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# Organic management of root-knot nematodes with non-host weed (*Asphodelus tenuifolius*) Extracts

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**Abstract**
This study was conducted to find the effect of non-host weeds on the organic management of root knot nematodes i-e *Meloidogyne javanica*. Initially survey was conducted in twenty fields and weeds plants were checked for galls on their roots. *Asphodelus tenuifolius* with no galls on the roots was selected for its efficacy against root knot nematodes. Root knot nematodes @ 2000 eggs were added to the rhizosphere of each plant after 10 days of transplantation except C0 (control un-inoculated) and C2 (Control with extracts). The aqueous extracts of *A. tenuifolius* S (100%), S1 (50%), S2 (33.3%) and S3 (25%) were applied @ 10ml to each plant except $C_0$ (Control un-inoculated and un-treated) and $C_1$ (Control inoculated). Study revealed that extracts from root, upper plant part and whole plant of *A. tenuifolius* were effective against root knot nematodes. Extracts applied as stock "S" showed significantly ($P \leq 0.05$) better results (25.87) followed by S1 (40.47) in terms of nematode mortality and galls per root system. Number of egg masses per inch of root system were reduced significantly with S and $S_1$ i-e 1.67 and 3.00 respectively. Number of eggs per egg mass were also reduced significantly with S (292.73) and $S_1$ (296.20) respectively. Aqueous extracts of *A. tenuifolius* stimulated fresh shoot weight i-e maximum in case of $C_2$ (33.17) followed by S (32.77) and dry shoot weight i-e maximum in case of $C_2$ (5.75) followed by S (4.72 ). In the same way it enhanced plant height i-e 95.67 and 91.53 with $C_2$ and S respectively, along with root length of tomato plants with $C_2$ (30.47) and S (30.47). No phytotoxicity of *A. tenuifolius* on tomato plants was observed.

**Keywords:** Organic management, root knot nematodes, *Asphodelus tenuifolius*, galls

## Introduction
Tomato (*Lycopersicon esculentum L.* Solanaceae), an extensively consumed crops, is grown as winter as well as summer vegetable all over the world. It is economically the second best vegetable after potato and an important source of vitamins A, B, C, iron and potassium [1]. Leading contributors towards tomato produce are China, United States, Italy, Turkey and India. Pakistan ranks 35th in tomato production [2]. In Pakistan average yield per hectare of tomato was 10.13 tones and in Khyber Pakhtunkhwa the yield per hectare was 9.0 tones [3].
Biotic and abiotic factors directly or indirectly affect yield, growth and quality of the plants. Tomato is susceptible to several pathogens including fungi, bacteria, nematodes, and viruses, which cause reduction in yield of tomato. Nematode parasitism is highly damaging and uncontrollable problem. Worldwide annual crop losses caused by nematodes are reported approximately US$ 100 billion [4]. In Pakistan, 40% yield losses have been reported in tomato by root knot nematodes which occur almost in all types of soil. Sandy soil favor the development and activities of nematodes. Most damaging obligate endoparasites are the root-knot nematodes (*Meloidogyne* sp) and cyst nematodes (*Heterodera* and *Globodera* spp) [5]. Root-knot nematode cause poor growth, yield, quality and can break the resistance of host plant and expose them to other pathogens [6]. Common agricultural weeds are present throughout the year, during and after the crop and serve as reservoir for plant pathogens and plant parasitic nematodes [7]. *Ageratum conzyoides*, *Amaranthus spinosus*, *Eleusine indica*, *Portulaca oleracea*, *Cyperus rotundus*, *Amaranthus* spp , *Chenopodium album*, and *Digitaria* spp. have been reported as weed hosts of root-knot nematodes [8] Cultural, chemical and biological methods have been developed for the control of root knot nematodes. Traditionally root knot nematode is control by chemicals [9]. However, chemicals disturb the ecological balance and overdoses may develop chemical resistance in root knot nematodes. Management of root-knot nematodes with chemicals, under field conditions is cost prohibitive, hazardous and can cause serious environmental pollution. These procedures may not provide full protection against nematodes for long time. People want to shift from the conventional use of

chemicals to the use of eco-friendly botanicals for the management of plant diseases [10]. For producing quality tomatoes, ideal and alternative organic nematicides are effective. Garlic, marigold and Castor oil plant have successfully been evaluated as a good source of biological nematicides again stroot knot nematode. Garlic leaf extracts indirectly disrupt the mobility of nematodes, food absorption and reproduction. Also garlic oil is effective against free-living soil inhabiting nematodes [11]. Insecticidal and antimicrobial properties are present in tropical castor oil plant which enhanced the abortions in *M. incognita* and also decreased female to male ratio [12]. Egg hatching inhibition and juvenile mortality has been reported with root, leaf and seed extracts of some angiosperm [13]. French marigold showed strong resistance to *Meloidogyne* spp [14]. Applications of organic soil amendments of crop residues, chicken manure, cow dungs and urine were used for the management of nematodes [15]. Activities and development of nematodes were inhibited by heat treatment, soil solarization and oil seed cakes [16]. Organic amendments are not only safe to use but can also improve plant conditions. Thus, control strategies are now directed towards the use of natural products. Bioactive products of plants are less persistent in environment, safe for mammals and other non-target organisms. Botanical pesticides are readily available in many places, often cheaper than synthetic chemicals. Their crude extracts are easy to prepare even by farmers. These also stop or slow down the development of resistance or resurgence in pests.

Keeping in view the importance of weeds in winter tomatoes as hosts and non-hosts, this project was initiated with the objective of studying the effect of non-host weed on the management of root knot nematodes.

## Materials and Methods

The study on organic management of root-knot nematodes with non-host weed extracts was carried out from March to November during 2014 in the University of Agriculture, Peshawar.

### Survey of weed hosts of root knot nematodes

Twenty fields were surveyed to obtain non host weed of root knot nematode such as *A. tenuifolius* in tomato growing fields of Dargai and Jabban area of Malakand, Khyber Pakhtunkhwa. Root knot incidence was also assessed on the basis of characteristic symptom (galls) on *A. tenuifolius* roots whose absence indicated that it is a non-host weed. For further identification, samples of non-host weed were brought to Department of Weed Science, The University of Agriculture, Peshawar.

### Identification of *Meloidogyne* species

Heavily galled roots were placed in a petri dish filled with tap water, and crushed with the help of a needle in order to extract adult females. Posterior bodies of the females were cut, discarding the anterior portion [17]. Perineal pattern morphology confirmed *M. javanica*. Ten to fifteen females were processed for the purpose of identification.

### Root knot nematodes culturing

After identification, the most prevalent *M. javanica*, found extensively in Khyber Pakhtunkhwa, was cultured and maintained on susceptible tomato cultivar (Reogrande) in green house in pots. Tomato germplasms were obtained from the seed market Gurh mandi, Peshawar. With the help of pipette single mature egg mass of the known *M. javanica* was inoculated into the rhizosphere of the three weeks old susceptible tomato seedlings in pots filled with sterilized potting mixture. This mass pure culture was sub-cultured by inoculating new tomato seedlings of the same cultivar with 10-15 egg masses, obtained from the pure culture, had sufficient inoculum for screening tomato germplasms experiment. The prevalent *M. javanica* inoculum was maintained in this experiment and re-identified morphologically for confirmation.

### Soil preparation and pasteurization

Potting mixture was prepared from silt, sand and FYM in a balanced ratio (1:1:1 v/v). The potting mixture was pasteurized at 60-80 °C for 45 minutes in heat resistant plastic bags.

### Raising tomato nursery

Nursery was raised from the obtained susceptible tomato germplasms in the sterilized potting mixture. Tomato germplasms were nursed separately in tray filled with sterilized potting mixture and was left for about four weeks to germinate, grow and became suitable seedlings to be transplanted.

### Transplantation

About 5-inches clay pots were filled with the sterilized potting mixture. The pots were watered and were left overnight. Proper drainage was provided to each pot to prevent water logging or stagnation of water. Four weeks post germination, uniform and healthy seedlings were transplanted into pots.

### Extraction of nematode eggs

Galled roots of tomato were washed to remove adhering soil particles and were blended in an electrical blender for 2 minutes in Sodium hypochlorite (NaOCl) solution [18]. By passing the suspension through 500, 400, 300, 250,200, 100, 63, 36 and 25µm mesh sieves using sieve shaker and collected the eggs in distilled water from 36 and 25µm mesh sieves. The eggs were counted in counting plate as eggs/ml and added known number of eggs to the soil in pot experiments. This procedure was repeated three times and average number of eggs was recorded at 200 eggs/ml. Eggs suspension were stored in 1% saline solution at 4 °C.

### Inoculation

All tomato plants except $C_0$ and $C_2$ (Controls) were inoculated with root knot nematode eggs. Two thousand eggs (200 eggs/ml) were applied to each plant 10 days after transplantation when the plants were established.

### Preparation of non-host weed extracts (treatments) and application

The collected stem, roots, leaves and whole plants of *A. tenuifolius* weed each of 25g were kept in 75ml of distilled water and were left for 12-24 hours. The extracts were boiled and filtered through muslin cloth. The yielded extracts were considered as stock solutions and designated as standard "S". By adding appropriate amount of distilled water different concentrations were prepared [19]. Different concentrations of treatments $T_1$=Stock solution S (100%), $T_2 = S_1$ (50%) (one ml

stock solution mixed with one ml of distilled water), $T_3 = S_2$ (33.3%) (One ml stock solution mixed with two ml of distilled water) and $T_4 = S_3$ (25%) (One ml stock solution mixed with three ml of distilled water) @ 10ml per plant were applied to tomato plants in pots against root knot nematodes. Along with control i-e $C_0$ = no nematodes and no treatments, $C_1$ = application of only nematodes and $C_2$ = application of only *A. tenuifolius* extract.

**Data collection**

The experiment was terminated 50 days after inoculation. Each plant was uprooted carefully, and the roots were washed gently with tap water. The data were recorded on plant height, fresh and dry shoot weight, fresh and dry root weight, number of galls per plant root system, the number of egg masses per inch of root system, galling index. Acid faschin @ 1 g/L was used for the staining of egg masses [20].

**Galling index *Meloidogyne javanica***

The root knot galling index was assessed on a scale of 0-5 as described by [21] Sasser (1984) as follow.

0 = No gall on roots, 1 = 1-2 galls, 2 = 3-10 galls, 3 = 11-30 galls, 4 = 31-100 galls, 5 = More than 100 galls.

**Statistical analysis**

Completely randomized design (CRD) was used in the experiment with five replications and three controls. Means were calculated and all the recorded data were subjected to statistical analysis using "STATISTIX 8.1" package for Analysis of Variance (ANOVA) and Least Significant Difference (LSD) test were used for mean separation [22].

**Results**

**Effect of *Asphodelus tenuifolius* extracts on plant height of tomato.**

Data subjected to Table 1 revealed that plant height was non-significantly affected by extracts from different parts of *A. tenuifolius*. A linear response of the extract doses were noted i.e. plant height increased with an increase in the extract strength and the maximum plant height was recorded with undiluted extract (91.53 cm) followed by 87.00 cm, 82.00 cm and 77.53 cm with $S_1$, $S_2$ and $S_3$ respectively. The plant extracts whether from whole plant or their parts significantly stimulated plant growth under un-inoculated condition when compared with control treatment. Significant interactive (Treatments x Plant parts) effect on plant height was noted. Maximum plant height (91.80 cm) was observed in undiluted extract (S) with root and whole plant extract application while minimum (76.40 cm) was observed in diluted extract ($S_3$) with upper plant part when compared with control treatment. Alkaloids are reported to be the nematicidal chemical group in *A. tenuifolius* extracts [23].

**Table 1:** Effect of *Asphodelus tenuifolius* extracts on plant height of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (cm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 71.40 | 71.40 | 71.40 | 71.40 g |
| No RKN & No Extracts ($C_0$) | 74.80 | 74.80 | 74.80 | 74.80 f |
| Extracts from plant parts & No inoculation ($C_2$) | 94.80 | 94.40 | **97.80** | **95.67 a** |
| Stock extract (S) + RKN ($T_1$) | 91.80 | 91.00 | 91.80 | 91.53 b |
| Stock extract (S1) + RKN ($T_2$) | 87.60 | 87.20 | 86.20 | 87.00 c |
| Stock extract (S2) + RKN ($T_3$) | 82.60 | 83.40 | 82.20 | 82.73 d |
| Stock extract (S3) + RKN ($T_4$) | 77.20 | 76.40 | 79.00 | 77.53 e |
| Means | 82.89 a | 82.66 a | 83.32 a | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 4.6546 CV= 4.46
$LSD_{(0.05)}$ (Treatment) =2.6873 * Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 1.7593

**Effect of *A. tenuifolius* extracts on root length of tomato.**

Mean square analysis of the data recorded in table 2 revealed that extracts of different plant parts of *A. tenuifolius* significantly enhanced the root length of tomato. Maximum root length (29.17 cm) was observed with the use of whole plant extracts application followed by root extracts applications (27.26 cm). A linear response of the extract doses were noted i.e. root length increased with an increase in the extract strength and the maximum root length was recorded with undiluted extract S (30.47 cm) followed by 29.80 cm, 29.67 cm and 28.60 cm with $S_1$, $S_3$ and $S_2$ respectively. The plant extracts whether from whole plant or their parts significantly stimulated root length under un-inoculated condition when compared with control treatment. Significant interactive (Treatments x Plant parts) effect on root length was noted. Maximum root length (33.20 cm) was observed in undiluted extract (S) with whole plant extract application while minimum (27.00 cm) was observed in diluted extract ($S_3$) with upper plant part when compared with control treatment.

**Table 2:** Effect of *Asphodelus tenuifolius* extracts on root length of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (cm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 20.00 | 20.00 | 20.00 | 20.00 e |
| No RKN & No Extracts ($C_0$) | 22.40 | 22.40 | 22.40 | 22.40 d |
| Extracts from plant parts & No inoculation ($C_2$) | 31.20 | 27.20 | 33.00 | 30.47 a |
| Stock extract (S) + RKN ($T_1$) | 30.80 | 27.40 | 33.20 | 30.47 a |
| Stock extract (S1) + RKN ($T_2$) | 29.40 | 27.60 | 32.00 | 29.67 b |
| Stock extract (S2) + RKN ($T_3$) | 29.20 | 27.60 | 32.60 | 29.80 b |
| Stock extract (S3) + RKN ($T_4$) | 27.80 | 27.00 | 31.00 | 28.60 c |
| Means | 27.26 b | 25.60 c | 29.17 a | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 1.1480 CV= 3.34
$LSD_{(0.05)}$ (Treatment) = 0.5602 * Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.4339

**Effect of *A. tenuifolius* extracts on fresh shoot weight fresh and fresh root weight of tomato.**

Mean square analysis of the data recorded in table 3 and 4 showed that maximum fresh shoot weight (29.43 gm) and fresh root weight (10.27 gm) were obtained with the use of whole plant extract application. A linear response of the extract doses were noted i.e. fresh shoot weight and fresh root weight increased with an increase in the extract strength and the maximum fresh shoot weight (32.77 gm) was recorded with undiluted extract followed by 30.00 gm, 26.67 gm and 24.70 gm with $S_1$, $S_2$ and $S_3$ respectively whereas maximum fresh root weight was recorded with undiluted extract (9.70 gm) followed by 9.49 gm, 9.44 gm and 9.10 gm with $S_2$, $S_1$ and $S_3$ respectively. The plant extracts whether from whole plant or their parts significantly stimulated shoot weight and root weight under un-inoculated condition when compared with control treatment. Significant interactive (Treatments x Plant parts) effect on shoot weight and root weight were noted. Maximum fresh shoot weight (34.20 gm) and fresh root weight (10.56 gm) were observed in undiluted extract (S) with root extract application while minimum fresh shoot weight (23.90 gm) was observed in diluted extract ($S_3$) with root extract and minimum fresh root weight (8.58 gm) was observed in diluted extract ($S_3$) with upper plant part extract when compared with control treatment. Similar studies were conducted by Mukhtar *et al.* (2013) [19] who also found that pure undiluted extracts of *Cannabis sativa* and *Zanthoxylum alatum* are more effective and nematicidal against *M. incognita.*

**Table 3:** Effect of *Asphodelus tenuifolius* extracts on fresh shoot weight of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (gm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 24.90 | 24.90 | 24.90 | 24.90 d |
| No RKN & No Extracts ($C_0$) | 30.20 | 30.20 | 30.20 | 30.20 b |
| Extracts from plant parts & No inoculation ($C_2$) | 34.00 | 31.90 | 33.60 | 33.17 a |
| Stock extract (S) + RKN ($T_1$) | **34.20** | 31.40 | 32.70 | 32.77 a |
| Stock extract (S1) + RKN ($T_2$) | 29.50 | 29.00 | 31.50 | 30.00 b |
| Stock extract (S2) + RKN ($T_3$) | 25.70 | 26.70 | 27.60 | 26.67 c |
| Stock extract (S3) + RKN ($T_4$) | 23.90 | 24.70 | 25.50 | 24.70 d |
| Means | 28.91 ab | 28.40 b | 29.43 a | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 2.2029 CV= 6.05
$LSD_{(0.05)}$ (Treatment) = 1.2718 * Root Knot Nematodes
$LSD_{(0.05)}$ (Application)=0.8326

**Table 4:** Effect of *Asphodelus tenuifolius* extracts on fresh root weight of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (gm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 13.16 | 13.16 | 13.16 | 13.16 a |
| No RKN & No Extracts ($C_0$) | 7.20 | 7.20 | 7.20 | 7.20 f |
| Extracts from plant parts & No inoculation ($C_2$) | 9.86 | 8.64 | 10.50 | 9.67 bc |
| Stock extract (S) + RKN ($T_1$) | 9.80 | 8.74 | 10.56 | 9.70 b |
| Stock extract (S1) + RKN ($T_2$) | 9.34 | 8.78 | 10.20 | 9.44 d |
| Stock extract (S2) + RKN ($T_3$) | 9.30 | 8.78 | 10.38 | 9.49 cd |
| Stock extract (S3) + RKN ($T_4$) | 8.86 | 8.58 | 9.86 | 9.10 e |
| Means | 9.13 c | 9.65 b | 10.27 a | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 0.3688 CV= 3.03
$LSD_{(0.05)}$ (Treatment) = 0.2130* Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.1394

**Effect of *A. tenuifolius* extracts on dry shoot weight of tomato and dry root weight of tomato.**

Results presented in Table 5 and 6 showed that aqueous extracts of *A. tenuifolius* has some effect on the dry shoot weight and dry root weight of tomato. Statistical analysis confirmed that dry shoot w**e**ight was non-significantly and dry root weight was significantly affected by the use of different parts of *A. tenuifolius*. Maximum dry shoot weight (4.70 gm) of tomato was observed with the use of upper plant part. Maximum dry root weight (5.15 gm) of tomato was observed with the use of whole plant extract application followed by root extract application while the minimum dry root weight (4.58 gm) was noted in upper plant extract application. A linear response of the extract doses were noted i.e. dry shoot weight and dry root weight increased with an increase in the extract strength. Significant interactive (Treatments x Plant parts) effect on dry shoot weight and dry root weight was noted. Maximum dry shoot weight (4.86 gm) and maximum dry root weight (5.28 gm) were observed in undiluted extract (S) with root extract application and whole plant extract application respectively. Minimum dry shoot weight (4.34 gm) and dry root weight (4.29 gm) were observed in diluted extract ($S_3$) with whole plant extract and upper plant extract application respectively, when compared with control treatment. Studies conducted by Siddiqui and Alam (1988) [24], *M. incognita* populations were suppressed more by extracts prepared from stem and whole plants rather than root portions

**Table 5:** Effect of *Asphodelus tenuifolius* extracts on dry shoot weight of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (gm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 3.11 | 3.11 | 3.11 | 3.11 c |
| No RKN & No Extracts ($C_0$) | 4.45 | 4.45 | 4.45 | 4.45 b |
| Extracts from plant parts & No inoculation ($C_2$) | 5.84 | 5.82 | 5.59 | 5.75 a |
| Stock extract (S) + RKN ($T_1$) | 4.86 | 4.58 | 4.73 | 4.72 b |
| Stock extract (S1) + RKN ($T_2$) | 4.68 | 4.99 | 4.24 | 4.64 b |
| Stock extract (S2) + RKN ($T_3$) | 4.40 | 5.02 | 4.74 | 4.71 b |
| Stock extract (S3) + RKN ($T_4$) | 4.74 | 4.90 | 4.34 | 4.66 b |
| Means | 4.58 ab | 4.69 a | 4.46 b | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 0.5232 CV= 9.08
$LSD_{(0.05)}$ (Treatment) = 0.3021*= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.1978

**Table 6:** Effect of *Asphodelus tenuifolius* extracts on dry root weight of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means (gm) |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 6.67 | 6.67 | 6.67 | 6.67 a |
| No RKN & No Extracts ($C_0$) | 3.60 | 3.60 | 3.60 | 3.60 d |
| Extracts from plant parts & No inoculation ($C_2$) | 4.93 | 4.32 | 5.25 | 4.83 b |
| Stock extract (S) + RKN ($T_1$) | 4.90 | 4.37 | 5.28 | 4.85 b |
| Stock extract (S1) + RKN ($T_2$) | 4.67 | 4.39 | 5.10 | 4.72 b |
| Stock extract (S2) + RKN ($T_3$) | 4.65 | 4.39 | 5.19 | 4.74 b |
| Stock extract (S3) + RKN ($T_4$) | 4.43 | 4.29 | 4.93 | 4.55 c |
| Means | 4.84 b | 4.58 c | 5.15 a | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 0.2276 CV= 3.73
$LSD_{(0.05)}$ (Treatment) = 0.1314 *= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.0860

**Effect of *A. tenuifolius* extracts on number of galls per root system and galling index of tomato.**

Mean square analysis of the data subjected to Table 7 and 8 showed that number of galls per root system and galling index were significantly affected by the use of different parts of *A. tenuifolius*. Maximum galls per root system of tomato were observed with the use of upper plant part extract application (42.14 galls) while minimum galls (28.14 galls) were observed in whole plant extract application. Similarly, Maximum galling index (G.I) was observed with the use of upper plant part extract application (2.86 G.I) while the minimum galling index was noted by the use of whole plant extract application (2.63 G.I). A linear response of the extract doses were noted i.e. number of galls per root system of tomato and galling index decreased with an increase in the extract strength. Minimum number of galls per root system of tomato were recorded with undiluted extract (25.87 galls) followed by 40.47 galls, 46.07 galls and 52.87 galls with $S_1$, $S_2$ and $S_3$ respectively. Minimum galling index was recorded with $S_1$ (3.33 G.I) followed by 3.80 G.I, 4.00 G.I and 4.00 G.I with S, $S_2$ and $S_3$ respectively. The plant extracts whether from whole plant or their parts significantly reduced the production of galls per root system of tomato and galling index under un-inoculated condition when compared with control treatment. Significant interactive (Treatments x Plant parts) effect on the number of galls per root system of tomato and galling index were noted.

**Table 7:** Effect of *Asphodelus tenuifolius* extracts on number of galls per root system of tomato

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 75.20 | 75.20 | 75.20 | 75.20 a |
| No RKN & No Extracts ($C_0$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Extracts from plant parts & No inoculation ($C_2$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Stock extract (S) + RKN ($T_1$) | 26.00 | 35.20 | 16.40 | 25.87 e |
| Stock extract (S1) + RKN ($T_2$) | 36.80 | 54.00 | 30.60 | 40.47 d |
| Stock extract (S2) + RKN ($T_3$) | 41.80 | 63.60 | 32.80 | 46.07 c |
| Stock extract (S3) + RKN ($T_4$) | 49.60 | 67.00 | 42.00 | 52.87 b |
| Means | 32.77 b | 42.14 a | 28.14 c | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 3.0783 CV= 7.12
$LSD_{(0.05)}$ (Treatment) = 1.7772 *= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 1.1635

**Table 8:** Effect of *Asphodelus tenuifolius* extracts on galling index.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 4.00 | 4.00 | 4.00 | 4.00 a |
| No RKN & No Extracts ($C_0$) | 0.00 | 0.00 | 0.00 | 0.00 d |
| Extracts from plant parts & No inoculation ($C_2$) | 0.00 | 0.00 | 0.00 | 0.00 d |
| Stock extract (S) + RKN ($T_1$) | 3.00 | 4.00 | 3.00 | 3.80 c |
| Stock extract (S1) + RKN ($T_2$) | 4.00 | 4.00 | 3.40 | 3.33 c |
| Stock extract (S2) + RKN ($T_3$) | 4.00 | 4.00 | 4.00 | 4.00 a |
| Stock extract (S3) + RKN ($T_4$) | 4.00 | 4.00 | 4.00 | 4.00 a |
| Means | 2.71 b | 2.86 a | 2.63 c | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 0.1504 CV= 4.37
$LSD_{(0.05)}$ (Treatment) = 0.0869 *= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.0569

**Effect of *A. tenuifolius* extracts on eggs per egg mass and on egg masses per inch of root system of tomato.**

Results presented in Table 9 revealed that aqueous extracts of different parts of *A. tenuifolius* significantly reduced eggs of root knot nematode per egg mass. Maximum eggs/egg mass were observed with the use of upper plant part extract application (218.94 eggs) followed by root extract application (217.57 eggs) while minimum eggs/egg mass (214.43 eggs) were recorded in whole plant extract application. A linear response of the extract doses were noted i.e. eggs/egg mass reduced with an increase in the extract strength and the minimum eggs/egg mass were recorded with undiluted extract (292.73 eggs) followed by 296.20 eggs, 305.40 eggs and 309.93 eggs with $S_1$, $S_2$ and $S_3$ respectively. The plant extracts whether from whole plant or their parts significantly minimized eggs/egg mass under un-inoculated condition when compared with control treatment. Maximum galls/egg mass (318.94 eggs) were observed in diluted extract ($S_3$) with upper plant part extract application while minimum (288.00) were observed in undiluted extract (S) with whole plant extract application when compared with control treatment. Sasanelli and Vito (1991) [25] suggested that there was a synergistic effect on egg hatchability of *Globodera rostochinensis* when treated with a combination of *T. erecta* leaf and root extracts.

**Table 9:** Effect of *Asphodelus tenuifolius* extracts on eggs per egg mass.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 314.60 | 314.60 | 314.60 | 314.60 a |
| No RKN & No Extracts ($C_0$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Extracts from plant parts & No inoculation ($C_2$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Stock extract (S) + RKN ($T_1$) | 293.20 | 297.00 | 288.00 | 292.73 e |
| Stock extract (S1) + RKN ($T_2$) | 298.20 | 299.60 | 290.80 | 296.20 d |
| Stock extract (S2) + RKN ($T_3$) | 306.80 | 308.40 | 301.00 | 305.40 c |
| Stock extract (S3) + RKN ($T_4$) | 310.20 | 313.00 | 306.60 | 309.93 b |
| Means | 217.57 b | 218.94 a | 214.43 c | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 2.6949 CV= 0.99
$LSD_{(0.05)}$ (Treatment) = 1.5559 *= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 1.0186

**Effect of *A. tenuifolius* extracts on egg masses per inch of root system of tomato.**

Mean square analysis in table 10 showed that egg masses inch-1 root system was significantly affected by the use of different parts of *A. tenuifolius*. Minimum egg masses inch$^{-1}$ root system were observed with the use of whole plant extract application (3.23 egg masses) followed by root extract application (3.51 egg masses) while the maximum egg masses inch$^{-1}$ root system were observed in upper plant part extract application (4.11 egg masses). A linear response of the extract doses were noted i.e. egg masses inch-1 root system decreased with an increase in the extract strength and the minimum egg masses inch-1 root system was recorded with undiluted extract (1.67 egg masses) followed by 3.00 egg masses, 4.07 egg masses and 7.00 egg masses with $S_1$, $S_2$ and $S_3$ respectively. The plant extracts whether from whole plant or their parts significantly reduced egg masses inch-1 root system under un-inoculated condition when compared with control treatment. Significant interactive effect on egg masses inch$^{-1}$ root system was noted. Minimum egg masses inch$^{-1}$ root system (1.60 egg masses) were observed in undiluted extract (S) with root and whole plant extracts application while maximum (8.20 egg masses) were observed in $S_3$ with upper plant part extract when compared with control treatment.

**Table 10:** Effect of *Asphodelus tenuifolius* extracts on egg masses per inch of root system of tomato.

| Treatments | Effect of *Asphodelus tenuifolius* | | | Means |
|---|---|---|---|---|
| | Root | Upper Plant part | Whole plant | |
| Only RKN*Inoculation ($C_1$) | 9.60 | 9.60 | 9.60 | 9.60 a |
| No RKN & No Extracts ($C_0$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Extracts from plant parts & No inoculation ($C_2$) | 0.00 | 0.00 | 0.00 | 0.00 f |
| Stock extract (S) + RKN ($T_1$) | 1.60 | 2.00 | 1.60 | 1.67 e |
| Stock extract (S1) + RKN ($T_2$) | 2.80 | 3.80 | 2.40 | 3.00 d |
| Stock extract (S2) + RKN ($T_3$) | 3.80 | 5.20 | 3.20 | 4.07 c |
| Stock extract (S3) + RKN ($T_4$) | 6.80 | 8.20 | 6.00 | 7.00 b |
| Means | 3.51 b | 4.11 a | 3.23 c | ------ |

Means in columns followed by different letter(s) are significantly different at 5 % level of significance.
$LSD_{(0.05)}$ (Application x Treatment) = 0.7233 CV= 15.88
$LSD_{(0.05)}$ (Treatment) = 0.4176 *= Root Knot Nematodes
$LSD_{(0.05)}$ (Application) = 0.2734

**Conclusion and Recommendations**

From the present study it can be concluded that whole plant extract of *A. tenuifolius* has an effective nematicidal activity against root knot nematode management. Therefore, the extract of the weed *A. tennuifolius* is recommended for root knot management. These plant extracts should also be tested against other parasitic nematodes. Further studies on bio-chemical assay should be conducted to identify the nematicidal compounds present in the extract.

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