  1) susceptible (S). Data were statistically analyzed using (F) test according to (Snedecor, 1966) and least significant differences between treatments were calculated at 5 %.

## **3- Relationship between *M. incognita* density and yield of certain grapevine varieties:**

The study of the correlation between yield and nematode population was carried out in naturally infested orchard with *M. incognita* in Behira governorate and grown with certain grapevine varieties i.e. Flame, King-Ruby. Perlette, Superior and Thompson. Soil and root samples were collected from these varieties at the begining of the season. Five samples were obtained from each variety ( three trees for each ). The number of second stage juveniles per 250 gm soil and nematode population in 2 gm root

were counted. Data on yield per feddan were estimated during fruit harvest of grapevine for each variety.

**4- Effect of certain treatments in controlling *M. incognita* infecting grapevine under field condition:**

This experiment was conducted in naturally infested orchard growing with cv Superior in Behira Governorate to determine the effect of some bioagents and organic soil amendments to control *M. incognita*. Seven trees were used for each treatment and other seven trees were served as control. Before application, samples were taken from all treatments to estimate the initial nematode population. The treatments of this experiment were as follow:

- 1- Diple 2x, Agriculture research center commercial bioproduct as bioagent containing an isolate of *Bacillus thuringiensis* was added to the soil at rate of 2 gm / 1 liter water.
- 2- EM1 (effective micro – organisms) commercial bioproduct containing group of micro organism include photosynthetic bacteria, lactic acid bacteria, yeasts, actinomycetes and fungi (Mashhour, *et al.*, 2001) was added at the rate of 0.5 ml / 1L water.
- 3- Mycorrhizal fungi ( *Glomus* spp.) was added at the rate of 1 ml / 100 ml water.
- 4- Chopped garlic cloves at rates of 40, 60, 80 gm/ tree .
- 5- Dried liquorice powder was added at the rate of (40,60,80 gm / tree).
- 6- Dried chamomile powder (40,60,80 gm / tree).
- 7- Control treatment (untreated trees).

After four months soil and root samples were collected from the rhizosphere of the treated trees. the second stage juveniles of *m. incognita* were counted in 250 gm soil and galls, egg – masses, developmental stages/ one gm root and eggs / egg mass was recorded for each replicate. nematode reproduction factor (rf) and reduction in nematode population were estimated. data were subjected to statistical analysis according to (Snedacor, 1966) and least significant differences between treatments were calculated.

## **RESULTS AND DISCUSSION**

**1- Plant parasitic nematodes associated with certain grapevine varieties:**

Data in Table (1) show the list of nematode genera recovered from the rhizosphere of certain grapevine varieties in Behira Governorate. Results indicated that the genera were detected on the varieties, Flame, King-Ruby, Perlette, Superior and Thompson were *Meloidogyne*, *Tylenchulus*, *Tylenchorhynchus*, *Xiphinema* and *Longidorus*. The root-knot nematodes were determined with the highest frequency occurrence (%F.O.), population density (PD) on Flame and Superior followed by Perlette, and King-Ruby with frequency values of 73.5, 70.6, 64.7 and 58.8 and population densities in 250gmsoil of 62.4, 60.3, 53.5 and 60 respectively . The obtained results are in a good line with those reported by (Khan, 1988; Vadivelu *et al.*, 1992; Robians *et al.*, 1995 and Park – So Deuk, *et al.*, 1999). They indicated that root knot nematodes, *M. javanica* and *M. incognita* were found with high

occurrence and high numbers in grapevine. They also reported that the predominant species on grapes was *M. incognita*.

## **2- Susceptibility of certain grapevine varieties to *M. incognita*:**

Five grapevine varieties i.e., Early Superior, Flame, King – Ruby, Perlette, Superior and Thompson were tested for their susceptibility to root – knot nematode, *M. incognita* under green house conditions. Data in Table (2) demonstrated that the above mentioned varieties were considered as susceptible hosts according to (Canto- Saenz, 1983). The varieties Perlette, Flame, Superior, and Early Superior were rated as susceptible while the varieties Thompson and King – Ruby were slightly resistant according to (Hadisoeganda and Sasser, 1982). The present results are in harmony with the findings reported by (Hassan, 1985; Melakeberhan *et al.*, 1988 and Mahmoud, 2003) who showed that King Ruby, Flame and Superior were susceptible to *M. incognita* while Thompson was moderately resistant.

## **3-Relationship between grapevine yield and nematode densities:**

Relationship between the population densities of *M. incognita* and the yield of certain grapevine varieties was tested under field conditions. Data in Table (3) and Fig. (1) revealed the relation between *M. incognita* density and the yield of the varieties Flame, King –Ruby, Perlette, Superior and Thompson. The results indicated that the yield was affected by the density of inoculum of *M. incognita*, but this effect deferred according to the varieties. These results can be explained by (Ferris and Mckenry, 1975 and Quader *et al.*, 2002) who illustrated that correlations between *M. incognita* densities and vine performance were variable and the damage threshold of the root –knot nematode for grapevine will vary between varieties. The results showed that the highest density of *M. incognita* was correlated with the medium production while the low yield trees had less number of nematode density in all varieties except Tomson variety.

It means that the high production trees were more infected with *M. incognita* than low production trees in the same variety as shown with King-Ruby and Flame. This correlation is not clear in the cases of Superior and Perlette. This results can be explained on the base that the low production trees had very weak root system and less root feeders than the root system of the high production trees which can able to carry more nematode reproduction.



**Fig.(1): Relation between yield / fedden of certain grapevine varieties and population nematode *Meloidogyne incognita***

**Table (3): The effect of the infection of root knot nematode *Meloidogyne incognita* on the yield of certain grapevine varieties.**

| Varieties | No. of nematode in 250gm soil | No. of nematode in 2gm root | Yield (ton / faddan) |
|-----------|-------------------------------|-----------------------------|----------------------|
| Flame     | 1158                          | 656                         | 11.3                 |
|           | 2617                          | 1488                        | 9.3                  |
|           | 339                           | 193                         | 4.8                  |
| King-Ruby | 2970                          | 1689                        | 12.5                 |
|           | 3090                          | 1757                        | 9.5                  |
|           | 300                           | 170                         | 5.2                  |
| Perlitte  | 465                           | 264                         | 9.7                  |
|           | 4050                          | 2302                        | 6.0                  |
|           | 750                           | 426                         | 4.0                  |
| Superior  | 1027                          | 584                         | 14.2                 |
|           | 2766                          | 1573                        | 10.6                 |
|           | 1534                          | 872                         | 6.3                  |
| Thompson  | 74                            | 45                          | 10.7                 |
|           | 48                            | 27                          | 8.5                  |
|           | 450                           | 256                         | 6.1                  |

**4- Effect of some biological compounds, mycorrhizal fungi and certain organic soil amendments in controlling root-knot nematode, *M. incognita* investing grapevine under field conditions:**

Data in Table (4) revealed the effect of all treatments either biological or organic soil amendments on the reproduction of *M. incognita* infesting grapevine cv Superior. All the treatments reduced nematode population. The application of chopped garlic cloves (80 gm / tree) gave the highest reduction percentage in nematode population of *M. incognita* in soil and roots as compared to the other treatments. The reduction percentage was 85%. Compared to control. This result is in harmony with those reported by (Sukul *et al.*, 1974; Rhode, 1978; Ali, 1994 ; Shady, 2001 and Shawky, 2005). They indicated that addition of chopped garlic cloves reduced root galling, number of eggs / root system and nematode population in soil. Nematicidal garlic properties were attributed to allicin diallyl disulfide, ammonia and pyruvic acid (Stoll and Sebeck, 1950). Mycorrhizal fungi ranked second to garlic in its effect on root-knot nematode, *M. incognita* where mycorrhizal fungi, *Glomus* spp. was effective in reducing the reproduction of *M. incognita* and the reduction percentage was 78%. The obtained results agree with those reported by (Carling *et al.*, 1989; Zawam, 1999 and El- Haddad *et al.*, 2005) who determined that the galling and eggs number of *M. incognita* were suppressed by inoculation with *Glomus* spp. On the other hand, the dried powder of liquaric (*Glycyrrhiza glabra* L.) at rate of 80 gm / tree had lethal effect against *M. incognita*, the percentage reduction in nematode population was 71 compared to control. This inhibition action due to the accumulation of glycyrrhizin material (Abou Zaid, Sh.N. (2000). The commercial bioproduct Diple 2x 2gm/ 1 liter water had also adverse effect on *M. incognita* as it reduced nematode population. Reduction percentage was 66. These results confirm those obtained by (Osman *et al.*, 1988; Mena *et al.*, 1996; Radwan *et al.*, 2004; El- Nagdi and Youssef, 2004). The mode of action of *B. thuringiensis* toxins is mainly inhibition of protein and nucleic acid synthesis (Sebesta *et al.*, 1969). Data also show that the dried powder of chamomile (*Matricaria chamomile*) was the least effective treatment in controlling *M. incognita* as compared to other treatments. The effect of chamomile due to Tri-hydroxy flavon (Hikal and Omar, 1993) . In conclusion, organic soil amendments and biological treatments under investigation exhibited nematicidal activities, since they caused reduction in the nematode population. Such materials can play an important role in the classical and natural biological control of root knot nematode, *M. incognita* infesting grapevine.



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**دراسات على حصر النيماطودا وقابلية العائل للإصابة ومكافحة" ميلودجيني إنكوجنيتا" على العنب بمركبات معينة والعلاقة بين الإصابة والمحصول  
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تصاب شجيرات العنب بالنيماطودا المتطفلة على النباتات وتعتبر نيماطودا تعقد الجذور من أخطر أنواع النيماطودا التي تصيب العنب. ويهدف هذا البحث إلى عمل حصر لبعض أصناف العنب الهامة اقتصاديًا لتحديد حساسية بعض الأصناف وهي الطومسون وكنج روبي والفليم والبرليت وسبريور، وتأكيدها حساسية هذه الأصناف باختبار حساسية تحت ظروف الصوبة. وأوضحت الاختبارات أن أكثر الأصناف حساسية هي أسبريور وكنج روبي والفليم، وعلى ضوء هذه النتائج تم اختيار الصنف الحساس أسبريور لدراسة تأثير بعض المعاملات الحيوية وهي EMI وفطر الميكروهيزا وبعض المنتجات الطبيعية لنباتات طبية وهي مهروس فصوص الثوم والمسحوق الجاف لنباتات العرقسوس والشاي على نيماطودا تعقد الجذور ميلودجيني إنكوجنيتا التي تصيب صنف اسبريور تحت ظروف الحقل. وأوضحت النتائج أن مهروس فصوص الثوم بجرعة 80 جم/شجرة وفطر الميكروهيزا معدل 1 مل/100 مل ماء أكثر المعاملات فاعلية في مكافحة هذا

النوع من نيماتودا تعقد الجذور، حيث حدث انخفاض في تعداد النيماتودا بنسبة 85%، 78% على التوالي مقارنة بالكنترول، كما لوحظ تأثير واضح لنيماتودا تعقد الجذور لنبات العرقسوس، حيث كان الانخفاض في تكاثر النيماتودا بنسبة 71% عند إضافة المسحوق الجاف لهذا النبات بجرعة 80 جم/شجرة.

وأجريت دراسة للعلاقة بين إنتاجية أشجار العنب والإصابة بنيماتودا تعقد الجذور لبعض أصناف العنب وهي الفليم وكنج روبي والبرليت وسبريور والطومسون وكانت النتائج كالتالي:

1- أعلى تعداد لهذا النوع من النيماتودا في التربة والجذور كان مرتبطاً بالمحصول المتوسط الإنتاجية. بينما التعداد المنخفض لهذا النوع من نيماتودا تعقد الجذور كان مرتبطاً بالإنتاج المنخفض ماعدا الصنف طومسون.

أوضحت النتائج أن الأشجار ذات الإنتاجية العالية مصابة بتعداد أعلى من نيماتودا تعقد الجذور بالمقارنة بالأشجار المنخفضة الإنتاج في نفس الصنف، كما هو واضح في صنفى كنج روبي والفليم.



**Table (1): Percentage of frequency occurrence, population density and prominence value of plant parasitic nematodes**

| Nematode genera         | Flame |      |       | King-Ruby |      |       | Superior |      |       | Perlette |      |       | Thompson |      |       |
|-------------------------|-------|------|-------|-----------|------|-------|----------|------|-------|----------|------|-------|----------|------|-------|
|                         | %F.O  | P.D  | P.V   | %F.O      | P.D  | P.V   | %F.O     | P.D  | P.V   | %F.O     | P.D  | P.V   | %F.O     | P.D  | P.V   |
| <i>Meloidogyne</i>      | 73.5  | 624  | 534.9 | 58.8      | 60   | 460   | 70.6     | 60.3 | 506.7 | 64.7     | 53.5 | 430.3 | 26       | 25.6 | 130.5 |
| <i>Tylenchulus</i>      | 35.3  | 31.7 | 188.3 | 25.9      | 22.2 | 112.9 | 32.4     | 45.5 | 259   | 2.7      | 33.3 | 173   | 17.7     | 11.4 | 48    |
| <i>Tylenchorhynchus</i> | 47.0  | 58.8 | 403.1 | 38.2      | 33.8 | 209   | 41.2     | 48.6 | 311.9 | 40.8     | 32.9 | 210.1 | 15       | 9    | 34.9  |
| <i>Xiphinema</i>        | 26.5  | 31.1 | 160.0 | 20.6      | 25.7 | 116.6 | 20.4     | 32   | 173.5 | 14.7     | 20   | 76.7  | 14.7     | 8.2  | 31.4  |
| <i>Longidorus</i>       | 17.7  | 16.7 | 70.2  | 14.6      | 16   | 61.1  | 23.5     | 18.8 | 91.1  | 11.8     | 15   | 51.5  | 8.8      | 6.5  | 19.3  |

associated with certain grape varieties in Behira governorate

Population density (P.D) =  $\frac{\text{Total number of individuals of a genus}}{\text{Number of samples containing this genus}}$

Frequency occurrence (%F.O) =  $\frac{\text{Number of samples containing a genus}}{\text{Number of collected samples}} \cdot X100$

Prominence value (P.V.) = population density x  $\sqrt{\text{frequency occurrence}}$

**Table (2): Host suitability of certain grape varieties to *M. incognita* infection under greenhouse conditions**

| Varieties      | No. of 2J s/pot | No. of galls /root system | *R. G.I. | No. of egg-masses /root system | No. of eggs/ eggmass | No. of developmental stages / root | R. factor | Host category |     |
|----------------|-----------------|---------------------------|----------|--------------------------------|----------------------|------------------------------------|-----------|---------------|-----|
| Early Superior | 2 5553          | 495.0                     | 5.0      | 174                            | 330                  | 737                                | 20.9      | S*            | S** |
| Flame          | 5707.0          | 363.0                     | 5.0      | 130                            | 302                  | 879                                | 15.3      | S             | S   |
| King Ruby      | 2533.0          | 56.0                      | 4.0      | 92                             | 268                  | 201                                | 9.2       | SR            | S   |
| Perlette       | 4586.0          | 181.0                     | 5.0      | 106                            | 283                  | 534                                | 11.7      | S             | S   |
| Superior       | 4946            | 214.0                     | 5.0      | 111                            | 311                  | 566                                | 13.3      | S             | S   |
| Thompson       | 1654.0          | 52.0                      | 4.0      | 38                             | 185                  | 205                                | 3.0       | SR            | S   |
| L.S.D at 0.05% | 1965.9          | 42.7                      | 0.0      | 78.03                          | 2107.9               | 2.9                                | 3.04      |               |     |

R Factor (indicator of nematode reproduction) =  $\frac{\text{Nematode final population}}{\text{Nematode initial population}}$

Host suitability based on

\* Root gall index (R.G.I.) according to Hadisoegande & Sasser (1982)

\*\* Root gall index and R factor according to Cant- Saenz (1983)

S = Susceptible, SR = slightly resistant\*

Table (4): Efficacy of certain biological compounds and soil amendments in controlling root- knot nematode *Meloidogyne incognita* infesting grapevine cv Superior under field condition.

| Treatment                          | Initial J2s/ 250 gm soil | Final J2s/ 250 gm soil | No. galls /1gm root | No. of egg masses/ 1gm root | No. of eggs / eggmass | No. of development al stages/ 1gm root | Final population in 250gm/soil and 1gm/root | R. Factor | Red% |
|------------------------------------|--------------------------|------------------------|---------------------|-----------------------------|-----------------------|--|---|-----------|------|
| Diple 2x                           | 1180                     | 1306                   | 27                  | 24                          | 219                   | 75                                     | 6640  | 5.6       | 66   |
| EM1                                | 1486                     | 1740                   | 34                  | 32                          | 276                   | 100                                    | 9516  | 6.4       | 61   |
| Chopped Garlic clove (40 gm)       | 1506                     | 1346                   | 26                  | 25                          | 279                   | 63                                     | 8318  | 5.5       | 67   |
| Chopped Garlic clove (60gm)        | 1753                     | 1273                   | 25                  | 23                          | 225                   | 50                                     | 6508  | 3.7       | 78   |
| Chopped Garlic clove (80gm)        | 2020                     | 1027                   | 20                  | 14                          | 204                   | 36                                     | 4964  | 2.4       | 85   |
| Dried powder of shamomile (40 gm)  | 1173                     | 2586                   | 51                  | 45                          | 297                   | 149                                    | 16100                                       | 13.7      | 17   |
| Dried powder of shamomile (60 gm)  | 1446                     | 2440                   | 48                  | 41                          | 288                   | 120                                    | 14368                                       | 10.4      | 37   |
| Dried powder of shamomile (80 gm)  | 1503                     | 2105                   | 41                  | 34                          | 259                   | 97                                     | 12272                                       | 8.1       | 51   |
| Dried powder of liquorices (40 gm) | 1413                     | 1387                   | 27                  | 26                          | 262                   | 64                                     | 8213  | 5.7       | 66   |
| Dried powder of liquorices (60 gm) | 1400                     | 1280                   | 22                  | 24                          | 280                   | 45                                     | 7372  | 5.2       | 69   |
| Dried powder of liquorices (80 gm) | 1927                     | 1613                   | 31                  | 30                          | 257                   | 54                                     | 9368  | 4.8       | 71   |
| Mycorrhizal fungi                  | 2106                     | 1354                   | 24                  | 21                          | 290                   | 56                                     | 7509  | 3.6       | 78   |
| Control                            | 1352                     | 3213                   | 102                 | 57                          | 353                   | 156                                    | 22364                                       | 16.6      | 0.0  |
| L.S.D at 0.05%                     | 149.12                   | 1624.5                 | 9.31                | 7.05                        | 39.17                 | 33.26                                  | 2270.73                                     | 1.14      |      |

R Factor = indicator of nematode reproduction =  $\frac{\text{final of nematode population}}{\text{initial of nematode population}}$

Red% indicate percentages nematode reduction in soil and root (% efficiency according to Handerson & Tilton formula (Anonymous (1981)

$$= 1 - \left( \frac{\text{Population in the treated trees after application}}{\text{Population in the treated trees before application}} \times \frac{\text{Population in the check trees before application}}{\text{Population in the check trees after application}} \right) \times 100$$