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Management of banana plants against *Meloidogyne incognita* with indigenous medicinal and aromatic plants

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Abstract

Twenty indigenous medicinal and aromatic plants *viz*., *Perovskia abrotanoides*, *Valeriana wallichii*, *Artemisia vulgaris*, *Peganum harmala*, *Saphora alopecuroides*, *Artemisia absinthium*, *Carum copticum*, *Berberis balochistanica*, *Matricaria lasiocarpa*, *Ephedra procera*, *Centratherum anthelminticum*, *Zatoria multiflora*, *Lallemantia royaleana*, *Mentha spicata*, *Withania coagulans*, *Achillea santolina*, *Ferula oopoda*, *Nepeta cateria*, *Teucrium stocksianum* and *Fagonia cretica* were screened for their efficacy test against *Meloidogyne incognita* both in laboratory and pot experiments at doses of 0.5g/lit water (0.5% w/v), 1.0g/lit water (1% w/v), 1.5g/lit water (1.5% w/v), 2g/lit water (2% w/v), 2.5g/lit water (2.5% w/v) and 3.0g/lit water (3% w/v). *Zatoria multiflora*, *Achillea santolina*, *Ferula oopoda* and *Nepeta cateria* showed more efficacies as compared to other medicinal and aromatic plants both in laboratory and pot experiments. During laboratory experiments highest mortality (100%) was exhibited by the extract of *Zatoria multiflora*, *Achillea santolina* and *Nepeta cateria* against dose of 3.0g/liter followed by *Teucrium stocksianum* and *Ferula oopoda* with mortality of 90 % and 89%, respectively at the same dose of 3.0g/liter. Further, in pot experiments all tested plants showed significant effect on management parameters of *M. incognita*; however, minimum juvenile population were recorded from extracts of *Matricaria lesiocarpa* which was 3532.5 at dose 3g/liter. Similarly minimum root-knot index (1.0) was recorded from extracts of fourteen medicinal and aromatic plants at dose of 3.0g/liter and reproductive factor was also minimum 0.56 at dose of 3.0g/liter from extracts of *Zatoria multiflora*, *Ferula oopoda* and *Matricaria lasiocarpa*.

Keywords: Management, medicinal plants, aromatic plants, *Meloidogyne incognita*.

M*eloidogyne incognita* is one of the most important nematode pests limiting productivity of agricultural crops. This species is distributed throughout Pakistan. About five species of the root-knot nematodes *viz*., *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949; *M. javanica* (Treub, 1885) Chitwood, 1949; *M. arenaria* (Neal, 1889) Chitwood, 1949; *M. graminicola* (Golden and Birchfield, 1965) and *M. hapla* (Chitwood, 1949) have been reported on a variety of crops (Zarina & Shahina, 2013). *Meloidogyne incognita* also attacks banana crop and causes heavy economic losses (Haseeb *et al*., 1984, 1985; Haseeb & Pandey, 1987) and also in Pakistan (Maqbool, 1991; Maqbool & Shahina, 2001; Shahina *et al*., 2009; Zarina & Shahina, 2010, 2013). Banana productions were considerably affected by RKN infestation and are a problem for bananas in the tropics especially in Asian countries (Quénéhervé *et al*., 2009).

At present, the major control method of nematode is based on the use of chemical nematicides. Chemical nematicides are often phytotoxic, cause environmental pollution

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endangering the life of animals and human; but due to their toxic and residual effects and their deleterious impacts on human health and the environment, scientists identified natural products with nematicidal activity such as plant extracts (Pavaraj *et al*., 2012).

These biological products remain the alternative and sustainable means for management of plant parasitic nematodes associated to banana crop (Ferji *et al*., 2013). A number of plant species including medicinal and aromatic plant species have been reported for their nematicidal activity (Sukul, 1992). Nematicidal phytochemicals are generally safe for the environment (Chitwood, 2002). Herbal aqueous extracts as one of the alternative nematode control strategies has also found safe and ecofriendly (Moosavi, 2012). Therefore, in this study efficacy of 20 indigenous medicinal and aromatic plants was evaluated against *Meloidogyne incognita.*

Material and Methods

Following twenty medicinal and aromatic plants were screened for nematicidal efficacy against *Meloidogyne incognita* in laboratory and pots experiments:*viz, Perovskia abrotanoides, Valeriana wallichii, Artemisia vulgaris, Peganum harmala, Saphora alopecuroides, Artemisia absinthium, Carum copticum, Berberis balochistanica, Matricaria lasiocarpa, Ephedra procera, Centratherum anthelminticum, Zatoria multiflora, Lallemantia royaleana, Mentha spicata, Withania coagulans, Achillea santolina, Ferula oopoda, Nepeta cateria, Teucrium stocksianum, Fagonia cretica.*

The screened plants were than subjected to extraction of crude compounds.

Extraction of crude compounds with distilled water

An amount of 100 grams of dehydrated powder of each plant was soaked separately in 1000ml distilled water in sterilized conical flasks. The mouths of conical flasks were closed with cotton bolls. These flasks were fixed on orbital shaker. Orbital shaker was set at 100rpm; this was set on continuous shaking for 24 hours. The conical flasks were then removed and the extracts were filtered through 40# filter papers. The extracts of all plants were than concentrated separately on a water bath. The concentrated extract was then transferred into a large size Petri plate with spatula. The extracts were dehydrated in a vacuum oven at 60ºC and weighed (Claudius-Cole *et al*., 2010; Egunjobi & Afolami, 1976).

Preparation of doses from plant extracts for efficacy test

Following doses were prepared from the each dehydrated crude extracts of medicinal plants in distilled water for efficacy evaluation as nematicide:

0.5g/lit water (0.5% w/v), 1g/lit water (1% w/v), 1.5g/lit water (1.5% w/v), 2g/lit water (2% w/v), 2.5g/lit water (2.5% w/v), 3g/lit water(3% w/v).

Nematode culture

Pure nematode culture was maintained on tomato at NNRC, University of Karachi. For experimental purpose juveniles were collected from the egg-masses of tomato roots and stored at 15 º C. 3-4 days olds juveniles were used for the experiments.

Efficacy assessment

Nematicidal efficacy assessments were done both in laboratory and pot experiments against most prevalent nematode i.e., *Meloidogyne incognita* by using following methods:

Efficacy in laboratory experiment

Twenty newly hatched juveniles of *Meloidogyne incognita* were placed in cavity glass blocks each containing different concentrations of each of the twenty medicinal plants. The juveniles were picked from the concentrated nematode suspension with a dropper. There were eight treatments for each twenty plant including one control (only distilled water) and furadan as a standard nematicide for comparison. Each

treatment was replicated three times and laid out in a completely randomized design (CRD). The mortality of 20 newly hatched juveniles of *Meloidogyne incognita* were observed after every, 1/2, 1, 2, 3, 4, 8, 12 and 24 hours for three days. The mortality percentage was calculated after three days.

Efficacy in pot experiment

The pot experiment was laid out in green house of Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Science, Uthal. Two months old banana plants obtained from farmers field were transplanted in 30 cm diameter plastic pots containing a mixture of steam-sterilized clay/sand soil (2:1). The soil was allowed to cool and then filled into pots (One plant in each pot).

The pots were arranged in randomized complete block design (RCBD). Each treatment was replicated three times. The plants were irrigated as required and kept weed-free by hand weeding. After one week of transplant, banana plants were inoculated with 25 egg-masses of *M. incognita*. Inoculation was done by slowly dispensing 2.5 ml of the prepared nematode suspension into test tubes obtained from pure culture.

Two week after inoculation the soil in each pot was drenched with prepared doses of each medicinal plant extracts and a standard Nematicide (Furadan). The controlled pots were drenched with the same amount of distilled water. After six weeks of inoculation pots were up turned over a polythene sheet and the root system was gently separated from the soil. Roots were macerated and nematodes extracted by the method used by Coyne *et al*., (2007) and Hussey & Barker (1973).

For population of root-knot nematodes, the soil from each pot was properly mixed and a 200 ml sample was taken for extraction using the pie pan method of Whitehead and Hemming (1965). The reproduction factor was assessed and root-gal index was estimated according to the scale given by Taylor & Sasser, 1978.

Statistical Analysis

The experiment was arranged in randomized complete block design (RCBD) and the results were statistically analyzed using EXCEL 2007 software. The mean comparisons among treatments were determined by Duncan's multiple range tests at 5 % level of probability.

Results

Efficacy of medicinal and aromatic plants against *Meloidogyne incognita*

Efficacy test against *Meloidogyne incognita* was performed both in laboratory and pot experiments at doses of 0.5g/lit water (0.5% w/v), 1g/lit water (1% w/v), 1.5g/lit water (1.5% w/v), 2g/lit water (2% w/v), 2.5g/lit water (2.5% w/v) and 3g/lit water (3% w/v). Furadan was used as a conventional nematicide for comparison. Systematics of these plants has given along with their distribution and economic importance.

***Ferula oopoda* Boiss**

Systematics of *Ferula oopoda*

Class: Magnoliopsida
Order: Apiales
Family: Apiaceae
Genus: *Ferula*
Species:*oopoda*
Local Names: Hing

Distribution

Afghanistan, Pakistan (Quetta, Balochistan), Iran (EC-Iran, S-Iran, W-Iran: Mts), Iraq (NE-Iraq), Caucasus.

Economic importance

The genus *Ferula* (Apiaceae) comprises of about 170 species worldwide. Genus is well-known in folk medicine for the treatment of various ailments. Almost all species of Ferula have strong antimicrobial activity (Amir and Mehrdad, 2010). *Ferula* sp. significantly inhibited egg hatching and activity of

Meloidogyne incognita (El-Sherbiny & Manal, 2012).

Bioactive compounds

Scoparone, terpenoids,β-phellandrene, thymol-methyle ether, Ferulic acid, Myrcene, α-ylangene and volatile sulphure compounds (Z-proprnyl-sec-butyle trisulphide upto 7%) Jamal *et al,* (2016) and Akhgar *et al,* (2013).

Efficacy of *Ferula oopoda*extracts against *Meloidogyne incognita*

The efficacy of *Ferula oopoda* extract at various doses against *M. incognita* has been depicted in Table1.

Significant difference was found in dose concentrations. The results showed proportional increase in mortality with increase in dose per liter. Maximum mortality of 89% was recorded at highest dose of 3g/liter, followed by 78%, 30%, 21%, 19% and12% mortality at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Further laboratory experiments showed more effectiveness as compared to pot experiment.

Data obtained in pot experiment also showed significant differences among treatments. Minimum juvenile population, 4226.5 was observed at highest dose of 3g/liter followed by 5477.2, 6797.5, 7467.4, 9896.5 and 10542.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was also minimum 1.0 at dose of 3g/liter followed by 1.18, 1.2, 1.9, 2.5 and 3.4 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Minimum reproductive factor (RF) 0.56 was observed at dose of 3g/liter followed by 0.87, 1.07, 1.1, 1.58 and 1.68 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Mortality of nematode species was significantly different with lowest dose in both laboratory and pot experiments. Lowest doses showed the lowest and highest doses having the highest mortality of the test species of nematode (*Meloidogyne incognita*). Similar results were reported earlier that *Ferula oopoda*was found more effective as compared to *Nigella sativa*, *Peganum harmala* and *Portulaca oleracea* against *Meliodogyne javanica* and mortality was directly propotional to the dose concentration (Alireza & Moosavi, 2016; El-Sherbiny & Manal, 2012).

Table 1. Efficacy of *Ferula oopoda* extracts against *Meloidogyne incognita.*

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	12^{f}*	10542	3.4^{a}	1.68^{a}
1.0^{g}	19^{e}	9896	2.5^{c}	1.58^{c}
1.5^{g}	21^{e}	7468	1.9^{d}	1.1^{d}
2.0^{g}	30^{d}	6697	1.2^{e}	1.07^{e}
2.5^{g}	78^{c}	5477	1.18^{f}	0.87^{f}
3.0^{g}	89^{b}	4226	1.0^{g}	0.56^{g}
Control	0^{f}	9976	3.2^{a}	1.59^{b}
Furadan	100^{a}	0	0^{h}	0^{h}
LSD	4.28		0.073	0.122

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Nepeta cateria* L.**

Systematics of *Nepeta cateria*

Class: Magnoliopsida
Order: Lamiales
Family: Lamiaceae
Genus: *Nepeta*
Species:*cateria*
Local Names: Catnip, seemsok.

Distribution

America, Europe, Asia: Pakistan (Balochistan, Quetta), Iran, Afghanistan.

Economic importance

The plant can be used for treatment of various disorders such as chest infection and cough. It possesses strong anti-microbial property. It has also proven that plant has different types of effects agianst insect pests. Acording to Pavaraj

et al., (2012) *Nepeta cateria* has strong nematicidal property.

Bioactive compounds

Germacrene A & D, bicyclogermacrene, β-bourbonene, β-elemene, spathulenol, cubenol, *trans*-caryophyllene, and δ-cadinene (*kopetdaghensis (*Abolfazl, *et al* 2014). It also contains Alkaloids, Flavonides and Terpenese (Nostro *et al*, 2000).

Efficacy of *Nepeta cateria* extracts against *Meloidogyne incognita*

The efficacy of *Nepeta cateria* extract at various doses against *M. incognita* has been depicted in Table 2.

In laboratory experiment maximum mortality of 100% was recorded at a dose of 3g/liter which is at par with standard control, followed by 77%, 29%, 21%, 17% and 4% at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. While pot experiment data showed minimum juvenile population, 3979 at highest dose of 3g/liter followed by 4268, 5174, 6382, 8069 and 8550 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Table 2. Efficacy of *Nepeta cateria* extracts *against Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5	4^{f}	8550	3.5^{b}	1.36^{b}
1.0	17^{e}	8069	3.5^{b}	1.29^{c}
1.5	21^{d}	6382	2.8^{c}	1.02^{d}
2.0	29^{c}	5174	1.7^{d}	0.82^{e}
2.5	77^{b}	4268	1.5^{e}	0.68^{f}
3.0	100^{a}	3979	1.0^{f}	0.63^{g}
Control	0^{g}	9992	3.6^{a}	1.59^{a}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	2.63		0.014	0.013

*Values in a column having different letters are significantly different from each other.

**Lab experiment

Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.4, 1.7 and 2.8 at doses of 2.5, 2.0 and 1.5 the doses of 1.0 and 0.5g/liter showed maximum root-knot index 3.5. Reproductive factor (RF) was also minimum 0.63 at dose of 3g/liter followed by 0.68, 0.82, 1.02, 1.29 and 1.36 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. All the values of mortality at different doses in laboratory experiments were significantly different from each other.

Similar pattern was observed in pot experiment. *Nepeta cateria* exhibited 78-86% mortality of *M. incognita* after 72hrs reported by Pavaraj *et al*., (2012); similar results were observed in this research study.

***Achillea santolina* L.**

Systematics of *Achillea santolina*

Class:Magnoliopsida
Order:Asterales
Family:Asteraceae
Genus:*Achillea*
Species:*santolina*
Local Names: Yarrow, Zawal, Boe matheran.

Distribution

North America, Europe, temperate areas of Asia: Afghanistan, Pakistan (Balochistan: Quetta, Kalat, Mastung, Ziarat), Iran.

Economic importance

There are a number of records that *Achillea santolina* has biological, pharmacological, immunologically and curative properties. *Achillea* name was derived from *Achilles* mean treatment of wounds. Genus *Achillea* has also strong nematicidal property (Al-Obaedi *et al.*, 1887).

Bioactive compounds

Various bioactive compound such as flavonoids, phenolic acids, coumarins, terpenoids (monoterpenes, sesquiterpenes, diterpenes, triterpenes) and sterols which have been frequently reported from *Achillea* species (Saeidnia, 2011).

Efficacy of*Achillea santolina* extracts against *Meloidogyne incognita*

The efficacy of *Achillea santolina* extract at various doses against *M. incognita* has been depicted in Table 3.

The results showed proportional increase in mortality with increase in dose per liter. Further laboratory experiments showed more effectiveness as compared to pot experiment. 100% mortality was recorded in laboratory experiment at 3g/liter dose, which is comparable with the conventional nematicide; followed by 60%, 42%, 21%, and 1% at doses 2.5, 2.0, 1.5, 1.0, respectively while dose 0.5g/liter showed no mortality.Data of pot experiment showed minimum juvenile population 3879.2at highest dose of 3g/liter followed by 4887, 5662, 7886, 8095 and 8678 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3gms/liter followed by 1.5, 2.0, 2.5, 3.0 and 3.5 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Reproductive factor (RF) was also minimum 0.62 at dose of 3g/liter followed by 0.78, 1.04, 1.26, 1.29 and 1.38 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Three concentrations of *Achillea santolina* extract @1%, 5% and 10%, exhibited the mortality of15%, 57% and 95%, respectively (Al-Obaedi *et al*., 1887).Similar results were obtained in the current study.

Table 3. Efficacy of *Achillea santolina extracts* against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{t}	8678	3.5^{b}	1.38^{b}
1.0^{g}	1^{e}	8095	3.0^{c}	1.29^{c}
1.5^{g}	21^{d}	7886	2.5^{d}	1.26^{d}
2.0^{g}	42^{c}	6562	2.0^{e}	1.04^{e}
2.5^{g}	60^{b}	4887	1.5^{t}	0.78^{t}
3.0^{g}	100^{a}	3879	1.0^{g}	0.62^{g}
Control	0^{t}	9899	3.7^{a}	1.58^{a}
Furadan	100^{a}	0	0^{h}	0^{h}
LSD	2.85		0.046	0.009

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Teucrium stocksianum* Boiss**

Systematics of *Teucrium stocksianum*
Class:Magnoliopsida
Order: Lamiales
Family: Lamiaceae
Genus: *Teucrium*
Species:*stocksianum*
Local Names: Kalpora

Distribution
Pakistan (Balochistan, Quetta, Zairat, Harnai, Kalat), Afghanistan, Iran, Iraq, UAE.

Economic importance
The plant contains novo chemicals for therapeutic uses, such chemicals can also be used for various pharmacological and pesticidal purposes. Reports are also available about anthelmintic property of plant (Rahim *et al*., 2012).

Bioactive compounds
The chemical composition essential oils and crude extract contains 72 compounds out of which the sesquiterpene alcohols, patchouli alcohol and α-cadinol are the main components (Assem & Karam, 2004).

Efficacy of *Teucrium stocksianum* extracts against *Meloidogyne incognita*
The efficacy of *Teucrium stocksanum* extract at various doses against *M. incognita* has been depicted in Table 4.

The results showed proportional increase in mortality with increase in dose per liter. Further laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 90% was in laboratory experiment at 3g/liter dose. In laboratory experiment maximum mortality of 90% was recorded at a dose of 3g/liter, followed by 30%, 4%, 2% and 1% at doses 2.5, 2.0, 1.5 and 1.0, respectively while dose 0.5g/liter was not effective. Pot experiment data showed minimum juvenile population 4848.2 at highest dose of 3g/liter followed by 7589.5, 8039.5,

8424.2, 8536.2 and 8785.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.5 at dose of 3g/liter followed by 2.5 and 3.4 at doses of 2.5 and 2.0, respectively. Further, the doses 1.5 and 1.0 showed same results of 3.2. Root-knot Index of 3.5 was observed at dose 0.5g/liter. Reproductive factor (RF) was also minimum 0.77 at dose of 3g/liter followed by 1.21, 1.28, 1.34, 1.36 and 1.40 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. All the dose values were significantly different from each other both in laboratory and pot experiments. Phytochemical and antioxidant properties of *Teucrium stocksianum* was reported by (Rahim *et al*., 2013). However, Nematicidal activity was not found during literature search.

Table 4. Efficacy of *Teucrium stocksianum* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{g}	8785	3.5^{b}	1.40^{b}
1.0^{g}	1^{f}	8536	3.2^{c}	1.36^{c}
1.5^{g}	2^{e}	8424	3.2^{c}	1.34^{d}
2.0^{g}	4^{d}	8039	3.0^{d}	1.28^{e}
2.5^{g}	30^{c}	7579	2.5^{e}	1.21^{f}
3.0^{g}	90^{b}	4848	1.5^{f}	0.77^{g}
Control	0^{g}	8884	3.6^{a}	1.42^{a}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	0.91		0.062	0.006

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Mentha spicata* Boiss**

Systematics of *Mentha spicata*
Class:Magnoliopsida
Order: Lamiales
Family: Labiatae
Genus: *Mentha*
Species:*spicata*
Local Names: Spearmint, poodina.

Distribution
Afghanistan, Albania, Bulgaria, China, Cyprus, France, Iran, Italy, Germany, Pakistan (Quetta, Kalat, Zairat, Peshawar, Mansehra, Swat, Pashine and Mastung).

Economic importance
Essential oil of *Mentha spicata* is enriched with piperitone oxide, piperitenone oxide (chemotype I), carvone and dihydrocarvone (chemotype II), which are potential nematicidal compounds (Caboni *et al*., 2013).

Bioactive compounds
Flavonoid compounds such as catechin, epicatechin, rutin, myricetin, luteolin, apigenin and naringenin and Phenolic compound such as rosmerinic acid (Mandana *et al*., 2011).

Efficacy of *Mentha spicata* extracts against *Meloidogyne incognita*

The efficacy of Mentha *spicata* extract at various doses against *M. incognita* has been depicted in Table 5.

The results showed proportional increase in mortality with increase in dose per liter. Further laboratory experiments showed more effectiveness as compared to pot experiment. During laboratory experiment maximum mortality of 39% was recorded at a dose of 3g/liter, followed by 14% and 1% at doses of 2.5 and 2.0, while doses 1.5g, 1.0g and 0.5g/liter were not effective at all. While pot experiment showed minimum juvenile's population 5004.2 at highest dose of 3g/liter followed by 5228.4, 6505.0, 7026.2, 7184.2, and 7369.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root- knot index (RKI) was minimum 1.5 at doses of 3.0 and 2.5g/liter followed by 2.0, 2.5, 2.8 and 3.0 at doses of 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Repruductive factor (RF) was also minimum 0.80 at dose of 3g/liter followed by 0.83, 1.04, 1.12, 1.14 and 1.17 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the values of mortality were significantly different from each other except zero values obtained at 1.5 g, 1.0g and 0.5g in laboratory experiment. Similar effect was observed in pot experiments. Our findings are in agreement with earlier researchers: Mint aqueous extracts showed nematicidal activity against the root-knot nematode *Meloidogyne incognita* (Caboni *et al*., 2013). Pandey *et al*., (1992) also identified bioactive compounds of *Mentha arvensis* which posseses nematicidal property at different level of concentrations.

Table 5. Efficacy of *Mentha spicata* extracts against *Melodoigyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5	0^{e}	7369	3.0^{b}	1.17^{b}
1.0^{g}	0^{e}	7184	2.8^{c}	1.14^{c}
1.5^{g}	0_{e}	7026	2.5^{d}	1.12^{d}
2.0^{g}	1^{d}	6505	2.0^{e}	1.04^{e}
2.5^{g}	14^{c}	5228	1.5^{f}	0.83^{f}
3.0^{g}	39^{b}	5004	1.5^{f}	0.80^{g}
Control	0.33^{e}	7446	3.2^{a}	1.19^{a}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	2.05	-	0.026	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Withania coagulans* Stocks**

Systematics of *Withania coagulans*
Class: Magnoliopsida
Order: Solanales
Family: Solanaceae
Genus: *Withania*
Species:*coagulans*
Local Names: Panirband, Indian rennet, Ashutosh booti

Distribution
It is abundantly found in sub-Himalayan tracts in India, *Pakistan* Canary Islands, Mediterranean, Africa, Iraq, S. Iran, Syria, Turkey, Palestine, Arabia, Sri Lanka, Afghanistan, Jordan, Egypt and Morocco.

Economic importance
Different parts of the plant are used for treatment of diseases and plant has a magic healer property; fruits are sedative, emetic and diuretic and healer of liver disorder, dyspepsia, flatulent coli and other intestinal infections, asthma and biliousness. It also possesses nematicidal and insecticidal properties (Gupta, 2012; Gupta and Keshari, 2013).

Bioactive compounds
Coagulin[A-S], Bispicropodophyllinglucoside, Sitosterol-β-d-glucoside, Coagulanolide, Withanolide F, Withaferin A and Withacoagin (Rakesh *et al*., 2010).

Efficacy of *Withania coagulans* extracts against *Meloidogyne incognita*
The efficacies of Withania *coagulans* extract at various doses against *M. incognita* have been depicted in Table 6.

The results showed little mortality at higher doses. Further Laboratory experiments showed more mortality as compared to pot experiment. The data of results showed that maximum mortality of 10% was recorded in laboratory experiment at 3g/liter dose, followed by 7% at doses of 2.5g/liter and remaining doses of 2.0, 1.5, 1.0 and 0.5g/liter showed no efficacy. While data of pot experiment showed minimum juvenile population 9048.2 at highest dose of 3g/liter followed by 9324.2, 9385.5, 9420.2, 9486.2 and 9555.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root- knot index (RKI) was minimum 3.0 at doses of 3g and 2.5g/liter followed by 3.5 at doses of 2.0, 1.5 g/liter and 3.6 and 3.8 at doses of 1.0, 0.5g/liter. Repruductive factor (RF) was also minimum 1.44 at dose of 3g/liter followed by 1.49 at dose 2.5g/liter, 1.50 at doses 2.0, 1.5g/liter and 1.52 at dose of 0.5g/liter.

The mortality values at 3.0 and 2.5 g/liter were significantly different from each other. All other doses of 2.0, 1.5, 1.0 and 0.5g/liter did not show any mortality.

Withania coagulans also showed some efficacy during the research conducted by Gupta (2012) in India.

Table 6. Efficacy of *Withania coagulans* extracts against *Meloidogyne incognita.*

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{d}	9555	3.8^{a}	1.52^{b}
1.0^{g}	0^{d}	9486	3.6^{c}	1.51^{c}
1.5^{g}	0^{d}	9420	3.5^{c}	1.50^{d}
2.0^{g}	0^{d}	9385	3.5^{c}	1.50^{d}
2.5^{g}	7^{c}	9324	3.0^{d}	1.49^{e}
3.0^{g}	10^{b}	9048	3.0^{d}	1.44^{f}
Control	0^{c}	9626	3.7^{b}	1.54^{a}
Furadan	100^{a}	0	0^{e}	0^{g}
LSD	1.34		0.016	0.0364

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Zatoria multiflora* Boiss**

Systematics of *Zatoria multiflora*
Class: Magnoliopsida
Order: Lamales
Family: Lamiaceae
Genus: *Zatoria*
Species:*multiflora*
Local Names: Saatar, Ezghand

Distribution
Afghanistan, Iran and Pakistan (Balochistan, Quetta, Kalat, Zairat, Mastung, Pashine),

Economic importance
The plant has been used in many problems as analgesic, antiseptic, carminative, stimulant, disphoretic, antispasmodic and diuretic. According to Ghazalbash and Abdollahi (2013) *Zatoria multiflora* possesses strong nematicidal property.

Bioactive compounds
Fifty volatile compounds are present in EO. of *Zatariamultiflora* the main compounds are linalool thymol, carvacrol, γ-terpinene, ρ-cymene, carvacrol methyl ether, α-pinene and myrcene (Hossein *et al*., 2015).

Efficacy of *Zatoria multiflora* extracts against *Meloidogyne incognita*
The efficacy of *Zatoria multiflora* extract at various doses against *M. incognita* has depicted in Table 7.

The results showed proportional increase in mortality with increase in dose per liter. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 100% in laboratory experiment at 3g/liter dose and the same dose also showed highest effect during pot experiment interm of root-knot index. Minimum mortality was 1% in laboratory experiment at a dose of 0.5g/liter. During laboratory experiment maximum mortality of 100% was recorded at a dose of 3g/liter, followed by 79%, 42%, 11%, 7% and 1% at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

While data obtained in pot experiment showed minimum juvenile population 4226.5 at highest doses of 3g/liter, followed by 5477.2, 6697.5, 7468.4, 9896.5, and 10542.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.2, 1.9, 2.0, 2.9 and 3.7 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Reproductive factor (RF) was also minimum 0.56 at dose of 3g/liter followed by 0.87, 1.07, 1.1, 1.58 and 1.68 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the mortality values showed significant difference from each other both in laboratory and pot experiments. The results of current research are closely related to the results obtained by Ghazalbash & Abdollahi (2013).

Table 7. Efficacy of *Zatoria multiflora* extracts against *Meloidogyne incognita.*

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5[g]	1[f]	10542	3.7[b]	1.68[b]
1.0[g]	7[e]	9896	2.9[c]	1.58[c]
1.5[g]	11[d]	7468	2.0[d]	1.1[d]
2.0[g]	42[c]	6697	1.9[e]	1.07[e]
2.5[g]	79[b]	5477	1.2[f]	0.87[f]
3.0[g]	100[a]	4226	1.0[g]	0.56[g]
Control	0[f]	12552	3.82[a]	2.0[a]
Furadan	100[a]	0	0[h]	0[h]
LSD	3.01		0.019	0.010

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Lallemantia royaleana* Boiss**

Systematics of *Lallemantia royaleana*
Class: Magnoliopsida
Order: Lamiales
Family: Lamiaceae
Genus: *Lallemantia*
Species:*royaleana*
Local Names: Tukhme malangian, Tukhme malanga, Balanga

Distribution
Iran (EC-Iran, S-Iran, W-Iran: Mts.), Afghanistan, Pakistan (Balochistan, Quetta), Iraq (NE-Iraq), China, Syria, some other European countries.

Economic importance
Lallemantia royleana (Benth. in Wall.) Benth. is a medicinal plant. The genus belongs to the family Lamiaceae having only five species. It is native to Iran and used in the treatment of various nervous, hepatic and renal diseases in Iranian traditional and folklore medicine. Antibacterial activities of *Lallemantia royleana* seeds were reported (Mahmood *et al*., 2013).

Bioactive compounds
Thirty-seven compounds have been known and main compounds are *trans*-pinocarvyl acetate, pinocarvone, β-pinene, (*E*)-β-ocimene, terpinolene, linalool, *trans*- pinocarveol, 3-thujen-2-one, myrtenal, verbenone, *trans*-carveol, *cis*-carveol, pulegone, carvacrol, dihydrocarvyl acetate and β-cubebene (Javad *et al*., 2014).

Efficacy of *Lallemantia royaleana* extracts against *Meloidogyne incognita*
The efficacy of *Lallemantia royaleana* extract at various doses against *M. incognita* is depicted in Table 8.

The results showed proportional increase in mortality with increase in dose per liter. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed that maximum mortality of 78% was in laboratory experiments at 3g/liter dose and same dose has also shown highest management effect in pot experiments. Minimum mortality was 10% in laboratory experiment at a dose of 1.5g/liter.

During laboratory experiments maximum mortality of 78% was recorded at a dose of 3gms/liter, followed by 42%, 22% and10% at doses of 2.5, 2.0 and 1.5, respectively while doses of 1.0 and 0.5g/liter showed no efficacy.While pot experiment showed minimum juvenile population 44369.5 at highest doses of 3g/liter followed by 5026.4, 5888.2, 6162.2, 6503.5 and 6595.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 2.0, 2.5 and 2.8 at doses of 2.5, 2.0 and 1.5, respectively. The doses 1.0 and 0.5g/liter showed 3.0 RKI. Repruductive factor (RF) was also minimum 0.69 at dose of 3g/liter followed by 0.80, 0.94, 0.98, 1.04 and 1.05 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the dose values of treatments were significantly different from each other both in

laboratory and pot experiments. Antibacterial activities of *Lallemantia royleana* seeds were reported (Mahmood *et al*., 2013) but nematicidal activity against *Meloidogyne* spp. was not found in literature search.

Table 8. Efficacy of *Lallemantia royaleana* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{e}	6595	3.0^{a}	1.05^{b}
1.0^{g}	0^{e}	6503	3.0^{a}	1.04^{c}
1.5^{g}	10^{d}	6162	2.8^{b}	0.98^{d}
2.0^{g}	22^{c}	5888	2.5^{c}	0.94^{e}
2.5^{g}	44^{b}	5026	2.0^{d}	0.80^{f}
3.0^{g}	78^{a}	4369	1.0^{e}	0.69^{g}
Control	0^{e}	6666	3.0^{a}	1.06^{a}
Furadan	100^{a}	0	0^{f}	0^{h}
LSD	3.57		0.117	0.001

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Perovskia abrotanoides* Boiss**

Systematics of *Perovskia brotanoides*
Class: Magnoliopsida
Order: Lamiales
Family: Lamiaceae
Genus: *Perovskia*
Species:*abrotanoides*
Local Names: Russian Sage, Guwari darnain,

Distribution
Afghanistan, Pakistan (Balochistan, Quetta), Iran (EC-Iran, S-Iran, W-Iran: Mts.), Iraq (NE-Iraq), China, Russia, North America and East Europe.

Economic importance
Perovskia has a long history of use in traditional medicine, especially as an antipyretic. It has also been employed as an antiparasitic and analgesic. In Balochistan, Pakistan, a decoction of the plant's leaves and flowers has been considered an anti-diabetic medication and a treatment for dysentery. This species is considered a candidate for use in control of insect and nematodes *(*Hussain *et al*., 2008, 2009).

Bioactive compounds
Sixty bio active compounds are known out of these sixty compounds major compounds are α-cadinol, 1,8-cineole, borneol, camphor, α-pinene , α-bisabolol, torreyol , methylcitronellate, nerol and Ethyl acetate. (Javad & Hossein, 2010).

Efficacy of *Perovskia abrotanoides* extracts against *Meloidogyne incognita*
The efficacy of *Perovskia abrotanoides* extracts against *M. incognita* is depicted in Table 9.

The results showed high mortality at higher doses in laboratory experiment. Further laboratory experiments showed more effectiveness as compared to pot experiments. The results showed maximum mortality of 79% in laboratory experiment at 3g/liter dose. Furthermore, the same doses have also showed positive effect in pot experiment.

In laboratory experiment maximum mortality of 79% was recorded at a dose of 3g/liter, followed by 70%, 11% and 6% at doses 2.5, 2.0 and 1.5g/liter, respectively. The doses of 1.0 and 0.5g/liter had no efficacy against *M. incognita.* Pot experiment showed minimum juvenile population 4876.2 at highest doses of 3g/liter followed by 5477.2, 6566.2, 7058.2, 7168.2, 7333.5 and 7365.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was observed minimum 1.5 at dose of 3g/liter followed by 2.5 at dose of 2.5g/liter, 2.8 at doses of 2.0 and 1.5 and 3.0 at doses of 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.78 at dose of 3g/liter followed by 1.05, 1.12 and 1.14 at doses 2.5, 2.0g/liter. The doses 1.0 and 0.5g/liter showed 1.17 reproductive factors.

All the values of mortality were significantly different from each other both in laboratory and pot experiments. Hussain *et al*., (2008-2009) considered this plant species is a best candidate for the controlling on insect and nematode.

Table 9. Efficacy of *Perovskia abrotanoides* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{f}	7365	3.0^{a}	1.17^{a}
1.0^{g}	0^{f}	7333	3.0^{a}	1.17^{a}
1.5^{g}	6^{e}	7168	2.8^{b}	1.14^{c}
2$^{.0}$	11^{d}	7058	2.8^{b}	1.12^{d}
2.5^{g}	70^{c}	6566	2.5^{c}	1.05^{e}
3.0^{g}	79^{b}	4876	1.5^{d}	0.78^{f}
Control	0.33^{f}	7255	3.0^{a}	1.16^{b}
Furadan	100^{a}	0	0^{e}	0^{g}
LSD	2.54		0.0615	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Valeriana wallichii* Boiss**

Systematics of *Valeriana wallichii*
Class: Magnoliopsida
Order: Dipsacales
Family: Valerianiaceae
Genus: *Valeriana*
Species:*wallichii*
Local Names: Mushke bala, Asaroon.

Distribution
Afghanistan, Pakistan (Balochistan, Quetta, Kalat Northern area, Kashmir)and India.

Economic importance
Plant root/rhizome parts are highly aromatic and as a result Valerian oil in great demand (Mathela *et al*., 2005). According to Kim *et al*., (2008) some of the medicinal plants and valerian (*Valeriana wallichii*) has good nematicidal property.

Bioactive compounds
Following bioactive compounds that possess nematicidal property have identified by Kim *et al*., (2008) are benzaldehyde, *trans*-cinnamyl alcohol, *cis*-asarone, octanal, nonanal, decanal, *trans*-2-decenal, undecanal, dodecanal, decanol, and *trans*-2-decen-1-ol.

Efficacy of *Valeriana wallichii* extracts against *Meloidogyne incognita*
The efficacy of *Valeriana wallichii* extract at various doses against *M. incognita* is depicted in Table 10.

The results showed an increase in mortality at higher doses both in laboratory and pot experiments. Further Laboratory experiments showed more effectiveness as compared to pot experiments. The results showed maximum mortality of 47% in laboratory experiments at 3g/liter. The same dose showed positive effect on RKI and RF in pot experiments.

During laboratory experiments maximum mortality of 47% was recorded at a dose of 3g/liter, followed by 21%, 16% and 12% at doses 2.5, 2.0 and 1.5, respectively; the doses of 1.0 and 0.5g/liter did not show any effect against *M. incognita*.

While pot experiment showed minimum juvenile population 5869.6 at highest dose of 3g/liter followed by 6505.3, 7012.4, 7626.5, 8035.2 and 8746.3 juveniles at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.5, 2.5, 2.8, 3.0 and 3.2 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.93 at dose of 3g/liter followed by 1.04, 1.12, 1.22, 1.28 and 1.39 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter.
All the dose values are significantly different from each other both in laboratory (mortality %) and in pot experiments (RKI and RF).

Similar observations were made by Kim *et al*., (2008) that some of the medicinal plants and valerian (*Valeriana wallichii*) has good nematicidal property.

Table 10. Efficacy of *Valeriana wallichii* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{f}	8746	3.2^{b}	1.39^{b}
1.0^{g}	0^{f}	8035	3.0^{c}	1.28^{c}
1.5^{g}	12^{e}	7626	2.8^{d}	1.22^{d}
2.0^{g}	16^{d}	7012	2.5^{e}	1.12^{e}
2.5^{g}	21^{b}	6505	1.5^{f}	1.04^{f}
3.0^{g}	47^{c}	5859	1.0^{g}	0.93^{g}
Control	0.33^{f}	8967	3.4^{a}	1.43^{a}
Furadan	100^{a}	0	0^{h}	0^{h}
LSD	1.9		0.109	0.001

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Matricaria lasiocarpa* L.**

Systematics of *Matricaria lasiocarpa*
Class: Magnoliopsida
Order: Asterales
Family: Asteraceae
Genus: *Matricaria*
Species:*lasiocarpa*
Local Names: Baboona, Pehun Pholi

Distribution
Afghanistan, Pakistan (Quetta, Kalat, Mastung, Zairat, Loralai, Peshawar, Mansehra, Kashmir), Iran, Russia and Europe.

Economic importance
Research with animals suggests anti-spasmodic, anxiolytic, anti-inflammatory and some anti-mutagenic. It has a strong anti-microbial property. It contains rare blue essential oil which has property to inhibit worms (Nematode) (McKay & Blumberg, 2006).

Bioactive compounds
Apigenin-7-*O*-glucoside. Phenolic compounds, glycoside (Srivastava & Gupta, 2009), flavonoid, gallic acid and quercetin (Haghi *et al*., 2014).

Efficacy of *Matricaria lasiocarpa e*xtracts against *Meloidogyne incognita*
The efficacy of *Matricaria lasiocarpa* extracts at various doses against *M. incognita* is depicted in Table 11.

The results showed increase in mortality at higher doses per liter as compared to low doses. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 50% in laboratory experiment at 3grm/liter dose. The same dose showed the highest positive effect on root-knot index and reproductive factor in pot experiments.

In laboratory experiment maximum mortality of 50% was recorded at a dose of 3g/liter, followed by 12%, and 4% at doses of 2.5 and 2.0 g/liter. The doses 1.5, 1.0 and 0.5g/liter showed no efficacy. Pot experiment showed minimum juvenile population 3532.5.2 at highest doses of 3g/liter followed by 3896.2, 4037.5, 5958.5, 6279.2 and 6854.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was also minimum 1.0 at dose of 3g/liter followed by 1.5, 2.5 and 2.8 at doses of 2.5, 2.0 and 1.5. Further the doses 1.0 and 0.5 showed same results of 3.0. Reproductive factor (RF) was also minimum 0.56 at dose of 3g/liter followed by 0.62. 0.64, 0.95, 1.0 and 1.09 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the dose values are significantly different from each other both in laboratory and pot experiments. Radwan *et al*., (2012) reported that *Matricaria lasiocarpa* showed high nematicidal property at different concentrations among nine different medicinal and aromatic plants against root-knot nematode on tomato.

Table 11. Efficacy of *Matricaria lasiocarpa* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort.% **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{e}	6854	3.0^{b}	1.09^{b}
1.0^{g}	0^{e}	6279	3.0^{b}	1.0^{c}
1.5^{g}	0^{e}	5958	2.8^{c}	0.95^{d}
2.0^{g}	4^{d}	4037	2.5^{d}	0.64^{e}
2.5^{g}	12^{c}	3896	1.5^{e}	0.62^{f}
3.0^{g}	50^{b}	3532	1.0^{f}	0.56^{g}
Control	0^{e}	6926	3.2^{a}	1.10^{a}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	1.34		0.012	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Ephedra procera* L.**

Systematics of *Ephedra procera*
Class: Gnetopsida
Order: Ephedrales
Family: Ephedraceae
Genus: *Ephedra*
Species:*procera*
Local Names: Naromb

Distribution
It is distributed in Asia from Iran to Russia including Pakistan, Afghanistan, China and India. It is also grown in Europe and America.

Economic importance

Ephedra spp. has been used for specific illnesses from date back to 5000 BC. It has traditionally been used by indigenous people for a variety of medicinal purposes, including treatment of asthma, hay fever and the common cold (Abourashed *et al*., 2003). Marby *et al*., (2016) reported that *A. procera* has nematicidal property.

Bioactive compounds

Ephedrine, *Pseudoephedrine*, *bis* (2-ethylhexyl) phthalate, pentacosane, docosane, citronellol, heptadecan, *cis*-3-Hexen-1-ol benzoate and 7-Octen-2-ol (Shahrokh *et al*., 2009).

Efficacy of *Ephedra procera* extracts against *Meloidogyne incognita*
The efficacy of *Ephedra procera* extract at various doses against *M. Incognita* is depicted in Table 12.

The results showed increase in mortality at high doses as compared to low doses. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 58% in laboratory experiment at 3g/liter. The same dose had also shown highest check in root-knot index and reproductive factors.

In laboratory experiments maximum mortality of 58% was recorded at a dose of 3g/liter, followed by 22%, 9%, 5%, 4% and 1% at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. While pot experiment showed minimum juvenile population 4587.5 at highest dose of 3g/liter followed by 5496.2, 6053.5, 6864.2, 7093.5 and 7385.2 juvenile population at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.8, 2.5, 2.8, 3.5 and 3.6 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.73 at dose of 3g/liter followed by 0.87, 0.96, 1.09, 1.13 and 1.18 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the values of mortality are significantly different from each other both in laboratory and pot experiments.

The result of current research is in conformity with the results of Qiu-Xue *et al*., (2008) who reported that out of 22 plants extracts *Ephedra*, *Artemisia* and six other plants showed high

mortality than others. The mortality of *M. incognita* was more than 50%.

Table 12. Efficacy of *Ephedera procera* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	1^{f}	7385	3.6^{a}	1.18^{a}
1.0^{g}	4^{e}	7093	3.5^{b}	1.13^{b}
1.5^{g}	5^{e}	6864	2.8^{d}	1.09^{c}
2.0^{g}	9^{d}	6053	2.5^{e}	0.96^{d}
2.5^{g}	22^{c}	5496	1.8^{f}	0.87^{e}
3.0^{g}	58^{b}	4587	1.0^{g}	0.73^{f}
Control	0^{f}	7065	3.2^{c}	1.13^{b}
Furadan	100^{a}	0	0^{h}	0^{g}
LSD	2.1		0.021	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Carum copticum* L.**

Systematics of *Carum copticum*

Class: Magnoliopsida
Order: Apiales
Family: Apiaceae
Genus: *Carum*
Species:*copticum*
Local Names: Ajwain

Distribution

Afghanistan, Pakistan, Iran

Economic importance

Ajwain with its characteristic aromatic smell and pungent taste is widely used in pharmaceutical industries. *Carum copticum* has been shown to possess antimicrobial, nematicidal and anthelmintic properties (Priestley *et al*., 2003; Bonjar, 2004; Pelczar *et al*., 1988).

Bioactive compounds

p-cyme-3-ol , o-cymene , gamma-terpines and beta-pinene, terpenoids, steroids, flavonoids, alkaloids glycosides and reducing sugar, Ca, Mg, Fe and Mn (Hassan *et al*., 2016).

Efficacy of *Carum copticum* extracts against *Meloidogyne incognita*

The efficacy of *Carum copticum* extract at various doses against *M. incognita* has depicted in Table 13.

The results showed mortality only at highest dose both in laboratory and pot experiments. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of only 23% in laboratory experiments at 3g/liter and same dose had also showed significant effect in reducing root-knot index and reproductive factor in pot experiments.

In laboratory experiment mortality of 23% recorded only at a dose of 3g/liter. Other doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter showed zero mortality. Similarly pot experiment showed minimum juvenile population 3857.5 at highest doses of 3g/liter followed by 4989.2, 5084.2, 5368.2, 5523.2 and 5757.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.5, 2.0, 2.2, 2.5 and 2.8 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.61 at dose of 3g/liter followed by 0.79, 0.81, 0.85, 0.88 and 1.08 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the dose values are significantly different from each other both in laboratory and pot experiments. Nematicidal and anthelmintic properties of *Carum copticum* was also proven by Priestley *et al*., (2003); Bonjar (2004) and Pelczar *et al*., (1988).

Table 13. Efficacy of *Carum copticum* extracts against *Meloidogyne incognita* during 2016.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5	0	5757	2.8	1.08
1.0	0	5523	2.5	0.88
1.5	0	5368	2.2	0.85
2.0	0	5084	2.0	0.81
2.5	0	4989	1.5	0.79
3.0	23	3857	1.0	0.61
Control	0	6223	3.0	0.99
Furadan	100	0	0	0
LSD	1.02		0.088	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Berberis balochistanica* Ahmad**

Systematics of *Berberis balochistanica*
Class: Magnoliopsida
Order: Ranunculales
Family: Berberidaceae
Genus: *Berberis*
Species:*balochistanica*
Local Names: Zarch

Distribution
Endemic into Balochistan, Pakistan.

Economic importance
Berberis contains active principles which are highly potent against parasites. Parasite causes a quantum of health hazard and economic losses to both animals and plants. The crude extract of *Berberis* is the best selection that has anthelmintic (Nematicidal) efficacy without any side effects (Bauri *et al.*, 2015).

Bioactive compounds
Alkaloids including barberine, plamitine, berbamine, baluchistanamine, karakoramine, gilgitine, jhelumine, punjabine, sindamine, chinabine, umbellatine, vitamin C, carbohydrates, protein, lipids, saponins, hydrolysable tannins and cardioactive glycosides (Gulfraz *et al*., 2004).

Efficacy of *Berberis balochistanica* extracts against *Meloidogyne incognita*
The efficacy of *Berberis balochistanica* extract at various doses against *M. incognita* is presented in Table 14.

The results showed proportional increase in mortality with increase in dose per liter. Further Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 56% was in laboratory experiment at 3g/liter and 2.5g/liter doses. The dose of 3g/liter has also shown highest effect in reducing RKI and RF values in pot experiments.

In laboratory experiments maximum mortality of 56% was recorded at doses of 3g and 2.5g/liter, followed by 22%, 15%, 4% and3% at doses 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Pot experiment showed minimum juvenile population 5176.5 at highest doses of 3g/liter followed by 5822.5, 6055.2, 7776.5, 8593.2 and 8866.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was minimum 1.5 at dose of 3g/liter followed by 2.0, 2.5, 2.8, 2.8, 3.2 and 3.5 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.82 at dose of 3g/liter followed by 0.93, 0.96, 1.24, 1.37 and 1.41 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the dose values are significantly different from each other both in laboratory and pot experiments.

The result obtained from current research was in agreement with t*he results of* Bauri et al., (2015) that mortality of M. incognita increased with increase in concentration and time spawn.

Table 14. Efficacy of *Berberis balochistanica* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5[g]	3[f]	8866	3.5[a]	1.41[a]
1.0[g]	4[e]	8593	3.2[b]	1.37[c]
1.5[g]	15[d]	7776	2.8[c]	1.24[d]
2.0[g]	22[c]	6055	2.5[d]	0.96[e]
2.5[g]	56[b]	5822	2.0[e]	0.93[f]
3.0[g]	56[b]	5176	1.5[f]	0.82[g]
Control	0[g]	8756	3.5[a]	1.40[b]
Furadan	100[a]	0	0[g]	0[h]
LSD	1.77	-	0.062	0.001

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Artemisia vulgaris* Boiss**

Systematics of *Artemisia vulgaris*

Class: Asterida
Order: Asterales
Family: Asteraceae
Genus: *Artemisia*
Species:*vulgaris*
Local Names: Jirr, Afsanthin, Mugwort.

Distribution

Afghanistan, Pakistan Iran, Iraq, Russia, China, Europe and America.

Economic importance

Phyto-extracts of *Artemisia* species (Asteraceae) are employed as natural biocides (anti-insects, anti-helminthes and anti-biotics) from many centuries. From *Artemisia* toxic effects were reported for the following Nematoda genera of agro-ecological interest: *Ditylenchus* (*D. dipsaci*), *Helicotylenchus* (*H. dihystera*), *Meloidogyne* (*M. incognita*, *M. javanica*, *M. megadora*), *Pratylenchus* (*P. vulnus*), *Rotylenchulus* (*R. reniformis*) by Salvatore (2011).

Bioactive compounds

Terpenes, including camphor, eucalyptol, alpha-pinene, and beta-pinene.Santoline, artemisine, camphene, α-thujone, 1, 8-cineole, γ-muurolene and β-caryophyllene (Sujatha & Bollipo, 2013; Barney *et al*., 2005)

Efficacy of *Artemisia vulgaris* extract against *Meloidogyne incognita*

The efficacy of *Artemisia vulgaris* extracts at various doses against *M. incognita* is depicted in Table 15.

The results showed increase in mortality at high doses. Further laboratory experiments showed more effectiveness as compared to pot experiments. The results showed maximum mortality of 44% in laboratory experiments at 3g/liter. The same dose had also shown highest mortality and significant effect on root-knot index and reproductive factor.

During laboratory experiments maximum mortality of 44% was recorded at a dose of 3g/liter, followed by 11%, 11%, 4%, 3%, and 1% at doses 2.5, 2.0,1.5, 1.0 and 0.5% g/liter. While pot experiment showed minimum juvenile population 5965.5 at highest doses of 3g/liter, respectively followed by 7224.5, 7296.2, 7395.5, 7702.2 and 7983.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Roo-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 2.5 at doses of 2.5, 2.0g/liter, 2.8 at dose of 1.5g/liter and 3.0 at doses of 1.0 a, 0.5g/liter. Reproductive factor (RF) was also minimum 0.95 at dose of 3g/liter followed by 1.15, 1.16, 1.18, 1.23 and 1.27 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.Mortality values of 11% were shown by both the doses of 2.5 and 2g/liter were not significantly different. However, it was significantly lower than 44% mortality at 3g/liter and higher than 4%, 3% and 1% shown by 1.5, 1.0 and 0.5g/liter.

Qiu-Xue *et al*., (2008) obtained the results as found in the current research that *Artemisia* showed high mortality of *M. incognita.*

Table 15. Efficacy of *Artemisia vulgaris* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	1^{e}	7983	3.0^{b}	1.27^{b}
1.0^{g}	3^{d}	7702	3.0^{b}	1.23^{c}
1.5^{g}	4^{d}	7395	2.8^{c}	1.18^{d}
2.0^{g}	11^{c}	7296	2.5^{d}	1.16^{e}
2.5^{g}	11^{c}	7224	2.5^{d}	1.15^{f}
3.0^{g}	44^{b}	5965	1.0^{e}	0.95^{g}
Control	0^{e}	8047	3.2^{a}	1.28^{a}
Furadan	100^{a}	0	0^{f}	0^{h}
LSD	1.62	-	0.014	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Peganum harmala* L.**

Systematics of *Peganum harmala*

Class: Magnoliopsida
Order: Sapindales
Family: Nitrariaceae
Genus: *Peganum*
Species:*harmala*
Local Names: Harmal, Kissa koor, Isband.

Distribution

Origin of *Peganum harmala* is of Asia. It is cultivated in Middle East, South Asia (India and Pakistan), Russia, Tibet, Mexico and United States (Davison *et al*., 2001).

Economic importance

Saeed *et al*., (2015) reported that *Peganum harmala* extract has nematicidal property against juveniles of various nematode species associated with banana. *Peganum harmala* based products have nematicidal property (El-Hassan *et al*., 2013).

Bioactive compounds

Harmaline, harmine, harmalol, harman, quinazoline derivatives, vasicine, vasicinone, anthroquinons and fixed oils (Jinous & Fereshteh, 2012).

Efficacy of *Peganum harmal a*extracts against *Meloidogyne incognita*

The efficacy of *Peganum harmala* extracts at various doses against *M. incognita* is depicted in Table 16.

The result showed very low mortality of 6.67% in laboratory experiments at 3g/liter dose and the same dose also showed significant effect on different management parameters in pot experiments. Maximum effect on RKI and RF was at dose of 3g/liter.While in laboratory experiments doses of 0.5, 1.0, 1.5, 2.0 and 2.5g/liter showed no efficacy. While pot experiment showed minimum juvenile population 5764.5 at highest doses of 3g/liter followed by 6075.5, 6218.5, 6273.2, 6456.5 and 6892.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.5 at dose of 3g/liter followed by 2.0 at doses of 2.5, 2.0g/liter, 2.5 at doses 1.5, 1.0g/liter and 2.8 at dose of 0.5g/liter. Reproductive factor (RF) was also minimum 0.92 at dose of 3g/liter followed by 0.97, 0.99, 1.0, 1.03 and 1.10 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.These results well agree with those obtained by other authors (Alireza and Moosavi, 2016; El-Hassan *et al*., 2013) who repored the nematicidal property of *Peganum harmala* against *Meloidogyne javanica.*

Table 16. Efficacy of *Peganum harmala* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{c}	6892	2.8^{b}	1.10^{b}
1.0^{g}	0^{c}	6456	2.5^{c}	1.03^{c}
1.5^{g}	0^{c}	6273	2.5^{c}	1.0^{d}
2.0^{g}	0^{c}	6218	2.0^{d}	0.99^{e}
2.5^{g}	0^{c}	6075	2.0^{d}	0.97^{t}
3.0^{g}	6.67^{b}	5764	1.5^{e}	0.92^{g}
Control	0^{c}	7002	3.0^{a}	1.12^{a}
Furadan	100^{a}	0	0^{t}	0^{h}
LSD	0.38	-	0.064	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Saphora alopecuroides* L.**

Systematics of *Saphora alopecuroides*
Class: Magnoliopsida
Order: Fabeles
Family: Fabaceae
Genus: *Saphora*
Species:*alopecuroides*
Local Names: Busunduk, Shampashtir

Distribution
Afghanistan, Pakistan, China and Iran.

Economic importance
Xiao-Ping (2000) in his research identified two alkaloids; aloperine and Δ^{11}-dehydroaloperine by GC-MS and HPLC from extracts of *Sophora* which were assayed agianst nematode. The results showed strong nematicidal activity.

Bioactive compounds
Three major alkaloid of biologically active viz., Sophoridine, matrine and oxymatrine have been identified **(**Zhu, 2012).

Efficacy of *Saphora alopecuroides* extract against *Meloidogyne incognita*
The efficacy of *Saphora alopecuroides* extract at various doses against *M. incognita* is depicted in Table 17.

The results showed considerable effect in pot experiment at 3g/liter dose followed by other doses. The same dose showed mortality of 40% in laboratory experiments followed by 14% at dose 2.5g/liter. Furthermore during laboratory experiments doses of 0.5, 1.0, 1.5, 2.0g/liter showed no efficacy. While pot experiment showed minimum juvenile population 5189.5 at highest doses of 3g/liter followed by 8217.5, 8493.5, 8584.2, 8675.5 and 8898.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 2.5 at dose of 2.5g/liter, 3.0 at doses of 2.0, 1.5g/liter, 3.2 at dose of 1.0g/liter and 3.5 at dose of 0.5g/liter. Reproductive factor (RF) was also minimum 0.83 at dose of 3g/liter followed by 1.31, 1.35, 1.37, 1.38 and 1.42 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter,respectively.

Mortality values in 3.0 and 2.5g/liter were significantly different. Higher doses showed high values of mortality. Same results were reported by Xiao-Ping (2000) that extracts of *Sophora* sp. showed strong nematicidal activity agianst nematodes.

Table 17. Efficay of *Saphora alopecuroides* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{d}	8898.2	3.5^{b}	1.42^{b}
1.0^{g}	0^{d}	8675.5	3.2^{c}	1.38^{c}
1.5^{g}	0^{d}	8584.2	3.0^{d}	1.37^{d}
2.0^{g}	0^{d}	8493.5	3.0^{d}	1.35^{e}
2.5^{g}	14^{c}	8217.5	2.5^{e}	1.31^{f}
3.0^{g}	40^{b}	5189.5	1.0^{f}	0.83^{g}
Control	0^{c}	9024.2	3.8^{a}	1.44^{a}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	1.6		0.016	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Artemisia absinthium* L.**

Systematics of *Artemisia absinthium*
Class:Asterida
Order: Asterales
Family: Asteraceae
Genus: *Artemisia*
Species:*vulgaris*
Local Names: Jirr, Afsanthin

Distribution
Afghanistan, Pakistan Iran, Iraq, Russia, China, Europe and America.

Economic importance
Artemisia sp. on Nematoda worms' toxic effects were reported for the following Nematoda genera of agro-ecological interest: *Ditylenchus* (*D. dipsaci*), *Helicotylenchus* (*H. dihystera*),

Meloidogyne (*M. incognita*, *M. javanica*, *M. megadora*), *Pratylenchus* (*P. vulnus*), *Rotylenchulus* (*R. reniformis*) by Salvatore (2011).

Bioactive compounds

Characterstic compound Afsinthine, quinine, Terpenes, including camphor, eucalyptol, alpha-pinene, and beta-pinene; Santoline, artemisine.camphene, α-thujone, 1, 8-cineole, γ-muurolene and β-caryophyllene (Sujatha & Bollipo, 2013; Barney *et al*., 2005).

Efficacy of *Artemisia absinthium* extract against *Meloidogyne incognita*

The efficacy of *Artemisia absinthium* extract at various doses against *M. incognita* is depicted in Table 18.

The results showed proportional increase in mortality with increase in dose per liter. Further Laboratory experiments showed more effectiveness as compared to pot experiments. The results showed maximum mortality of 64% in laboratory experiments at 3g/liter dose. The same dose also showed highest effect in pot experiments. Minimum mortality was 1% in laboratory experiments at a dose of 0.5g/liter.

During laboratory experiments maximum mortality of 64% was recorded at a dose of 3g/liter, followed by 23%, 11%, 7%, 4% and 1% at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Pot experiment showed minimum juvenile population 4564.2at highest doses of 3g/liter followed by 5008.2, 6048.2, 6393.5, 6573.2 and 6784.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.5, 2.0, 2.5, 2.8 and 3.0 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter. Reproductive factor (RF) was also minimum 0.73 at dose of 3g/liter followed by 0.80, 0.96, 1.02, 1.05 and 1.08 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

All the dose values were significantly different from each other both in laboratory and pot experiments.

Qiu-Xue *et al*., (2008) reported that *Artemisia* and other plants possess strong mortality property against *M. incognita* as we also found the similar findings.

Table 18. Efficacy of *Artemisia absinthium* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	1^{g}	6784	3.0^{a}	1.08^{a}
1.0^{g}	4^{f}	6573	2.8^{b}	1.05^{c}
1.5^{g}	7^{e}	6393	2.5^{c}	1.02^{d}
2.0^{g}	11^{d}	6048	2.0^{d}	0.96^{e}
2.5^{g}	23^{c}	5008	1.5^{e}	0.80^{f}
3.0^{g}	64^{b}	4564	1.0^{f}	0.73^{g}
Control	0^{f}	6666	2.8^{b}	1.06^{b}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	1.8	-	0.018	0.002

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Centratherum anthelminticum* Boiss**

Systematics of *Centratherum anthelminticum*

Phylum: Tracheophyta
Class: Magnoliopsida
Order: Asterales
Family: Asteraceae
Genus: *Centratherum*
Species:*anthelminticum*
Local Names: Purple Flebane, Kalijirri

Distribution

Afghanistan, Pakistan (Balochistan, Quetta), Iran (EC-Iran, S-Iran, W-Iran: Mts.), Iraq (NE-Iraq), Caucasus.

Economic importance

As the name *"anthelminticum"* indicated that it acts as anthelmintic, which is likely to be more effective against roundworm and tapeworm and a wide range of intestinal worms (Nematodes) It

is also best for the diseases including ulcer, eczema, skin irritation leucoderma and diabetes (Sing, 2016).

Bioactive compounds

Polyphenolic compounds *viz.*, gallic acid, protocatechuic acid, caffeic acid, ellagic acid, ferulic acid, quercetin and kaempferol **(**Ani & Akhilender, 2008)

Efficacy of *Centratherum anthelminticum* extracts against *Meloidogyne incognita*

The efficacy of *Centratherum anthelminticum* extract at various doses against *M. incognita* is depicted in Table 19.

The results showed proportional increase in mortality with increase in dose per liter. Laboratory experiments showed more effectiveness as compared to pot experiments. The results showed maximum mortality of 54% in laboratory experiments at 3g/liter dose. The same dose also showed highest effectiveness in pot experiment. Minimum mortality was 2% in laboratory experiments at a dose of 1.0g/liter. In laboratory experiment maximum mortality of 54% was recorded at a dose of 3g/liter, followed by 22%, 8%, 7% and 2% at doses of 2.5, 2.0, 1.5, and 1.0g/liter, respectively. While dose 0.5g/liter showed no efficacy. While pot experiment showed minimum juvenile population 4545.5 at highest doses of 3g/liter followed by 5245.5, 7376.2, 7883.5, 8946.2 and 8135.5 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively.

Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 2.0, 2.5, 2.8 at doses of 2.5, 2.0, 1.5g/liter and 3.0 at doses of 1.0, 0.5g/liter. Reproductive factor (RF) was also minimum 0.72 at dose of 3g/liter followed by 0.81, 1.18, 1.26, 1.28 and 1.30 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter.

In laboratory experiments there was significant difference between mortality of 54% and 22% obtained at 3 and 2.5g/liter. Similarly the 7% and 2% mortality values obtained at 1.5 and 1g/liter were also significant from each other.
Only 8% and 7% mortality values obtained at 2 and 1.5g/liter were non-significant from each other in laboratory experiments. However, in pot experiments all the values were significant from each other.

Table 19. Efficacy of *Centratherum anthelminticum* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{f}	813	3.0^{a}	1.30^{a}
1.0^{g}	2^{e}	8046	3.0^{a}	1.28^{c}
1.5^{g}	7^{d}	7883	2.8^{b}	1.26^{d}
2.0^{g}	8^{d}	7376	2.5^{c}	1.18^{e}
2.5^{g}	22^{c}	5245	2.0^{d}	0.83^{f}
3.0^{g}	54^{b}	4545	1.0^{e}	0.72^{g}
Control	0^{f}	8065	3.0^{a}	1.29^{b}
Furadan	100^{a}	0	0^{f}	0^{h}
LSD	1.45		0.018	0.011

*Values in a column having different letters are significantly different from each other.
**Lab experiment

***Fagonia cretica* Boiss**

Systematics of *Fagonia cretica*

Phylum: Tracheophyta
Class: Magnoliopsida
Order: Zygophyllales
Family: Zygophyllaceae
Genus: *Fagonia*
Species:*cretica*
Local Names: Tirkh

Distribution

Found in deserts and dry areas from India to Tropical Africa and in Chile as well as USA. In UAE it is widespread. In Pakistan it is wildly grown in all provinces.

Economic importance

Fagonia sp. (Zygophyllaceae) is commonly used in the indigenous system of medicine for

treatment of conditions like diabetes, cancer, fever, asthma, toothache, stomach troubles and kidney disorders. Research studies showed that *Fagona* sp. hasantimicrobial (Antibacterial, nematicidal, antifungal) and cytotoxic activitis. (Umbreen *et al*., 2013).

Bioactive compounds

Terpenoids, flavonoids, quinovic acid , quinovic acid-3*β*-O-*β*-D-glycopyranoside, quinovic acid-3*β*-O-*β*-D-glucopyranosyl-(28→1)-*β*-D-glucopyranosyl ester, stigmasterol and triterpenoidlupeol. Sulfate dtriterpenes, sulfated triterpene glycosides, sapogenins 3β, 27-dihydroxyolean-12-en-28-oic acid and 3β, 27-dihydroxyurs-12-en-28-oic acid (Angela *et al*., 2007).

Efficacy of *Fagonia cretica* extractsagainst *Meloidogyne incognita*

The efficacy of *Fagonia cretica* extract at various doses against *M. Incognita* is depicted in Table 20.

The results showed considerable increase in mortality with increase in dose per liter. Further, Laboratory experiments showed more effectiveness as compared to pot experiment. The results showed maximum mortality of 54% in laboratory experiment at 3g/liter dose. The same dose also showed highest effect in pot experiments.

In laboratory experiments maximum mortality of 54% was recorded at a dose of 3g/liter, followed by 17% and 11% at doses of 2.5 and 2.0g/liter. While doses of 1.5, 1.0 and 0.5g/liter showed no mortality. While pot experiment showed minimum juvenile population 4366.2 at highest doses of 3g/liter followed by 5088.3, 5286.2, 6999.2, 7186.5, and 7954.2 at dose rates of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Root-knot index (RKI) was minimum 1.0 at dose of 3g/liter followed by 1.5, 2.0.2.5, 2.8 and 3.0 at doses of 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. Reproductive factor (RF) was also minimum 0.69 at dose of 3g/liter followed by 0.81, 0.84, 1.11, 1.14 and 1.27 at doses 2.5, 2.0, 1.5, 1.0 and 0.5g/liter, respectively. The dose values obtained in laboratory and pot experiments were significantly different from each other. The results are in accordance with the results obtained by Umbreen *et al*., (2013) but mortality was more in the current activity than reported earlier.

Table 20. Efficacy of *Fagonia cretica* extracts against *Meloidogyne incognita*.

Treatment (g/liter)	Mort. % **	Pot Experiment		
		J_2 popul.	RKI	RF
0.5^{g}	0^{e}	7954	3.0^{a}	1.27^{a}
1.0^{g}	0^{e}	7186	2.8^{b}	1.14^{c}
1.5^{g}	0^{e}	6999	2.5^{c}	1.11^{d}
2.0^{g}	11_{d}	5286	2.0^{d}	0.84^{e}
2.5^{g}	17^{c}	5088	1.5^{e}	0.81^{f}
3.0^{g}	54^{b}	4366	1.0^{f}	0.69^{g}
Control	0^{e}	7864	3.0^{a}	1.25^{b}
Furadan	100^{a}	0	0^{g}	0^{h}
LSD	1.02		0.064	0.010

*Values in a column having different letters are significantly different from each other.
**Lab experiment

Discussion

In vitro all the tested plant extracts were significantly different in their toxcicity (Mortality %); *Zatoria mutiflora*, *Nepeta cateria* and *Achillea santolina* were highest in their efficacy (100% mortality) followed by *Teucrium stocksianum* (90%) and *Ferula oopoda* (89%). The least efficacy was observed in *Peganum harmala* and *Withania coagulans* (7 and 10% mortality), respectively. Similar results were recorded in pot experiments. The effect of treatments on root-knot nematodes density (J_2 population), gall index (RKI) and reproduction rate (RF) under Banana crops has Indicated in Table 1-20. Root-knot index, reproductive factor and juvenile population in soil were significantly reduced in plants extract treated with highest dose (3g/liter) as compared to control and Furadan. In pot experiments all tested plants showed significant effect on management

parameters of *M. incognita*; however, lowest juvenile population was recorded from extracts of *Matricaria lasiocarpa* which was 3532.5 at dose 3g/liter. Similarly lowest root-knot index (1.0) was recorded from extracts of fourteen medicinal and aromatic plants at dose of 3.0g/liter and reproductive factor was also minimum 0.56 at dose of 3.0g/liter from extracts of *Zatoria multiflora*, *Ferula oopoda* and *Matricaria lasiocarpa*. Regarding the root damage, all the tested plant erxtracts caused similar result with a significant reduction in the gall index compared to control.The results suggest that these plants extracts may contain phytochemical which is responsible for controlling root-knot nematode infection.

Many researchers reported the nematicidal efficacy of medicinal plant extracts in the management of plant parasitic nematodes (Abd-Elgawad and Omer, 1995; Ghazalbash and Abdollahi, 2013) especially root-knot nematodes (Korayem *et al*., 1993). Nematicidal and antifungal activity of medicinal plants viz., *F. angulata* and *Z. multiflora* were reported by Ghazalbash and Abdollahi (2011) and Abdollahi and Ghazalbash (2012). Similar observations were also reported by El-Nagdi and Mansour (2003) in their investigations of medicinal plants effect against root-knot nematodes. Our results are in agreement with the results of these earlier researchers.

All the eight major plant parasitic nematode species encountered from banana plantations in this research study are potentially damaging. The abundance and prevalence and damage associated with *M. incognita* on banana in the current study is contrary to previous studies that indicate *R. similis* and *P. goodeyi* as the most prevalent and damaging nematodes on banana (Gaidashova *et al*., 2009). *M. incognita* has been found as a most prevalent and dominant nematode species in banana crops in Pakistan especially Sindh and Balochistan where environmental conditions, temperature, soil type and rainfall are optimal for both the banana crop and *M. incognita* (Maqbool, 1991).

The results of this study revealed the significant prevalence of *Meloidogyne* spp., *Helicotylenchus multicinctus, Radopholus similis* and *Rotylenchulus reniformis*, the four most important nematodes on banana. These species are known to cause severe damage and yield losses throughout most banana growing areas in the tropical and subtropical regions of the world and their distribution is very closely linked to altitude and temperature. The current comprehensive study provides baseline information upon which further studies can extend the investigations.

Natural plant products or phytochemicals may be used as environmentally safe alternatives to control plant parasitic nematodes. Their use will be appealing and beneficial for banana growers because of the growing problem of environmental pollution by chemical nematicides. Treated plants with extracts showed greater mortality % at higher doses as compared to low dose treatment or non-treated plants in laboratory experiments. However, these phytochemicals were less effective at reducing nematodedensity in the soil which leaves the plants vulnerable to future infestations.

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