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NEMATICIDAL ACTIVITY OF JIMSON WEED (*DATURA* SPP.) FOR MANAGEMENT OF PLANT-PARASITIC NEMATODES WITH EMPHASIS ON ROOT KNOT NEMATODE: A REVIEW

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A B S T R A C T

Datura is poisonous flowering plants (Family: Solanaceae) and annual or biennial herbs. It contains different structurally diverse plant secondary metabolites like tropane alkaloids such as scopolamine, hyoscyamine and atropine. Root-knot nematode (RKN) considered from the most ten predominant plant pathogenic nematodes widely attacking economic and non-economic crops all over the world. The present review focus on the role of *Datura* spp. in nematode control, antiemetic properties, and their mechanism of control. Obtainable knowledge on the efficacy of this botanical against the most tested plant-parasitic nematodes (PPN) affecting crops from many centuries. The nematicidal activity in mortality, egg hatching, nematodes control and enhancement of plant growth as well mode of action is discussed. Data from our ongoing research regardless of Datura were included. Obtainable results revealed that Datura showed a great role in RKN management via affecting nematode egg hatching, larvae mortality, root galling or plant growth promotion by different mode of actions.

Keywords: Botanicals, Datura, plant-parasitic nematodes, *Meloidogyne* spp.

INTRODUCTION

Plant-parasitic nematodes (PPN) are deemed as one of the primaries most plant pathogens beside fungi, bacteria and viruses that critically influenced on plant production worldwide. A considerable number of PPN exceed 4000 species were described by Decraemer and Hunt (2013). The losses in plant quality and quantity according to the nematode species population level, the environmental conditions including soil and nutrients and the host plant sensitivity (Bakr and Ketta, 2018). he PPN attack host plant by different strategies as they can be an ecto-parasites, semi-ecto or semi-endo parasitic and endoparasite. The most important genera of PPN were sedentary endo-parasites such as root-knot, root lesion and cyst nematode, which induced changes in the host roots by parasitism and feeding (Hunt *et al*. 2018).

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To date up to 98 species of RKN were described but most common distributed four species were *M. incognita*, *M. arenaria, M. javanica*, and *M. hapla* (Jones *et al*., 2013). Root-knot nematode has a broad host range exceed than 3000 plant species belonging to different plant families of the most essential crops (Abad *et al*., 2003). The recorded annual losses worldwide by *Meloidogyne* spp. of about USD$ 100 billion (Brand *et al*., 2010).

Root-knot nematodes registered as a significant limiting factor in intensive agricultural cultivation system and productivity throughout the worldwide and may discourage most farmers in the newly reclaimed land from cultivating many crops (Ibrahim *et al*., 2010; Bakr *et al*., 2011,2020). It impacts on the quantity and quality of marketable vegetable yields (Kingland, 2001). Infected plants suffer vascular damages which disturb water and mineral uptake, yellowing and poor growth. Intensity galled roots of infected plants are limited the ability of roots to uptake enough water and nutrients for plant growth. Yield losses over 30% in eggplant, tomato, and melon (Sikora and Fernández, 2005). The damage extent influenced by different factors such as the cultivar, nematode species, level of soil infestation and environmental conditions. Zero yields of tomato plants may occur when grown in sandy soils infested with high nematodes population, especially in the summer season, which will influence the economic income and the control processing is exceptionally challenging (Andres *et al*., 2012). Chemicals synthetic nematicides are highly toxic to both human and the environment (Abawi and Widmer, 2000). Thus, recently the development of acceptable alternative natural eco-friendly control strategies and sustainable long-term integrative approaches using biodegradable pesticides is highly urgently needed to replace the chemical nematicides (Chitwood, 2002, Martin, 2003 and Kim *et. al*., 2005 and Ntalli *et al*., 2020). New registration procedures related to green revolution and clean agriculture lead to use natural products in crop protection (Dayan *et al*., 2009). The higher plants are among the most prominent source of different natural resources (Archana and Prasad, 2014). Plants give nutrients, fibers, wood and differentiation many chemical compounds such as oils, flavonoids and medicinal compounds such as alkaloids. The isolation, identification and bio-assaying of an active chemical component will help in the improvement of plant products in nematicides discovery (Duke, 1990). The Phytochemicals from plant metabolites are produced into the environment through volatilization, exudation from roots or leaching from plants or decomposition of the plant residues. These Phytochemicals are potency when used at small quantities, quickly decompose in the soil which leads to short persist time and less pollution problems to the environment. (Kokalis-Burelle and Rodriguez-Kabana, 2006). The phytochemicals are secondary volatile or non-volatile exudates from plant different parts viz., leaf, stem, root and flower, and became a part of integrated nematode management (INM) strategies (Manju, and Nature, 2015). Several modes of action suggested during plant-parasitic nematodes by phytochemicals included antifeedant, inducers of resistance, deterrent, repellent, juvenile toxicant, ovicidal and growth disruption properties (Kokalis-Burelle and Rodriguez-Kabana, 2006).

Plants of the genus *Datura*, family Solanaceae, are annual or biennial herbs whose height ranges between 30 to 150 cm. Descriptions of their flowers, fruits, leaves and seeds show variations (Duke, 1985; Lampe and McCann, 1985). The genus Datura has consisted of 13 species originating from the New World (Bye and Sosa, 2013). The most world widely distributed are *D. alba*, *D. arborea, D. fastuosa, D. innoxia, D. metel* and *D. stramonium*. Previous studies by many researchers were undertaken and showed the crucial role of *Datura* spp. as natural biocides against different species of plant-parasitic nematode management in many centuries.

Hence the present review was undertaken to point out the potential role of *Datura* spp. in plant-parasitic nematodes population, on egg hatching and larvae mortality, chemical component and mode of action and methods of application.

Main text

This review research carried out to provide a clear view on the possibility of using *Datura* as a nematicidal plant for PPN control using research articles, review articles, and books updated until 2020. We are entirely certain about the inability to survey all published related articles and data, but at least relevant information was provided. Our bibliographical research was conducted using our research regardless of *Datura*, different and several web search engines for data sources such as:

1- Egyptian National Agricultural Library (http://nile.enal.sci.eg)
2- Egyptian libraries union (http://srv3.eulc.edu.eg/eulc)
3- Science direct (https://www.sciencedirect.com)
4- National Centre for Biotechnology Information-Pub Med (https://www. ncbi.nlm.nih.gov/pub med).
5- Google Scholar(https://scholar.google)
6- CAB Direct (https://www.cabdirect.org/cabdirect).
7- Springer link (https://link.springer.com/)

Related previous references were collected, reads well, and important data extracted. Then data presented and organised in two figures and 8 tables. Different topics were discussed such as:1) advantages of nematicidal plants, 2) previous studies using *Datura* against different genera of plant parasitic nematodes, 3) Used parts and methods of application 4) the nematicidal effect of datura on egg hatching and 5) larvae mortality,6) efficacy on RKN control, 7) chemical contents of *Datura* and 8) mode of action in nematodes control.

Advantage of using nematicidal plants

According to the harmful effect of chemical nematicides i.e., air pollution, carcinogenicity, ozone depletion, toxicity for workers, groundwater pollution, residual effect on plant and animals and the expensive costs recent control strategies are promoting the use of natural bio-products as alternatives to the existing chemical nematicides. The most promising advantages of nematicidal plants were summarized in figure (1) as follows:

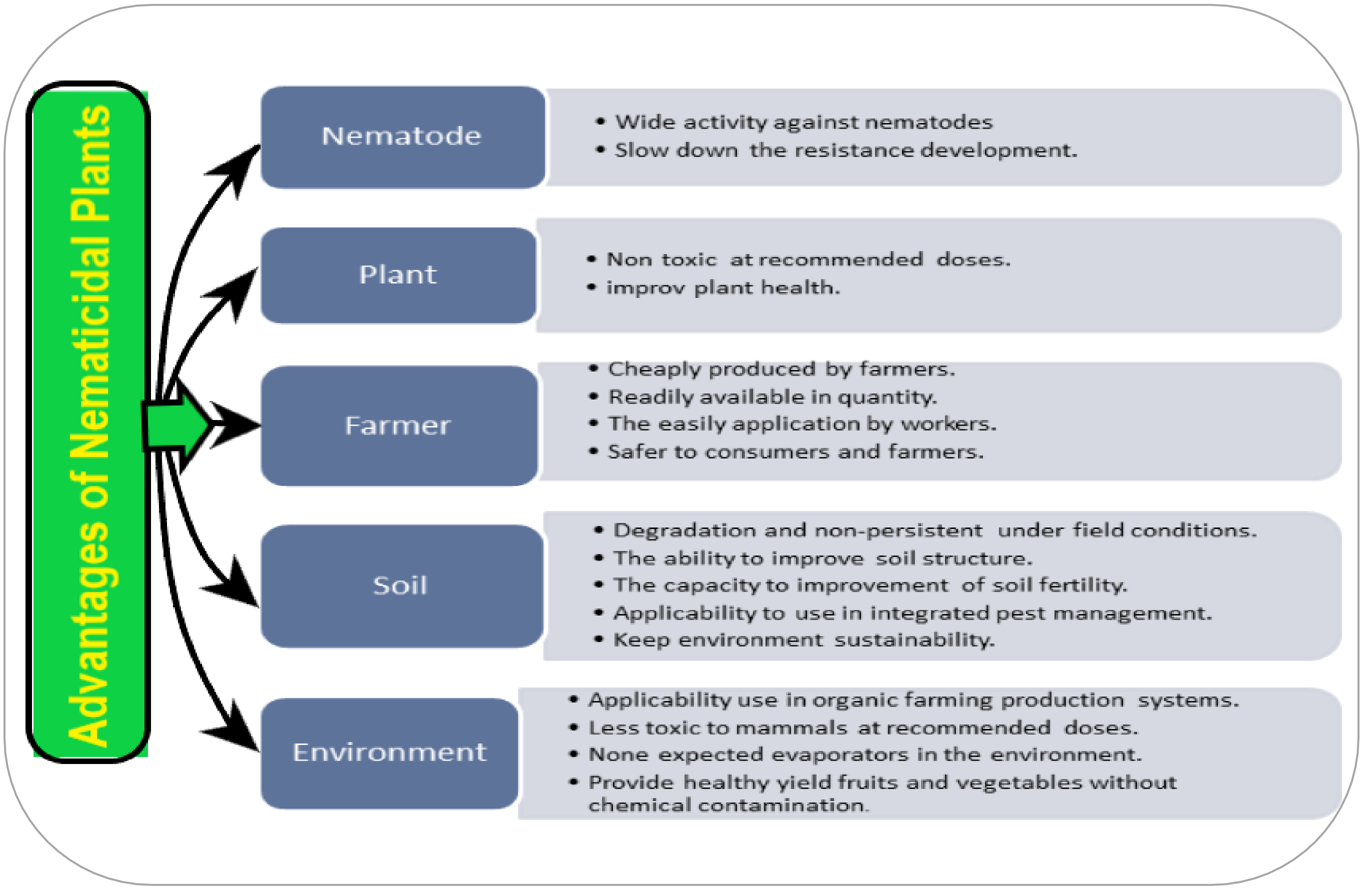

Figure 1. Advantages of using Nematicidal Plants.

Plant-parasitic nematodes controlled by Datura spp.

Datura plants using different application methods globally evaluated against various genera of PPN. The most selected species were *D. alba, D. fastuosa, D. innoxia D. metel, D. stramonium* and *D. tatula*. The toxic and nematicidal effects of *Datura* spp. reported for different PPN genera, as shown in Tables (1-8).

Table 1. Survey of previous studies of *D. alba* nematicidal effects against some plant parasitic nematode genera.

Target nematode	Used Part/ type	Test	Conditions	Country	Reference
Tylenchulus semipenetrans	Stem and roots extracts.	larval mortality	Citrus	Pakistan	Shakeel, (2000)
	Aqueous leaves extract	Nematode mortality	Laboratory	Pakistan	Ahmad *et al.*, (2004)
	Leaf extracts	larval mortality	Laboratory	Pakistan	Awan, (1992)
M. incognita	Root extracts	Egg hatching, Nematode mortality.	Laboratory	Pakistan	Kayani *et al.*, (2001)
	Leaf extract	Nematode population	Tomato	Pakistan	Pathan, (2002)
	Seed decoction	Egg hatching and mortality	Laboratory	Pakistan	Ahmad *et al.*, (1991)

Table 2. Survey of previous studies of *D. arbore* nematicidal effects against some plant parasitic nematode genera

Target nematode	Used Part/type	Test	Crop	Country	Reference
M. javanica	Plant leaves	Nematode population	Sunflower	Egypt	Amin and Youssef (1997,1999)
Rotylenchulus reniformis	Plant leaves	Nematode population	Sunflower	Egypt	Amin and Youssef (1997,1999)

Table 3. Survey of previous studies of *D. fastuosa* nematicidal effects against some plant parasitic nematode genera

Target nematode	Used Part/type	Test	Crop	Country	Reference
M. incognita	Dry leaves powder	Nematode population	Mung-bean	Pakistan	Abid *et al*., (1995)
	Leaves	Juveniles	Pigeon pea		Upadhyay *et al*., (2007)
M. javanica	Dry leaves powder	Mortality- galling	Brinjal-Okra-Mung Bean-Chickpea	Pakistan	Abid, (1996)
	Dry leaves powder	Nematode population	Okra	Pakistan	Ehteshamul-Haque *et al*., (1996)
	Leaves extracts	Nematode population	Brinjal	Pakistan	Zarina, (2003)
	Leaves extracts	Nematode population	Banana	Pakistan	Zarina, (2007)
	Ethanol extract	Nematode mortality	Laboratory	Pakistan	Abid *et al*., (1997)
	Extract of Leaves + Shoots	Egg hatching and mortality	Laboratory	Pakistan	(Shahwar, (1993)
Helicotylenchus dihystera	leaves extracts	nematode mortality-Nematode population	Laboratory-Tomato	Pakistan	Firoza and Maqbool (1996a,b)

Table 4. Survey of previous studies of *D. metel* nematicidal effects against some plant parasitic nematode genera

Target nematode	Used Part/type	Test	Crop	Country	Reference
M. incognita	Leaves	Juvenile's mortality, Egg hatching, Nematode population	Soybean	Nigeria	Akpheokhai *et al*., (2012)
	Chopped leaves	Nematode population	Eggplant	India	Alam, (1986)
	Fresh Leaves aqueous extracts	Egg hatching+ Juvenile's mortality	Chickpea	India	Parul *et al*., (2011a)
	Leaves aqueous extracts	Nematode population	Eggplant	India	Singh and Devi (2012)
	Chopped leaves	Nematode population	Potato	India	Hasan *et al*. 2014)
	Ethanol leaves extract	Juvenile's mortality	Laboratory	India	Nandakumar *et al*. (2017)
	Seed coating fresh and dried leaves	Nematode population	Chickpea	India	Parul *et al*., (2011b)
	Extract	Nematode population	Okra	Kenya	Owino (1992)
	Aqueous leaves extracts	Nematode population	Eggplant	India	Shah *et al*., (2018)
M. javanica	Intercropping and dry leaves	Galling	Tomato	Kenya	Oduor-Owino (1993,2003b)
	Dried Leaves extracts	Larval mortality and Egg hatching	Laboratory	Azarbaijan	Eskandarzadeh et al. (2020)
Tylenchorhynchus brassicae	Chopped leaves	Nematode population	Eggplant	India	Alam, (1986)
Hoplolaimus indicus	Plant extract	Larval mortality	Laboratory	Pakistan	Qamar *et al*., (1995)

Table 5. Survey of previous studies of *D. Stramonium* nematicidal effects against *M. javanica.*

Used Part/type	Test	Crop	Country	Reference
Leaves extracts	Nematode immobility	Laboratory	India	Nandal and Bhatti (1986a)
Leaves extracts	Egg hatching and galling	Brinjal	India	Nandal and Bhatti (1986b)
Intercropping	Galling	Tomato	Kenya	Oduor-Owino (2003a)
Leaves extracts	Larval mortality- galling and Nematode population	Sweet Melon	Nigeria.	Umar and Ngwamdai (2015)
Chopped and finely ground leaves	Penetration, galling and Nematode population	eggplant	India	Nandal and Bhatti (1990)
Aqueous extract	Larval mortality	tomato		Al Saba *et al*. (2001)
Fresh leaves aqueous extracts	Larval mortality	Laboratory	India	Sidhu *et al*., (2017)
Fresh Chopped leaves	Nematode population	Bottle gourd	India	Parihar *et al*., (2012)
Methanol extract	Larval mortality and Egg hatching	Laboratory	Greece	Oplos *et al*. (2018)
Aerial parts plant extract	Eggs hatching and larval mortality	Tomato	Iran	Moazezikho *et al*. (2020)
Dried Leaves extracts	Larval mortality and Egg hatching	Laboratory	Azarbaij-an	Eskandarzadeh *et al*. (2020)

Table 6. Survey of previous studies of *D. Innoxia* nematicidal effects against some plant parasitic nematode genera

Target nematode	Used Part/Type	Test	Crop	Country	Reference
Tylenchulus semipenetrans	Leaves water extracts	Nematode mortality-Nematode population	Key lime	Iran	Ayazpour *et al*., (2010)
M. incognita	Aqueous Leaves extract	Juvenile's mortality	Laboratory	Yemen	Saeed *et al*., (2015)
	Aqueous Leaves extract	Egg hatching +Juvenile's mortality	Laboratory	India	Singh *et al.,* (2015)
	Aqueous and ethanol extracts of leaves + roots+ seeds	Egg hatching and mortality-nematode population	Laboratory and tomato	Germany	Babaali *et al*. (2017)
	Ethanol leaves extract	Juvenile's mortality	Laboratory	India	Nandakumar *et al*. (2017)
	Leaf extract	Nematode population	Tomato	Pakistan	Pathan (2002)
	Aqueous dried Leaves extracts	Galls. Adult females and egg masses	Tomato	Pakistan	Ahmad (2020)
M. javanica	Aqueous extract of seeds	juvenile mortality	Okra-Cowpea	Pakistan	Siddiqui (2017)

Table 7. Survey of previous studies of *D. Stramonium* nematicidal effects against *M. incognita.*

Used Part/type	Test	Crop	Country	Reference
Leaf extracts	Larval mortality and Egg hatching	Laboratory	India	Rao *et al*., (1986)
Chopped leaves	Nematode population-Galling	Tomato	India	Imran and Saxena (1993)
Leaves extracts	Larvae mortality	Laboratory	India	Mani and Chitra (1989)
Hot water and ethanol extracts	Eggs hatching	Laboratory	Eritrea	Chaudhary *et al*., (2013)
Seed and shoot methanol extract	Larval mortality and Egg hatching	Laboratory	Greece	Oplos *et al*., (2018)
Fresh leaf extracts	Egg hatching	Cumin	India	Sharma and Trivedi (2002)
Leaves extracts	Egg hatching, larvae mortality and Nematode population	Tomato	Egypt	Bakr (2014)
Aqueous Leaves extract	Egg hatching, larvae mortality	Laboratory	Algeria	Sellami and Mouffarrah (1994)
Dried leaf powder	nematode population	Cucumber	Egypt	Mostafa *et al*. (2016)
Leaves aqueous extracts	Larvae mortality and Nematode population	Tomato	Nepal	Keshari and Gupta (2015)
Chopped leaves	Nematode population	okra	India	Safiuddin (2010)
Green chopped leaves	Nematode population	Tulsi	India	Verma and Khan (2004).
Dried ground leaves	Nematode population	okra	Pakistan	Hussain *et al*., (2011)
Dried ground leaves	Nematode population	Tomato	Egypt	Radwan *et al*., (2007)
Methanol extract of dried leave	Egg hatching and mortality	Mulberry	India	Kumari and Devi (2013) Nelaballe and Mukkara (2013a)
Leaf powder	Nematode population	Brinjal	Pakistan	Hussain *et al*. (2018)
Soil amended with leaves	Nematode population	Tomato		Chattopadhyay (1991)
Aqueous and ethanol extracts of leaves+ roots+ seeds	Egg hatching and mortality-nematode population	Laboratory and tomato	Germany	Babaali *et al*., (2017)
Seed treatment	Nematode population	okra	India	Sharma *et al*., (2006)
Leaves extracts - powder	Mortality -Nematode population	Laboratory Tomato	Nepal	Keshari and Gupta (2015)
Leaf powder	Nematode population	Tomato	Pakistan	Khan *et al*., (2000)
Water extracts	Mortality -Nematode population	Mung-bean	India	Prasad *et al*., (2002)
Extract of leaf, seed, and stem	Mortality	Laboratory	Sudan	Elbadri *et al*., (2008)
Aqueous Leaves extracts	Juvenile's mortality	Laboratory	Yemen	Saeed *et al*., (2015)
Leave powder	Nematode population	Eggplant	Egypt	Osman *et al*., (2016)
Chopped leaves	Nematode population	Mung-bean	India	Singh *et al*., (2017)

Table 8. Survey of previous studies of *D. Stramonium* nematicidal effects against *Meloidogyne* spp. and other plant parasitic nematode genera

Target nematode	Used Part/type	Test	Crop	Country	Reference
Meloidogyne spp.	Aqueous extracts (roots, leaves or fruits)	larvae mortality	Laboratory	Algeria	Hadj-Sadok *et al.,* (2014)
	Plant extracts	Nematode control	Tomato	Bulgaria	Mateeva and Ivanova (2000)
Xiphinemaamericanum	Leaf, flower, root	Nematode immobility	Laboratory	Chile	Insunza *et al*., (2001)
Helicotylenchusmulticinctus	Plant extracts	Larval mortality	Laboratory	Pakistan	Qamar *et al*., (1995)
Rotylenchulusreniformis	Leaves and roots	Juveniles	Laboratory	India	Singh and Prasad (2010)
	Water extracts	Mortality - Nematode population	Mung bean	India	Prasad *et al*., (2002)
	Dried leaf powder	Nematode population	Cantaloupe	Egypt	Mostafa *et al*., (2016)
Pratylenchus coffeae	Dried leave extract	Nematode mortality	Laboratory	India	Sundararaju and Cannayane (2002)
	Dry and fresh leaves	Nematode population	Banana	India	Sundararaju *et al*., (2003)
Tylenchulus semipenetrans	Aqueous leaf and root extracts	larvae mobility and Nematode population	Citrus rootstocks	Egypt	Elzawahry *et al*., (2014)
Globodera rostochiensis	Leaves, roots, and seeds extracts	Juvenil's mortality	Laboratory	Kenya	Kamau *et al*., (2020)

Used Parts and Methods of Application: Different researchers tested the components and metabolites of Datura plant for their potential in the management of PPN. Different parts of Datura reported to used such as: plant dried or fresh parts (Leaf, stem, root, flower and seeds), plant extracts and oils. Different application methods used, i.e., soil amendments with plant residues (dried or fresh green parts). Adding of organic amendments (OA) into soil explored previously as a method for suppressing PPN (D'Addabbo, 1995; Akhtar and Malik, 2000; Chitwood, 2002). The decomposition of the plant materials is affected by different factors include parts size, distribution in the soil and the level of soil moisture during the tissue incorporating and decomposition (Morra and Kirkegaard 2002). Soil drench and rhizomes or root dipping using plant extracts confirmed as promising methods. Extraction using aqueous or chemicals can be used such as acetone, chloroform, ethanol, methanol, petroleum ether and ethyl acetate. Furthermore, the extracts act faster and are often more effective easy to apply (Olaniyi, 2015).

Effect on Egg Hatching: Inhibition or reduction of PPN egg hatching is a significant factor in reducing the amount of available inoculum level in the soil by reducing the fresh hatched larvae which consider the infective stage in many PPN genera. Previous laboratory studies showed a significant inhibitive potential of using botanical extract against egg hatching of different genera of PPN. Use of *D. stramonium* leaves extract at 1:5, and 1:20 dilution gave a significantly better in the reduction of *M. javanica* egg hatching under laboratory conditions (Nandal and Bhatti, 1986b). Rao *et al*., (1986), found that *D. stramonium* aqueous leaf extracts inhibited egg hatching of *M. incognita* by 55 % compared with control under laboratory conditions. The treatment with the aqueous extract of *D. metel* leaves inhibited the percentage of *M. incognita* egg hatching (Goswami and Vijayalakshmi, 1987). Likewise, Sellami and Muofarrah (1994), reported that aqueous extracts of *D. stramonium* plants leaves and roots inhibited egg hatch of *M. incognita*. Also, the root extracts of *D. alba* were effective in inhibiting egg hatching of *M. incognita*, and standard extracts give 86.67 and 94.48% after 2 and 6 days of exposure time (Kayani and Muhammad,2001). Sharma and Trivedi (2002), Showed that fresh leaf extracts of *D. stramonium* have inhibitory in action against root-knot nematode *M. incognita* egg hatching. Hatching was maximum after 72 hours in lowest concentration (Stander/100). In a preliminary study using *D. stramonium* dried leaves extracts against the root-lesion nematode, *Pratylenchus coffeae* infesting banana, the plant extract exhibited a nematicidal activity in mortality at 24 hrs exposure period Sundararaju and Cannayane (2002). In another study, the aqueous extract of *D. metel* fresh leaves of at 10 % reduced the egg hatching of *M. Incognita* compared with control treatment (Parul and Mishra, 2011a). While Akpheokhai *et al*., (2012), determine the nematicidal effect of *D. metel* on *M. incognita* by exposed the nematode eggs to 0 mg/kg (control), 25,000 and 1 50,000 mg/kg 1 concentrations of water extract. The water extract at 25,000 and 50,000 mg/kg 1 were very effective in inhibiting egg hatch by over 70% within ten days. Moosavi (2012), reported that the water extract of *D. metel* leaves and *D. metel* seeds inhibited *M. javanica* egg hatching by 24.4 and 34.7 % after 7 days of application. Chaudhary *et al*., (2013), studied the nematicidal potential of aqueous and ethanol extracts of *D. stramonium* against root-knot nematode, *M. incognita* and they found that the hot water extracts of *D. stramonium* caused 75-100% egg hatching inhibition compared with 80-100 % by the ethanolic extract. Kumari *et al*.,2013, Nelaballe and Mukkara, (2013), revealed that *D. stramonium* plant extract showed nematicidal activity by affecting the hatching of eggs of root-knot nematode, *M. incognita* Chitwood. The hatching of nematode eggs observed to be varying after 24, 48 and 72 hrs in different concentrations. The highest percentage of egg hatching inhibition was 75.9% compared with control treatment. Bakr (2014) determined the effect of different Datura plant extracts on the percentage of egg hatching of *M. incognita*. The extracts were effective in inhibiting egg hatch during the period of observation. Egg hatching was low with all the extracts compared to the control. Petroleum ether extract at 3% concentration was the most effective to inhibit egg hatching after 48 and 96 hours of exposure by 87 and 82% respectively. These studies have clearly shown that the Datura extracts inhibit egg hatching of root-knot nematodes. Babaali *et al*., (2017), evaluated the efficacy of aqueous and ethanol extracts of *D. innoxi*a, *D. stramonium* and *D. tatula* on egg hatching of *M. incognita*. Plant extracts at different concentrations (6.25, 12.5, 25, 50 and 100%) and exposure times (10, 30, 60, 120 min and 20 h). All aqueous and ethanol extracts were effective in reducing egg hatching of *M. incognita* compared to untreated control. However, ethanol extract was more effective than aqueous extract. Oplos *et al*., (2018), reported that methanol extract of *D. stramonium* was effective in decreasing the egg hatching and cell division in *M. incognita* eggs. In a recent study by Moazezikho *et al*., (2020), mentioned that *D. stramonium* presents a good inhibitory effect in *M. javanica* egg hatching.

Effect on Nematode Mortality: The increasing of mortality plant-parasitic nematodes juveniles has a good role in reducing the nematode population build-up and the amount of available inoculum. Nematologists reported a significant juvenile mortality potential of Datura plant extract against PPN. Nandal and Bhatti (1986a), found that leaves extract of *D. stramonium* at 1:5 and 1:20 dilution gave significant second stage mortality of *M. javanica* after 6 weeks of treatment. Rao *et al*., (1986), evaluated the nematicidal effect of *D. stramonium* aqueous leaf extracts against root-knot nematode *M. incognita* by study their effect on larval mortality. They found that aqueous leaf extracts of *D. stramonium* killed the second stage larvae of *M. incognita.* Likewise, Mani and Chitra (1989), showed that leaf extract of *D. stramonium* at 500 and 1000 ppm caused high mortality of the second-stage juveniles of *M. incognita*. Sellami and Muofarrah (1994), reported that *D. stramonium leaves* aqueous extracts markedly affect the larval mortality of *M. incognita*. Abid, (1996), reported that crude ethanolic extract of *D. fastuosa* exhibited 100 % mortality of *M. javanica* after 48hours of application. found that the leaves extract of *D. fastuosa* var. *abla* were toxic to *Helicotylenchus dihystera*. Datura leaf extracts gave 80 % of nematode mortality. The toxicity of nematode increased by increase the extract concentration as well as the exposure time. Abid *et al*., (1997), obtained 100 % mortality of *M. javanica* juveniles after 72hr exposure to ethanol extracts of *D. fastuosa* and the juveniles mortality increased with length of exposure to the extract. Shakeel (2000), observed the effect the *D. alba* on citrus nematode (*Tylenchulus semipenetrans*) larval mortality. The extracts of leaves were more toxic than stem and roots.

The standard extracts were more toxic to *T. semipenetrans* larvae than other diluted concentrations. In another study, the aqueous extract of *D. stramonium* was more effective on reducing the second stage 'juvenile's mortality of *M. javanica* infected tomato plants as reported by Al-Saba *et al*., (2001) Insunza *et al*., (2001), tested the nematicidal activity of *D. stramonium* plant aqueous extracts on Chilean populations of *Xiphinema americanum in vitro*. They found that 100% nematode immobility recorded after 24h of application. Ahmed *et al.* (2004), evaluated the effects of water extracts of *D. alba* on citrus nematode (*T. semipenetrans)* larval mortality. The collected results were affected the larval mortality *T. semipenetrans* larvae significantly at the high concentration than other lower concentrations and the maximum larvae mortality recorded after 48 hours of exposure followed by 24 and 12 hours. *Datura stramonium* presents a great ability in RKN *M. incognita* 'population's infecting tomato plants when amending the soil with dried leaves at 10 g/kg (Radwan *et al*.,2007). Ayazpour *et al*., (2010), examined plant extracts of *D. innoxia* against *T. semipenetrans* under laboratory conditions. Results showed that gradual increase in concentration and exposure time caused an increased percentage of nematode mortality. The aqueous extract of fresh leaves of *D. metel* at 5 and10 % reduced the egg hatching of *M. incognita* by 70 and 81% after 72hrs of exposure compared with zero in the control treatment (Parul *et al.*, 2011a). Akpheokhai *et al*., (2012), experimented the nematicidal effect of *D. metel* on *M. incognita* juvenile's mortality at 0 mg/kg (control), 25,000 and 150,000 mg/kg 1 concentrations of water extract. Results revealed that juvenile mortality at 50,000 mg/kg 1 concentration was the maximum by 92%. Moosavi (2012), found that the mortality and immobility of *M. javanica* second-stage juveniles by *D. metel* leaves extract was33.9 and 16.2 % while *D. metel* seeds extract gives 26.1 and 13.6% after 48 h of application. Chaudhary *et al*., (2013), studied the nematicidal potential of ethanol and aqueous extracts of *D. stramonium* against *M. incognita*. *Datura stramonium* exhibited the highest mortality at 72 h of exposure 50 and 100 mg/ml concentrations. Nelaballe and Mukkara, (2013), reported that juvenile mortality of *M. incognita* was 52.8% after 24 hrs of exposure to *D. stramonium* methanol extract. Bakr (2014) recorded a significant increase in mortality of *M. incognita* by exposure to *D. stramonium*. Petroleum ether extract of Datura at 3% was the most effective on larvae mortality by 84%, followed by ethanol extract by 82% compared to 7 % of the control. Generally, mortality increased with the exposure period. Results also revealed that there was an increase in the percentage of mortality by increasing the concentration of plant extracts. El-Zawahry *et al*., (2014), reported that *D. stramonium* reduced the larval population of *T. semipenetrans* and their effect increase as the period increase under greenhouse when they investigate the effect on the severity of *T. semipenetrans* on citrus rootstocks. Leaf extracts of *D. stramonium* at 5% concentration, for 48h exposure, showed the highest toxicity for nematode larvae mobility 45.3% under laboratory conditions. Hadj-Sadok *et al.,* (2014), tested the nematicide effect of aqueous extracts from different organs roots, leaves and fruits of *D. stramonium* on larvae (L2) of *Meloidogyne* spp. The greater toxicity reported in extracts used at high concentrations (80,100 and 120 g/l) and after 72 hours of immersion time. The toxicity of the aqueous extracts of the plants varies according to the organ used. The extracts from the leaves show higher toxicity compared to the ones from roots or fruits. Keshari and Gupta (2015), evaluated the nematicidal potency of *D. stramonium* against root-knot nematode *M. incognita* under laboratory. The results indicated that leave extract of *D. stramonium* recorded 72.0% of larval mortality. Singh *et al*., (2015), evaluated the effect of *D. inoxia* aqueous extract against *M. incognita* under *in-vitro* trials, the results presented inhibition of egg hatching and larvae mortality of *M. incognita.* Umar and Ngwamdai (2015), Shows the effect of different levels of concentrations of *D. stramonium* on juvenile mortality of *M. javanica*. The result shows that the crude extract recorded the highest juvenile mortality 97 % compared to 0% in control. Sidhu *et al*., (2017), revealed that *D. stramonium* fresh leaves aqueous extracts at 20% w/v increased the mortality of *M. javanica* second-stage juveniles and the mortality increased by increasing extracts concentration and the exposure time. Babaali *et al*., (2017), evaluated the effect of aqueous and ethanol extracts of *D. innoxia, D. stramonium* and *D. tatula* plants on the motility of *M. incognita* J2S at five different concentrations as follow: 6.25, 12.5, 25, 50 and 100% and 10, 30, 60 and 120 min of exposure times. The J2S inactivity increased by increasing the exposure time and extract concentration. Efficacy of ethanol extracts was higher than aqueous extracts and the extracts from leaves and mixed plant parts present more effect than roots extracts. Moazezikho *et al*., (2020), tested the effect of *D. stramonium* aqueous plant extracts at 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, and 8%. They mentioned that by an increase in plant extract concentrations, the numbers of *M. javanica* dead J2s increased. In a study by Kamau *et al*., (2020), they evaluated the nematicidal effect D. stramonium aqueous plant extracts against *Globodera rostochiensis* juvenile's mortality. They recorded 100% mortality after 24 h exposure to crude extracts (100%) of all used extracts and 50% dilution of roots and seeds.

Effect on Nematode control: Previous studies showed that phytochemicals present a great potential effect in nematode control as nematicides themselves or their derivatives (Chitwood, 2002, Adegbite, 2003 and Oka *et al*., 2006). Treatments with Datura plant as leaves, seeds or steam with different status at different methods reduced all related nematode parameters, i.e., number of galls, egg-masses, females and development stage/ root system. Alam(1986), found that organic soil amendments with *D. metel* chopped shoots (100g/pot) recorded a significant reduction on the population of root-knot nematode *M. incognita* and stunt nematode *Tylenchorhynchus brassicae* on Eggplant. Nandal and Bhatti (1986b), found that leaves extract of *D. stramonium* had a significantly fewer galls of *M. javanica* in Brinjal under pot experiments compared with untreated pots. Nandal and Bhatti (1990), tested the effect of chopped and finely smashed leaves of *D. stramonium* on *M. javanica* penetration and gall formation in Brinjal. They found that leaves extract of *D. stramonium* had a significantly fewer penetration rate and galls formation at all doses in Brinjal under laboratory and pot experiments compared with untreated control. Imran and Saxena (1993), reported that application of chopped leaves of *D. stramonium* in tomato plants infected by 1000 juveniles of *M. incognita* markedly reduced the gall index in tomato plants roots with reduction percentage 85.7 in the number of galls. Oduor-Owino (1993, 2003a), evaluated the nematicidal effect of *D. metal* and *D. stramonium* for control of *M. javanica* infected tomato plants in Kenya. *Datura metel* had significantly greater suppressive effects on gall formation than *D. stramonium*. Abid *et al*., (1995), mentioned that soil amendment with *D. fastuosa* at 0.1, 0.5 and 1% w/w reduced infection of *M. incognita* and gall formation on Mung bean. Abid (1996), used dry leaf powder of *D. fastuosa* as organic amendment for control of *M. javanica* in Brinjal, Okra, Mung bean and Chickpea. Results showed that root-knot infestation was significantly reduced by Datura treatments at 0.5, 1.0 and 3.0 % w/w. Ehteshamul-Haque *et al*., (1996), found that organic amendment with powder of *D. fastuosa* dried leaves effectively reduced the infection of *M. javanica* and galls index in Okra root system. Firoza and Maqbool (1996b), reported that soil amendment with leaves of Datura reduced the population of *H. dihystera* infecting tomato (*Lycopersicon esculentum* Mill.) plants. The nematode population reduction was correlated with an increase in the rate of application. The leaves of Datura reduced disease severity caused by *M. javanica* and *Rotylenchulus reniformis* on sunflower. The dry leaves of *D. arborea* significantly decreased the total number of *M. javanica* in plant and pots soil and reduced females inside the root by 86.4% (Amin and Youssef, 1999). Khan *et al*. (2000), confirmed that combination of Datura, sawdust and neem leaves are effective in the management of *M. incognita* in tomato plants. Mateeva and Ivanova (2000), evaluated the nematicidal potential of *D. stramonium* plant extracts was for control of root-knot nematodes on tomatoes planted in pots at 1% and 0.5% by pre-planting and 4 times after planting. Pre-planting treatments of extracts were more effective than -post-planting treatments. The number of galls after 30 days of planting reduced compared to control plants. Prasad *et al*., (2002), evaluated the nematicidal effect of *D. stramonium* against second-stage juveniles of *M. incognita* and its control in mung bean. Results showed that the mortality more than 50 % and the highest reduction in number of galls were observed. Verma and Khan (2004), evaluated the green chopped leaves of *D. stramonium* to manage root-knot nematode, *M. incognita* in Tulsi (*Ocimum canum*). The treatments significantly reduced the nematode fecundity at varying levels. Zarina *et al*., (2006), found that soil amendments with leaf extracts of Datura significantly reduced root-knot infection caused by *M. javanica* (Treub) Chitwood in okra plant as compared with un-amended control. Radwan *et al*., (2007), have assessed the nematicidal activity of dried ground leaves of *D. stramonium* at both rates 5 and 10 g/kg soil against the root-knot nematode, *M. incognita*, on tomato under glass-house conditions. They found that populations of *M. incognita* in the soil and root galling of tomato were significantly suppressed by Datura dried leaves. Control of the nematode was best with the highest rate of application. Eradication of the nematode was obtained by amending the soil with 10 g of dried leaves of *D.*

stramonium /kg soil. Elbadri *et al.,* (2008), screened methanol or hexane leaf extracts of *D. stramonium* for the nematicidal activity against second-stage juveniles of *M. incognita* in the laboratory. They found that the mortality rates of juveniles increased with the increase in exposure time. The mortality rates were 43, 55 and 68.8 after 24, 48 and 72 hrs, respectively. Safiuddin (2010), receded the greatest reduction in *M. incognita* on okra by using chopped leaves of *D. stramonium* under greenhouse conditions. Hussain *et al*., (2011), reported that application by leaf amendments at different dosages significantly reduced the infections of okra by root-knot *M. incognita* and the number of galls, egg masses and the nematode reproduction factor compared with the untreated control. Parul *et al*., (2011b), showed that coated seeds of Chickpea with fresh or dried leaves of *D. metel* reduced the root galling and *M. incognita* juveniles in soil. Application by dried callus powders derived from *D. stramonium* on tomato seedlings grown in soil naturally heavy infested with *M. incognita* under field conditions significantly reduced the total number of galls, egg-masses and eggs in egg-masses especially with dried callus powder (Nour El-Deen, 2011). Akpheokhai *et al*., (2012), determine the nematicidal effect of air-dried milled plant parts of *D. metel* at 50 and 100 kg/ha on soybean cultivar TGX 1440-1E inoculated with *M. incognita* in a pot experiment. The milled plant parts significantly (P 0.05) reduced number of nematode eggs in the root, root galls, number of J2 in soil and the total population of *M. incognita* in the pot. Moosavi, (2012), illustrated that soil amendment with 7.5% of *D. metel* seeds is more effective than extracted leaves for controlling of *M. javanica* in tomato and in reducing the root galling and number of J2s in the soil. In parallel, reported that application of soil with *D. stramonium* leaves at 100g/kg soil concentration significantly decreased the *M. javanica* population, number of galls and females /root system of Bottle Gourd plant compared untreated inoculated control under glasshouse conditions (Parihar *et al*.,2012). Singh and Devi (2012) conducted an experiment to evaluate the effect of *D. metal* on management of root-knot nematode, *M. incognita* on *Solanum melongena* L. they found that treatment reduced the incidence of root-knot nematode as compared to control. Youssef and Lashein (2013), in pot experiment tested chopped and aqueous extracts of green and dry leaves of *Datura* spp. against *M. incognita* on Eggplant. They found that *Datura* spp. significantly ($p \leq 0.05$) reduced the nematode criteria such as the number of galls, egg masses, females, and developmental stages in eggplant roots. Under greenhouse experiment, soil application with *D. stramonium leaves extracts* markedly affected all nematode parameters under greenhouse conditions. All the treated plants showed a reduction in the galls' number, eggmasses and females/ root system up to 98 % with petroleum ether extract at 3%, followed by chloroform and ethyl alcohol at 3% compared to untreated control (Bakr, 2014). Saeed and Shawkat (2014), found that soil amendment with *D. stramonium* and *D. innoxia* leaves powders controlling *M. incognita* in tomato and significantly ($p<0.05$) reduced the root galling, second-stage juvenile’s population in the soil, egg masses and developmental stages under greenhouse conditions. Keshari and Gupta (2015), evaluated the nematicidal potency of *D. stramonium* against root-knot nematode *M. incognita* in tomato plants greenhouse conditions. The results indicated that leaves powder showed potency in reducing root gall index in Nepal. Saeed *et al*., (2015), tested the nematicidal potential of *D. stramonium* and *D. innoxia* aqueous leaf extracts against *M. incognita* second stage juveniles under laboratory conditions for 6, 12, 24 and 48 hrs at 12.5, 25 and 50% of leaf extracts. Leaf extracts of *D. stramonium* and *D. Innoxia* give100 % juveniles’ mortality at 25% concentration after 24 and 48hrs of exposure and after 12 and 24 hrs at 50% respectively. Regarding the field trials, the nematicidal effect of *D. stramonium* at 5, 10 and 15 g of the powder in sweet melon plants infected by *M. javanica* was measured. Recorded results illustrated that the lowest galling index and nematode population recorded in plants treated with 15 g of *D. Stramonium* in comparison to the untreated control plants (Umar and Ngwamdai, 2015). Mostafa *et al*., (2016), tested the nematicidal effect of dried powder of *D. stramonium* at 1,3 and 5 g/plant against root-knot nematode *M. incognita* infecting cucumber (*Cucumis sativus*). The dried leaf powder of *D. stramonium* significantly suppressed the root-knot nematode population in soil and plants root, root galling and number of egg masses. Osman *et al*., (2016), reported that leaves powder of *D. stramonium* reduced the *M. incognita* and related parameters in Eggplant. Babaali *et al*., (2017), tested the nematicidal effect of *D. stramonium, D. innoxia* and *D. tatula* aqueous and ethanol extracts against *M. incognita* in tomato under greenhouse experiment. Results cleared that ethanol extracts of the tested Datura species significantly reduced the nematode reproduction and gall index of *M. Incognita* in tomato roots. Nandakumar *et al.,* (2017), screening the ethanolic leaf extracts of *D. metel*, *D. innoxia* against root knot nematode juveniles *M. incognita* mortality. The maximum larval mortality of *M. incognita* was 53% and 44% at 1000 ppm concentration in 72 hrs of exposure time by using *D. metel* and *D. innoxia* respectively. Siddiqui (2017) reported that seed treatments of okra plants by *D. innoxia* aqueous extract of decreased in root knots of okra plants. Singh *et al*., (2017) in a pot experiment under greenhouse condition they found that application with chopped leaves of *D. stramonium* at 50g/pot reduced the number of galls and nematodes parameters in Mung bean infected by *M. incognita*. In, India, Shah *et al*., (2018), illustrated that application with 10 and 20 ml water leaf extracts of *D. metel* (50 gm fresh leaves/ 500ml distilled water) was effective in controlling the root knot in Brinjal (*Solanum melongena)* and reduced the number of *M. incognita* juveniles in pot soil, number of females and root galling index. On the other hand, Oplos *et al*., (2018), in Greece evaluated the nematicidal effect of incorporating *D. stramonium* shoots in infested soil on inhibition of root-knot nematodes in tomato plants. Results cleared those treatments with *D. stramonium* powder reduced the nematodes densities in tomato roots as well as gall formation was significantly suppressed. In a study by Ahmad *et al*., (2020), water dried leaves extract of *Datura inoxia* significantly reduced the number of galls, adult females, and egg masses of *M. incognita* in tomato root system. Moazezikho *et al*., (2020), mentioned that soil drench with *D. stramonium* at 1.8% reduced the number of eggs, galls and egg masses per root system and the reproduction factor of *M. javanica* in tomato plant roots.

Effect on Plant Growth

The addition of organic amendments to the soil as fresh, dried or extract not only help in nematodes management but also maybe can enhance the plant growth parameters of cultivated plants. Several previous studies by nematologistis explain the effect of Datura using by different treatment methods in the plant growth parameters of nematodes infected host plants from different families worldwide. Oduor-Owino (1993), reported that the application by *D. metal* and *D. stramonium* significantly enhanced the shoot growth and fruit yield of tomato plants than control plants infected by *M. javanica* in Kenya. Abid (1996), found that dry leaf powder of *D. fastuosa* at .5, 1.0% increased root length, fresh and dry weight of and shoots while 3.0 % reduced the shoot length and root, fresh and dry weight Brinjal, Okra, Mung bean and Chickpea. Firoza and Maqbool (1996a, b), confirmed that leaves extract of *D. fastuosa* markedly improved the growth of tomato plants and reducing *H. dihystera* population. Sundaraju *et al*.,(2003), showed that the application of *D. stramonium* was effective in increasing the Banana yield significantly and reducing *P. coffeae* population in India. Verma and Khan (2004), confirmed that treatments green chopped leaves of *D. stramonium* significantly reduced the *M. incognita* fecundity and improved plant growth of Tulsi. Zarina *et al*., (2006), evaluated the soil amendments with leaf extracts of Datura on okra plant. They observed a significant increase in plant growth and reduction in root gall development at stock concentration(S) followed by S/2, S/4, S/8, and S/16 concentrations. Hussain *et al*., (2011), showed that application by leaf Datura at different used dosages significantly improved okra plant growth characteristics and markedly reduced root-knot infections compared with the untreated control plants. Mousa, *et al*., (2014), demonstrated that chloroform, petroleum ether and ethanol extract of *D. stramonium* were effective in enhancing the plant growth parameters of tomato plants under greenhouse conditions. Parul *et al*., (2011b), reported that coated chickpea seeds with fresh or dried leaves of *D. metel* enhanced the plant growth parameters of Chickpea infected by *M. Incognita.* Akpheokhai *et al.*, (2012), recorded an increasein plant growth parameters and yield of Soybean when treatment with air-dried crushed D. metel at 50 and 100 kg/ha. Singh and Devi(2012),mentioned that *D. metal* leaves extract enhanced the plant growth parameters of Eggplant inculcated by the root-knot nematode, *M. incognita*. Youssef and Lashein (2013), reported that Datura chopped leaves at100g were effective in increasing bottle gourd of plant growth parameters in pots experiment. Hasan *et al*., (2014), mentioned that *D. metel* significantly improved the potato growth shoot, root and tuber length (cm), root and tuber weight (g), tuber width (cm) and the number of tubers in potato plant. Bakr, (2014), studied the effect of *D. stramonium* plant extracts on plant growth parameters of tomato plants. Results clear that tomato plant growth parameters were affected by the different extracts under greenhouse conditions. Also, *D. Stramonium* aqueous extract improved plant growth characters of tomato plants infected with root-knot nematode *M. Incognita* under greenhouse conditions in Nepal (Keshari and Gupta,2015). Singh *et al*., (2017), found that application with chopped leaves of *D. stramonium* increased the plant growth parameters of Mung bean infected by *M. incognita* such as plant high, shoot and root weight and plant yield. Soil drenching by *D. innoxia* significantly increases the shoot length, root length, shoot weight and leaf area of Cowpea plants observed by Siddiqui (2017). Also, aqueous extract of *D. inoxia* dried leaves significantly enhanced the shoot and root length per root system of tomato inoculated with *M. incognita* under greenhouse conditions (Ahmad *et al*., 2020).

Phytochemical components: The phytochemical screening of the datura plant presents its richness with different chemical components. In a study by Banso and Adeyemo (2006), the ethanol extracts of Datura dried leaves included alkaloids, saponins, tannins, and glycosides.

The most extracted substances in *Datura* species tissues were tropane alkaloids with scopolamine and hyoscyamine as mentioned by El Bazaoui *et al*., (2011).Using GC-MS Chromatography analysis of different *D stramonium* extracts showed the presence of amides, ethers, phenol and alkanes, aldehydes, terpens and ketones compounds (Bakr,2014). The phytochemical screening by, *Nandakumar et al.,* (2017), confirmed the presence of different bioactive compounds such as alkaloids, anthroquinone glycosides, flavonoids, terpenoids, phenolic compounds, tannins, saponins, steroids and triterpenes in the ethanolic extract of *D. innoxia* and *D. metel* leaves. Similary, Tsialtas *et al*.,(2018), reported that in *D. stramonium, D. stramonium f. tatula,* and *D. ferox* are a source ofalkaloids, oil and protein.Similar results were obtained by Babaali *et al*.,(2021),as they indicated that tropane alkaloids hyoscyamine and scopolamine in *Datura* plants present a strong nematicidal activity against *M. incognita.*

Mode of action: The obtained previous results confirmed that Datura fresh or dried parts or plant extracts are present larvicidal or ovicidal properties under laboratory conditions and decreased the nematode population and root galling and increasing the plant growth parameters under green house or field conditions.

Datura provide Substitutes for Synthetic Nematicides

Release of several toxic compounds, directly or during the organic matter decomposition in soil which present a nematicidal effect against plant parasitic nematodes. Atropine, hyoscyamine and scopolamine (hyoscine) as the main tropane alkaloids present in the phytochemical analysis of most species Datura which are useful in plant parasitic nematode management (Shonle and Bergelson, 2000). This results in agreement with previous findings by Qamar *et al*., (1995), who reported that alkaloids from *D. stramonium* killed 90-100% of *Hoplolaimus indicus*, *Helicotylenchus multicinctus*, and *M. incognita*, while hyoscine gives 90% mortality with *H. indicus* only. Also, Shahwar *et al*., (1995), clarifies that *D. fastuosa* contain tigloidine, apoatropine, hyoscyamine and scopolamine which showed nematicidal activity. These chemicals with ovicidal or larvicidal properties could kill the eggs or destroying embryonic development as described by Choi *et al*., (2007), who reported the nematicidal activities of Phenols, alcohols, ketones, acids, aldehydes, and hydrocarbons. The reduction in root-knot population in root system of the host plant could be attributed to the reduction of the second stage 'juvenile's penetration rate then reduction of reproduction and this in agreement with theory suggested by Abid (1996). The use of Datura as organic soil amendments not only change soil physical and chemical properties but also may be support and enhance a wide variety of effective antagonistic microorganisms such as fungi, bacteria, etc. (Jaffee *et al*., 1998; Timm *et al*., 2001), these effective antagonistic microorganisms may act via antibiosis, competition or parasitism then affect the plant pathogens such as PPN. The amino acids single and in combination have ovicidal and larvicidal properties which effect on embryonic development or killed the eggs or even dissolved the eggs and then inhibited hatching (Kayani *et al*., 2001). The plant essential oils in medicinal plants are previously used for nematode management as it directly affects nematodes or degraded to safety component for the ecosystem (Chitwood, 2002 and Oka, 2010).The using of plant extracts can act by affecting on nematode by inhibition of enzymes, degrading or denaturing of proteins and interfering with ADP phosphorylation or respire-tory chain (Susan and Noweer, 2005).Phenolic compounds which present in the chemical composition of *Datura* leave extracts such as benzoic acid (Bakr, 2014) previously confirmed to possess nematicidal potency and activity against *M. javanica* in Mung bean (Shaukat and Siddiqui ,2001). The presence of several phenolgroups in the phenolic compounds acts as chemical barriers against invading pathogens and protecting the plant (Kale *et al*., 2011).

Phytochemicals or their derivatives may be changed one or more physiological processes in nematodes such as the membrane permeability, electron transport, ion uptake, enzymatic activity and cell division (Anaya, 2006).The permeability of eggshells to the toxic phytochemicals materials will killing the developing juveniles inside the eggs then egg hatchability reduced and the the inoculum in the soil will be decreased.

The nematicidal effect of Phytochemicals may probability attributed to their contents of oxygenated compounds with lipophilic properties. This compound may dissolve the cytoplasmic membranes of nematode cells. Also, the functional groups of this compound could be interfering with the enzyme protein structure in nematodes (Knoblock *et al*., 1989). In this manner, several fatty acid esters were evaluated against nematodes and results confirmed the nematicidal and toxicity effects such as fatty acids that can be in the, cyclopropane, epoxide hydroxylated or methylated (Pinkerton and Kitner, 2006).

Phenols compounds in the phytochemicals play a role as constitutive protection agents against nematodes by convert the root attractiveness to nematodes and host plant resistance as a plant defense molecule to nematode then the infestation and development as the previous studiessuggested the correlation between the levels of phenols in the roots and the delaying of giant cells formation then the poor nutrition supply to the larvae (Stirling, 1991, Tiyagi and Alam, 1995;Shaukat *et al*., 2002; Makoi and Ndakidemi, 2007; Siji *et al*., 2010). Using of plants leaves some times was more effective than other plant parts and this could be related to the primaryphysiological role of leaves as the centres of metabolism which lead to formation of active metabolites in leaves (Elbadri *et al*., 2008). High concentrations of alkaloids such as Apoatropine, Hyoscyamine, Scopolamine, Tigloidine, Tropine found particularly in *D. stramonium* and *D. ferox*, as well as in *D. innoxia*. Alkaloids are mentionedas a component of nematicidal plants and showed nematicidal. Nematostatic potency against PPN (Thoden *et al*., 2009)and the mode of action of Alkaloids mostly was as protease inhibitors in nematodes (Wen *et al*., 2013).

The most suggested mechanism of action of tropane alkaloids was attributed to the competitive antagonism effect at the muscarinic acetylcholine receptors, which preventsthe binding of acetylcholine. Nextly the functions of exocrine gland cells, smooth muscles, respiration and functions in the central nervous system consequently changed according to the specificity and selectivity of muscarinergic acetylcholine receptors ability in different organs (Ahmad *et al*., 2004).The Anthraquinones have nematicidal, and pesticide potency and this reflect their inhibitory action effect on the enzymes necessary for the microorganisms (Abu-Darwish and Ateyyat, 2008; Nandakumar *et al*.,(2017). Flavonoids involved in the chemical compositionof Datura are phenolic compounds which are toxic to broadplant pathogens including nematodes (Carlsen and Fomsgaard, 2008) their activity is probably referred to the ability to destroy the pathogen proteins and cell walls (Ionela and Ion,2007).

Tannins play a role in the mechanism defence of the host plants against pathogens by inducingchanges in the morphology of pathogens through action on cell membranes by destabilization of cytoplasmic and plasmamembranes, inhibition of extracellular microbial enzymes and metabolism and substrate deprivation required for microbial growth (Kumbasli *et al*., 2011). Saponins are one of plant secondary metabolites probably inhibit DNA, RNA, proteinsand hemolysisin mammals (Fatoki and Fawole, 2000; Ibrahim and Srour, 2013). Previous researchers reported that saponins may induce formation of transmembrane pores, then a reduction in membrane integrity of cells (Bernards *et al*., 2006). Ghayal *et al*., (2010),showed that saponins are interacting with larvae cuticle membrane, eventually disarranging the membrane, which could be the most candidate reason for the larval death whileIbrahim and Srour, (2013),suggested that the nematicidal potency of saponins probably refers to their ability to inhibit cholesterol accumulation in larva and or egg.

Datura Enhance Soil Fertility: Addition of OA to the soil could be referring to increase the soil fertility and nutrients content. Moreover, increase water-holding capacity and improving soil structure (Nyczepir and Thomas, 2009) which leads to a better environment for the growth of the roots. Availability of suitable soil environmental conditions consequence might be markedly decreased damage occurs by PPN as suggested by Abubakar *et al*., (2004).

Datura Enhance Soil Microbes: Soil amendment with some organic matter encourages the presence and action of beneficial soil microorganisms, including some antagonists of plant-parasitic nematodes (McSorley, 2011). Also, the addition of soil amendment may be providing another beneficial role such as enhancing plant growth-promoting or plant health soil microorganism, which leads to increased plant growth. The application with *D. stramonium* organic matter stimulated the parasitic activity of the bio-control agent *Paecilomyces lilacinus* against *M. javanica* eggs (Oduor-Owino *et al.*, 1993, 2003b).The differences in valiabale toxicity may be attributed to the plant part used, application methods,active component concentration in the plant material that may be affected by several different factors such as the age of the plant, method of extraction,soil moisture and type of extracting solvent (Bakr, 2018).

So that, Datura as a nematode-suppressing plant may work against RKN direct or indirect by one or more methods as follows in Figure-2.

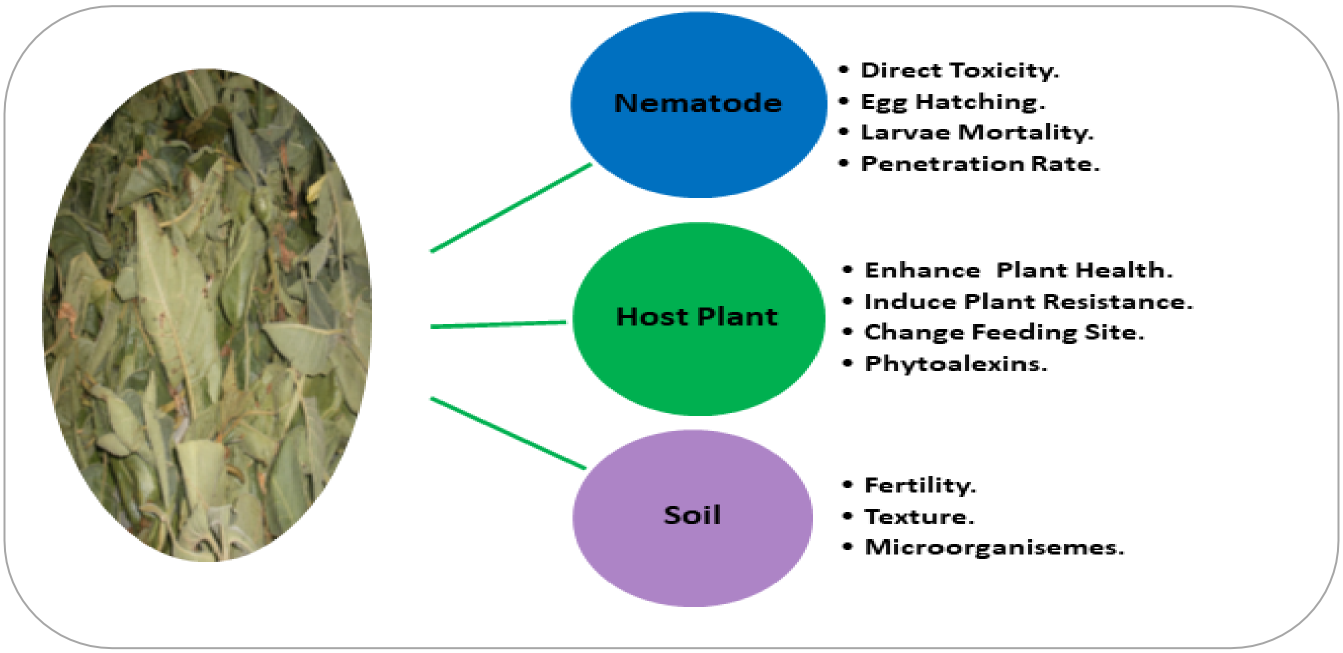

Figure 2. Different suppression methods of nematodes by Datura.

CONCLUSION AND FUTURE PROSPECTS

Using of Botanicals products in field applications provide an enhancement of plant growth in addition to plant pathogens control such as nematode. Emerging of botanicals soil application in advanced agricultural programs showed an excellent advantage as mentioned before for farmers, customers, animals, and environment. From this review, the medicinal plants *Datura* spp. possess phytochemicals and nematicidal activity. Literature is rich by the experiments, and studies showed the effect of Datura in control of root-knot nematodes. So, these plants would serve as a source for novel nematicidal agents. At the same time, limited information clears the chemical component and active ingredient of the used materials. Further efforts are recommended to 1) Isolation, purify, evaluation active ingredient.2) Develop formulation and mode of application to improve their nematicidal efficacy and stability.

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REFERENCES

Abad, P., B. Favery, M. Rosso and P. Castagnone-Sereno. 2003. Root-knot nematode parasitism and host response: molecular basis of a sophisticated interaction. Molecular Plant Pathology, 4: 217-224.

Abawi, G. S. and T. L. Widmer. 2000. Impact of soil health management practices on soil borne pathogens, nematodes and root diseases of vegetable crops. Applied Soil Ecology, 15: 37-47.

Abid, M. 1996. Studies on the control of root-knot nematodes (*Meloidogyne* spp.) with botanical toxicants. PhD thesis, University of Karachi, Karachi, pp. 345.

Abid, M., M.I. Choudhary, M.A. Maqbool, and A. Ur-Rahman. 1997. Preliminary screening of some plants for their nematicidal activity against *Meloidogyne javanica*. Nematologia Mediterranea, 25: 155–157.

Abid, M., S. Ehteshamul-Haque, V. Sultana, J. Ara, A. Ghaffar and M.A. Maqbool. 1995. Comparative efficacy of neem cake and other organic amendments in the control of root-knot nematode in Mung-bean. Pakistan Journal of Nematology, 13:

103-107.

Abubakar, U., T. Adamu, and S.B. Manga. 2004. Control of *Meloidogyne incognita* (Kofoid and White) Chitwood (root-knot nematode) of *Lycopersicon esculentus* (tomato) using cow dung and urine. African Journal of Biotechnology, 3: 379-381.

Abu-Darwish, S. M., and A. M. Ateyyat. 2008. The pharmacological and pesticidal actions of naturally occurring 1, 8-dihydroxyanthraquinones derivatives. World Journal of Agricultural Sciences, 4: 495-505.

Adegbite, A. A. 2003. Comparative effects of carbofuran and water extract of *Chromolaena odorata* on growth, yield, and food components of root-knot nematode-infested soybean (*Glycine max* (L.) Merrill). Ph. D thesis. University of Ibadan. Nigeria.

Ahmad, M. S., T. Mukhtar and R. Ahmad. 2004. Some studies on the control of citrus nematode (*Tylenchulus semipenetrans*) by leaf. Asian Journal of Plant Sciences, 3: 544-548.

Ahmad, R., M. Tariq, N. Javed and M. Inam-ul-Haq. 1991. Effect of extract of various plants on egg hatching and larval mortality of root-knot nematode, *Meloidogyne incognita.* Pakistan Journal of Phytopathology, 3: 38-42.

Ahmad, S., B. Safia, I. Naz, I. Khan, A. R. Saljoqi, G. Jan, J. Uddin, M. Abdal and S. Wali Khan .2020. Management of Tomato Parasitic Nematode through Organic Nematicides in Peshawar. Journal of Agricultural Science and Technology, 22: 1099-1108.

Akhtar, M. and A. Malik. 2000. Roles of organic soil amendments and soil organisms in the biological control of plant-parasitic nematodes: a review. Bioresource Technology, 74: 35-47.

Akpheokhai, I.L., A. O. Claudius-Cole and B. Fawole. 2012. Evaluation of some plant extracts for the management of *Meloidogyne incognita* on Soybean (*Glycine max*). World Journal of Agriculture Science, 8: 429-435.

Al Saba, R.F., S.N. Ammi and A. J. B. Al-Zarry. 2001. Effect of *Datura stramonium* extracts on root-knot nematodes *M. javanica* in tomato plant. Dirasat Agricultural Sciences, 28: 219-226.

Alam, M. M.1986. Possible use of weeds as soil amendment for the management of root-knot and stunt nematodes attacking eggplant. Agricultural wastes, 16: 97-102.

Amin, A.W. and M.M. A. Youssef. 1999. Comparative study on the efficiency of dry and green manuring of certain plant leaves against *Meloidogyne javanica* and *Rotylenchulus reniformis* infecting sunflower. Journal of Pest Science, 72: 166-168.

Amin, A.W., and M. M. A. Youssef. 1997. Efficiency of certain plant leaves for controlling *Meloidogyne javanica* and *Rotylenchulus reniformis* infecting Sunflower in Egypt. International Journal of Nematology, 7: 198-200.

Anaya, A. L. 2006. Allelopathic organisms and molecules: Promising bioregulators for the control of plant diseases, weeds, and other pests. Pp 31-78. In Inderjit and Mukerjit, K. G. (eds.) Allelochemicals: biological control of plant pathogens and diseases (Springer), 31-78.

Andrés, M. F., A. González-Coloma, J. Sanz, J. Burillo and P. Sainz. 2012. Nematicidal activity of essential oils: a review. Phytochemistry Reviews, 11: 371-390.

Archana, U. S. and D. Prasad. 2014. Management of plant-parasitic nematodes by the use of botanicals. Journal of Plant Physiology and Pathology, 2: 1-10.

Awan, M.A., N. Javed., R. Ahamd and M. Inamul Haq. 1992. Effects of some leaf extracts of four plant species on the larval mortality of citrus nematode (*T. semipenetrans* Cobb.) and citrus plant growth. Pakistan Journal of Phytopathology, 441-445.

Ayazpour, K., H. Hasanzadeh, and M.S. Arabzadegan. 2010. Evaluation of the control of citrus nematode (*Tylenchulus semipenetrans*) by leaf extracts of many plants and their effects on plant growth. African Journal of Agricultural Research, 5: 1876-1880.

Babaali, D., J. Roeb, M. Hammache, and J. Hallmann. 2017. Nematicidal potential of aqueous and ethanol extracts gained from *Datura stramonium*, *D. innoxia* and *D. tatula* on *Meloidogyne incognita*. Journal of Plant Diseases and Protection, 124: 339-348.

Babaali, D., J. Roeb, S. Zaidat, B. Reguige, M. Hammache and J. Hallmann. 2021. Nematicidal activity of the tropane alkaloids hyoscyamine and scopolamine against the root-knot nematode *Meloidogyne incognita*. Nematology, 1: 1-9.

Bakr, R. A. and H. A. Ketta. 2018. Nematicidal potential of some botanical products against *Meloidogyne incognita* infecting Eggplant. Indian Journal of Nematology, 48: 203-211.

Bakr, R. A., M.E. Mahdy and E.M. Mousa. 2011. A survey of root-knot and citrus nematodes in some new reclaimed lands in Egypt. Pakistan Journal of Nematology, 29: 165-170.

Bakr, R. A., M. E. Mahdy and E. M. Mousa. 2020. Survey of root-knot nematodes *Meloidogyne* spp. associated with different economic crops and weeds in Egypt. Egyptian Journal of Crop Protection, 15: 1-14.

Bakr, R.A. 2018. Bionematicidal potential of some incorporating plants on *Meloidogyne javanica* control on Tomato. International Journal of Current Microbiology and Applied Sciences, 7: 1457-1464.

Bakr, R.A. 2014. Mechanism of some bio-control agents and plant extracts to control root-knot nematode disease. PhD. thesis, Faculty of Agriculture, Menoufia University, Egypt.

Banso, A, and Samuel A. 2006. Phytochemical screening and antimicrobial assessment of *Abutilon mauritianum*, *Bacopa monnifera* and *Datura stramonium*. Biokemistri, 18: 39-44.

Bernards, M. A., L.F. Yousef, and R. W. Nicol. 2006. The allelopathic potential of ginsenosides. In Inderjit and Mukerjit, K. G. (eds.) Allelochemicals: biological control of plant pathogens and diseases (Springer), 157-175.

Brand, D., C.R. Soccol, A. Sabu and S. Roussos. 2010. Production of fungal biological control agents through solid state fermentation: a case study on *Paecilomyces lilacinus* against root-knot nematodes. Micologia Aplicada International, 22: 31-48.

Bye, Robert, and Victoria Sosa. 2013. Molecular phylogeny of the jimsonweed genus *Datura* (Solanaceae). Systematic Botany, 38: 818-829.

Carlsen, S. C. K. and I. S. Fomsgaard. 2008. Biologically active secondary metabolites in white clover (*Trifolium repens* L.) a review focusing on contents in the plant, plant–pest interactions and transformation. Chemo Ecology, 18: 129-170.

Chattopadhyay, P.R. 1991. Nematicidal properties of some plant materials on tomato (*Lycopersicon esculentum* cultivar local) infested with *Meloidogyne incognita*. Geobios, 18: 232-326.

Chaudhary, K.K., A. Haile, Z. G. Ayresea, G. Semereab and T. Weldegergish. 2013. Nematicidal activity of Eritrean weed plants against the root-knot nematode *Meloidogyne incognita*. Nematropica, 43: 207-215.

Chitwood, D. J. 2002. Phytochemical based strategies for nematode control. Annual Review of Phytopathology, 40, 221-249.

Choi, I, J. Kim, S Shin and I. Park. 2007. Nematicidal activity of monoterpenoids against the pine wood nematode (*Bursaphelenchus xylophilus*). Russian Journal of Nematology, 15: 35-40.

D'Addabbo, T.1995. The nematicidal effect of organic amendments: a review of the literature, 1982-1994. Nematologia Mediterranea, 23: 299-306.

Dayan, F. E., C. L. Cantrell and S. O. Duke. 2009. Natural products in crop protection. Bioorganic and medicinal chemistry, 17: 4022-4034.

Decraemer, W. and D. J. Hunt. 2013. Structure and classification. in: Plant Nematology, 2nd Edn, eds R. N. Perry, and D. J. Hunt (Wallingford: CAB International).

Duke, J. 1985. CRC handbook of medicinal herbs. (Boca Raton: CRC Press, Inc.).

Duke, S. O. 1990.Natural pesticides from plants." In Advances in new crops. Proceedings of the first national symposium 'New crops: research, development, economics., 23-26 October 1988., 511-517. Indianapolis, Indiana, USA: Timber Press.

Ehteshamul-Haque, S., M. Abid, V. Sultana, J. Ara, and A. Ghaffar. 1996. Use of organic amendments on the efficacy of biocontrol agents in the control of root rot and root knot disease complex of okra. Nematologia Mediterranea, 24: 13-16.

El Bazaoui, A., M.A., Bellimam and A. Soulaymani. 2011. Nine new tropane alkaloids from *Datura stramonium* L. identified by GC/MS. Fitoterapia, 82: 193-97.

Elbadri, G.A., D. W. Lee, J. C. Park, H.B. Yu and H. Y. Choo. 2008. Evaluation of various plant extracts for their nematicidal efficacies against juveniles of *Meloidogyne incognita*. Journal of Asia-Pacific Entomology, 11: 99-102.

Eskandarzadeh, N., S. Moslehi and N. Vaez. 2020. Evaluation of the Effects of Thorne-apple and Henbane on Egg Hatching and Mortality of Juveniles of *Meloidogyne javanica*. *Journal of Applied Research in Plant Protection*, 9: 45-60.

El-Zawahry, A., M, A. M. A. Mahran, and M. A. Allam. 2014. Management of citrus nematode (*Tylenchulus semipenetrans*) by certain plant species. Journal of Phytopathology and Pest Management, 1: 46-52.

Fatoki, O. K. and B. Fawole. 2000. Identification of nematicidal ingredients from neem leaves, siam weed leaves and roots. African Journal of Plant Protection, 10: 33-38.

Firoza, K. and M. A. Maqbool. 1996a. Nematicidal properties of leaves of some plant species against *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1963 on tomato. Pakistan Journal of Nematology, 14: 107-110.

Firoza, K. and M.A. Maqbool. 1996b. Effect of plant extracts in the control of *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961. Pakistan Journal of Nematology, 14: 61-66.

Ghayal, N., A. Padhye and K. Dhumal. 2010. Larvicidal activity of invasive weeds *Cassia uniflora* and *Synedrella nodiflora*. International Journal of Pharma and BioSciences, 1: 1-10.

Goswami, B. K. and K. Vijayalakshmi. 1987. Studies on the effect of some plant and non-edible oil seed cake extracts on larval hatching of *Meloidogyne incognita*. Journal Research of Assam Agricultural University, 8: 62-64.

Hadj-Sadok, D. N., S. Hadroug and F. Taoussi. 2014. Activity nematicide in vitro of aqueous extracts of medicinal plants *Artemisia campestris, Ziziphus lotus, Datura stramonium et Urginea maritima* on larvae of Meloidogyne." In AFPP– Dixième Conférence Internationale Sur Les Ravageurs En Agriculture. Montpellier. 22 et 23 Octobre 2014.

Hasan, H. H., S. Simon and A. A. Lal. 2014. Effect of selected botanical extracts against *Meloidogyne incognita* (Kofoid and White) Chitwood on potato (*Solanum tuberosum* L.). International Journal of Agricultural Science and Research, 4: 101-108.

Hunt, D. J., M. Luc and R. H. Manzanilla-López. 2018. Identification, morphology and biology of plant parasitic nematodes.' in D. Coyne R. Sikora, J. Hallmann, P. Timper (ed.), Plant Parasitic Nematodes in Subtropical Tropical Agriculture (CABI Publisher: Wallingford, England.).

Hussain, M. A., S. Ahmad, W. Anum, M. Khanum, H. Raza, and M. N. Aslam. 2018. Microenvironmental alteration by the use of some plants for the effective control of root-knot nematode (*Meloidogyne incognita*) on brinjal. Plant Protection, 2:93-99.

Hussain, M.A., T. Mukhtar and M. Z. Kayani. 2011. Efficacy evaluation of *Azadirachta indica*, *Calotropis procera*, *Datura stramonium* and *Tagetes erecta* against root-knot nematodes *Meloidogyne incognita*. Pakistan Journal of Botany, 43: 197-204.

Ibrahim, I.K.A., A.A. Mokbel and Z.A. Handoo. 2010. Current status of phytoparasitic nematodes and their host plants in Egypt. Nematropica, 40: 239-262.

Ibrahim, M. A.R. and H. A.M. Srour. 2013. Saponins suppress nematode cholesterol biosynthesis and inhibit root knot nematode development in tomato seedlings. Natural Products Chemistry and Research, 2: 1-6.

Imran, M. and S.K. Saxena. 1993. Effect of plant materials on the population of tomato root-knot nematode (*Meloidogyne incognita*). Indian Journal of Mycology and Plant Pathology, 23: 180-182.

Insunza, V., E. Aballay and J. Macaya. 2001. In vitro nematicidal activity of aqueous plant extracts on Chilean populations of *Xiphinema americanum* sensu lato. Nematropica, 47-54.

Ionela, D.C. and I.B. Ion. 2007. Plant products as antimicrobial agents. Section Genetics Molecular Biology, 8: 151.

Jaffee, B.A., H. Ferris and K. M. Scow. 1998. Nematode-trapping fungi in organic and conventional cropping systems. Phytopathology, 88: 344-50.

Jones, J.T., A. Haegeman, E.G. Danchin, H.S. Gaur, J. Helder, M.G. Jones, T. Kikuchi, R. Manzanilla-López, J.E. Palomares-Rius, W.M. Wesemael and R.N., Perry. 2013. Top 10 plant-parasitic nematodes in molecular plant pathology. Molecular Plant Pathology, 14: 946-961.

Kale, A. A., R. C. Torane, N. R. Deshpande and J. P. Salvekar. 2011. Antioxidant potential from stem bark of *Juglans regia* L. Annals of Biological Research, 2: 176-180.

Kamau, N.W., J.M. M., D.O. Otaye and S. Haukeland. 2020. Effect of aqueous extracts of *Datura stramonium* W. seeds, leaves and roots on mortality of second stage juveniles of *Globodera rostochiensis* in Kenya. African Journal of Biological Sciences. 2, 99-106.

Kayani, M. Z., G. Sarwar and S. Muhammad. 2001. Control of root-knot nematode (*Meloidogyne incognita*) on tomato plants by using root extracts of plants. Journal of Agriculture in the Tropics Subtropics, 102: 143-146.

Keshari, A.K. and R. Gupta. 2015. Management of root-knot nematode, *Meloidogyne incognita* on tomato using extracts of indigenous plants of Nepal. Annals of Plant Protection Sciences, 23: 131-134.

Khan, H.U., R. Ahmad, M.A. Khan and A.S. Akhtar. 2000. Integrated management of root-knot disease of tomato. Pakistan Journal of Biological Sciences, 3: 2109-2111.

Kim, D. I., J. D. Park, S. G. Kim, H. Kuk, M. S. Jang and S. S. Kim. 2005. Screening of some crude plant extracts for their acaricidal and insecticidal efficacies. Journal of Asia-Pacific Entomology, 8: 93-100.

Kingland, GC. 2001. Diseases and insects of fruit and vegetable crops. In 30-35. Clemson Press, Victoria, Seychelles.

Knoblock, K., K. Weisand R. Wergent. 1989. Mechanism of antimicrobial activity of essential oils." In Proceedings of 37th Annual Congress Medicine Plant Research (ACMPR'89). Braunisweig. 5 -9 PP.

Kokalis-Burelle, N. and R. Rodríguez-Kábana. 2006. Allelochemicals as biopesticides for management of plant-parasitic nematodes. Pp 15-30. In Inderjit and Mukerjit, K.G (eds.).' in, Allelochemicals: biological control of plant pathogens and diseases (Springer). The Netherlands.

Kumari, N. V. and M. Lakshmi Devi. 2013. Effect of some indigenous plant extracts on the inhibition of egg hatching of nematode *Meloidogyne incognita* Chitwood infesting mulberry. HortFlora Research Spectrum, 2: 35-39.

Kumbaşli, M., É.Bauce, S. Rochefort and M. Crépin. 2011. Effects of tree age and stand thinning related variations in balsam fir secondary compounds on spruce budworm *Choristoneura fumiferana* development, growth and food utilization. Agricultural Forest Entomology, 13: 131-141.

Lampe, K. F. and M. A. McCann. 1985. AMA handbook of poisonous and injurious plants (American Medical Association). PP. 432.

Makoi, J. H. and P. A. Ndakidemi. 2007. Biological, ecological and agronomic significance of plant phenolic compounds in rhizosphere of the symbiotic legumes. African Journal of Biotechnology, 6: 1358-1368.

Mani, A. and K.C. Chitra. 1989. Toxicity of certain plant extracts to *Meloidogyne incognita*. Nematologia Mediterranea, 17: 43-44.

Manju, P. and S. Meena.2015. Antinemic properties of the botanicals. International Journal of Science and Nature, 6: 125-134.

Martin, F. N.2003. Development of alternative strategies for management of soil-borne pathogens currently controlled with methyl bromide. Annual Review of Phytopathology, 41: 325-350.

Mateeva, A. and M. Ivanova. 2000. Alternative methods for control of root-knot nematodes, *Meloidogyne* spp. Acta Horticulture, 532: 109-114.

Mcsorley, R. 2011. Overview of organic amendments for management of plant-parasitic nematodes, with case studies from Florida. Journal of Nematology, 43: 69-81.

Moazezikho, A., H. Charehgani, M. Abdollahi and R. Rezaei. 2020. Evidence of inhibitory effect of *Pseudomonas fluorescens* CHA0 and aqueous extracts on tomato plants infected with *Meloidogyne javanica* (Tylenchida: Heteroderidae). Egyptian Journal of Biological Pest Control, 30: 1-8.

Moosavi, M.R. 2012. Nematicidal effect of some herbal powders and their aqueous extracts against *Meloidogyne javanica*. Nematropica, 42: 48-56.

Morra, M.J. and J.A. Kirkegaard. 2002. Isothiocyanate release from soil-incorporated Brassica tissues. Soil Biology and Biochemistry, 34: 1683-1690.

Mostafa, F., A. Refaei, A. Khalil and M. El-Deriny. 2016. Potential use of botanicals rich in alkaloids for controlling *Meloidogyne incognita* and *Rotylenchulus reniformis* infecting cucurbits. Egyptian Journal of Agronematology, 15: 29-43.

Mousa, E.M., M.E. Mahdy and R.A. Bakr. 2014. Bionematicide effect of some plant extracts on *Meloidogyne incognita* control on tomato. 6th International Congress of Nematology, 4-9 May 2014, Cape Town, South Africa.

Nandakumar, A., M. M. Vaganan, P. Sundararaju and R. Udayakumar 2017. Phytochemical analysis and nematicidal activity of ethanolic leaf extracts of *Datura metel*, *Datura innoxia* and *Brugmansia suaveolens* against *Meloidogyne incognita*. Asian Journal of Biology: 1-11.

Nandal, S.N. and D. S. Bhatti. 1986a. The effect of certain edaphic factors on the nematicidal activity of plant extracts. Nematologia Mediterranea, 14: 295-298.

Nandal, S.N. and D. S. Bhatti. 1986b. Influence of four plant extracts on the hatching of *Meloidogyne javanica* and invasion of host roots. Nematologia Mediterranea, 14: 291-294.

Nandal, S.N. and D. S. Bhatti. 1990. Efficacy, persistence and field application potential of some weeds/shrubs for controlling *Meloidogyne javanica* on Brinjal. Nematologia Mediterranea, 18: 113-115.

Nelaballe, V. K. and L. D. Mukkara. 2013a. A Preliminary study on the nematicidal effect of some local flora on *Meloidogyne incognita* chitwood infesting Mulberry. International Journal of Chemical, Environmental & Biological Sciences, 1: 475-77.

Nour El-Deen, A. H. 2011. Integrated control of *Meloidogyne incognita* infesting tomato plants using callus powders derived from certain plants either alone or in combination with oxamyl under out-door conditions. Journal of Agricultural Sciences and

Technology, 1: 225-30.

Ntalli, N., Z. Adamski, M. Doula and N. Monokrousos. 2020. Nematicidal Amendments and Soil Remediation. Plants, 9: 429.

Nyczepir, A.P. and S.H. Thomas. 2009. Current and future management strategies in intensive crop production systems.' in R.N. Perry, Moens, M., Starr, J. (ed.), Root-Knot Nematodes (CAB International: Wallingford, UK.

Oduor-Owino, P. 1993. Effects of aldicarb, *Datura stramonium*, *Datura metel* and *Tagetes minuta* on the pathogenicity of root-knot nematodes in Kenya. Crop Protection, 12: 315-317.

Oduor-Owino, P. 2003a. Control of root-knot nematodes in Kenya with aldicarb and selected antagonistic plants. Nematologia Mediterranea, 31: 125–127.

Oduor-Owino, P. 2003b. Integrated management of root-knot nematodes using agrochemicals, organic matter and the antagonistic fungus, *Paecilomyces lilacinus* in natural field soil. Nematologia Mediterranea, 31: 121-123.

Oduor-Owino, P., S.W. Waudo and W.L. Makhatsa. 1993. Effect of organic amendments on fungal parasitism of *Meloidogyne incognita* eggs and growth of tomato (*Lycopersicon esculentum* Mill) cv. Moneymaker. International Journal of Pest Management, 39: 459-461.

Oka, Y. 2010. Mechanisms of nematode suppression by organic soil amendments: a review. Applied Soil Ecology, 44: 101-115.

Oka, Y., B. Ben-Daniel and Y. Cohen. 2006. Control of *Meloidogyne javanica* by formulations of *Inula viscosa* leaf extracts. Journal of Nematology, 38: 46-51.

Olaniyi, M.O.2015. The use of botanicals in the management of plant parasitic nematodes. The International Journal of Science and Technoledge, 3: 300-309.

Oplos, C., K. Eloh, U. Spiroudi, C. Pierluigi and N. Ntalli. 2018. Nematicidal weeds, *Solanum nigrum* and *Datura stramonium*. Journal of Nematology, 50: 317-328.

Osman, A.A., A.M. Kheir, and E. O. Abdel-ra'ouf. 2016. Nematode biomanagement as an alternative strategy to chemical approach. Egyptian Journal of Biological Pest Control, 26: 75-81.

Owino, P.O. and S.W. Waudo.1992. Medicinal plants of Kenya: Effects of *Meloidogyne incognita* and the growth of okra. Afro-Asian Journal of Nematology, 2: 64-66.

Parihar, K., B. Rehman and M. A. Siddiqui. 2012. Impact of organic additives for sustainable management of root-knot nematode in bottle gourd. Biosciences International, 1: 102-105.

Parul, A., A.K. Chaubey and S.D. Mishra. 2011a. In vitro evaluation of nematicidal efficacy of the extracts of some botanicals and bioagents on egg hatching and larval mortality of juveniles of *Meloidogyne incognita* Race-1. Current Nematology, 22: 63-67.

Parul, A., A.K. Chaubey and S.D. Mishra. 2011b. Evaluation of neem and other plant products as seed coating against root-knot nematode, *Meloidogyne incognita* (Race-1) infesting chickpea (*Cicer arietinum* L.). Current Nematology, 22: 11-14.

Pathan, M.A., M.M. Jiskani, A.M. Lodhi, K.H. Wagan and M. R. Saheto. 2002. Effect of extract of different plant parts and carbofuran on management of *Meloidogyne incognita* infecting tomato. National Symposium on Nematology. January 7-9, 2002. National Nematological Research Centre, University of Karachi, Karachi, Pakistan, P.117-124.

Pinkerton, C.B. and D.R. Kitner. 2006. Effects of biologically derived products on mobility and reproduction of the root-lesion nematode, *Pratylenchus penetrans* on strawberry. Nematropica, 36: 181-196.

Prasad, D., R. Dala and I. Ahmad. 2002. Management of plant parasitic nematodes by the use of botanicals. Annals of Plant Protection Sciences, 10: 360-364.

Qamar, F., Z. Kapadia, S.A. Khan and Y. Badar. 1995. *Datura metel* L., a plant with nematicidal potential. Pakistan Journal of Scientific and Industrial Research, 38: 319-321.

Radwan, M.A., E.K. El-Maadawy and M.M. Abu-Elamayem. 2007. Comparison of the nematicidal potentials of dried leaves of five plant species against *Meloidogyne incognita* infecting tomato. Nematologia Mediterranea, 35: 81-84.

Rao, C. V., A. Mani, and P. K. Rao. 1986. Effect of plant products on egg hatch and larval mortality of *Meloidogyne incognita*. Indian academic science: Animal Sciences, 95: 397-401.

Saeed, M. R. M., G.A. M. Awadh, M. A. Al-Thobhani and A. Taj Al- Deen. 2015. In vitro nematicidal activity of ten plant extracts against juveniles of *Meloidogyne incognita*. Egyptian Journal of Agronematology, 14: 78-90.

Saeed, M. and J. Shawkat. 2014. Nematicidal Effect of Some Botanical Powders and Poultry Manure Against the Root-Knot Nematode *Meloidogyne incognita* (Kofoid and White) Chitwood infecting Tomato Plants.

Egyptian Journal of Agronematology, 13: 160-171.

Safiuddin, S.S. 2010. Use of botanicals for the management of *Meloidogyne incognita* and *Rhizoctonia solani* disease complex in okra. Current Nematology, 21: 1-4.

Sellami, S. and A. Mouffarrah. 1994. Effect of some aqueous plant extracts on juvenile hatching and larval mortality against *Meloidogyne incognita*. Medelingen Faculteit-Land Bouwkundige-EN TOEYE Paste lologishewntensch APPEN Univesitei Gent, 59: 813-816.

Shah, N.H., A. R. Dar, I.A. Qureshi, A. Akhter, M. R. Wani and L. Andleeb. 2018. Control of root-knot disease of Brinjal (*Solanum melongena* L.) by the application of leaf extracts of certain medicinal plants. Indian Journal of Agricultural Research, 52: 444-447.

Shahwar, D., M. Abid, A.U. Rehman, M.A. Maqbool and M.I. Chaudhary. 1993.Nematicidal constituents of *Datura fastuosa*. Fifth National Chemistry Conference, Department of Chemistry, Quaid-i-Azam University, p. 284-285.

Shahwar, D., M. Abid, A.U. Rehman, M.A. Maqbool, and M.I. Choudhary. 1995.Nematicidal compounds from *Datura fastuosa*. 19th IUPAC Symposium on the chemistry of Natural Products, Ata-Ur-Rehman, 171-79. HEJ Res. Inst. of Chemistry, University of Karachi, Karachi 75270- Pakistan, p. 409.

Shakeel, M.A. 2000. Control of citrus nematode (*Tylenchulus semipenetrans*) by the extracts of different plants (Neem, Datura, Ak) and their effect on plant growth variables. MSc. thesis, University of Agriculture, Faisalabad.

Sharma, H.K., D. Prasad and P. Sharma. 2006. Bio-management of *Meloidogyne incognita* infesting Okra. Annals of Plant Protection Sciences, 14: 191-193.

Sharma, N. and P.C. Trivedi. 2002. Screening of leaf extracts of some plants for their nematicidal and fungicidal properties against *Meloidogyne incognita* and *Fusarium oxysporum*. Asian Journal of Experimental Sciences, 16: 21-28.

Shaukat, S. S., I. A. Siddiqui, G. H. Khan and M.J. Zaki. 2002. Nematicidal and allelopathic potential of *Argemone mexicana*, a tropical weed. Plant and Soil, 245: 239-47.

Shaukat, S.S. and I.A. Siddiqui. 2001. Effect of some phenolic compounds on survival, infectivity and population density of *Meloidogyne javanica* in Mung-bean. Nematologia Mediterranea, 29: 123-126.

Shonle, I. and J. Bergelson. 2000. Evolutionary ecology of the tropane alkaloids of *Datura stramonium* L.(Solanaceae). Evolution, 54: 778-788.

Siddiqui, A. 2017. Studies on the use of seeds of some indigenous plants for the control of root-knot nematodes. PhD. thesis, University of Karachi, Karachi, Pakistan.

Sidhu, H.S., V. Kumar and M. R. Madhu. 2017. Eco-Friendly Management of Root-knot Nematode, *Meloidogyne javanica* in Okra (*Abelmoschus esculentus*) crop. International Journal of Pure and Applied Bioscience, 5: 569-574.

Siji, J.V., C.A. Jayaprakas, M.S. Sheela and C. Mohandas. 2010. Efficacy of *Cleome viscosa* L. against *Meloidogyne incognita* infestation in okra (*Abelmoschus esculentus* L.). Thai Journal of Agricultural Science, 43: 151-156.

Sikora, R.A. and J. Bridge. 2005. Nematodes parasites of vegetables. in S. Gowen, P. Quénéhervé and M. Luc (eds.), Plant parasitic nematodes in subtropical and tropical agriculture (CAB International, Wallingford (GBR)).

Singh, A. U., D. Prasad and I.K. Kushwaha. 2017. Effect of chopped *Datura stramonium* leaf against *Meloidogyne incognita* on Mung-bean. Annals of Plant Protection Sciences, 25: 448-449.

Singh, S. and D. Prasad. 2010. Management of *Rotylenchulus reniformis* on Sunflower through botanicals. Annals of Plant Protection Sciences, 18: 220-222.

Singh, S., B. Singh and C. Sellaperumal. 2015. Effect of Botanical Extracts and *Purpureocillium lilacinum* on Root-Knot Nematode, *Meloidogyne incognita* Infection and Growth of Okra. Indian Journal of Nematology, 45: 217-224.

Singh, S.P. and L. S. Devi. 2012. Management of root-knot nematode, *Meloidogyne incognita* on Brinjal (*Solanum melongena* L.) with some plant extracts. Current Nematology, 23: 65-72.

Stirling, G. 1991.Biological control of plant parasitic nematodes: progress, problems and prospects/by Graham Stirling. Wallingford, UK: CAB International, 282 p.

Sundararaju, P. and I. Cannayane. 2002. Antinemic activity of plant extracts against *Pratylenchus coffeae* Infecting Banana. Indian Journal of Nematology, 32:121-124.

Sundararaju, P., B. Padmanaban and S. Sathiamoorthy. 2003. Efficacy of certain botanicals against root-lesion nematode, *Pratylenchus coffeae* in Banana. Nematologia Mediterranea, 31: 201-205.

Susan, A.H. and E.M. Noweer. 2005. Management of Root-Knot Nematode *Meloidogyne incognita* on Eggplant with some Plant Extracts. Egyptian Journal of Phytopathology, 33: 65-72.

Thoden, T. C., J. Hallmann and M. Boppre. 2009. Effects of plants containing pyrrolizidine alkaloids on the northern root-knot nematode, *Meloidogyne hapla*. European Journal of Plant Pathology, 123: 27-36.

Timm, L., D. Pearson and B. Jaffee. 2001. Nematode-trapping fungi in conventionally and organically managed corn-tomato rotations. Mycologia, 93: 25-29.

Tiyagi, S. A. and M. M. Alam. 1995. Efficacy of oil-seed cakes against plant-parasitic nematodes and soil-inhabiting fungi on Mung-bean and Chickpea. Bioresource Technology, 51: 233-239.

Tsialtas, J.T., E. Kostoglou, D. Lazari and I. G. Eleftherohorinos. 2018. Annual Datura accessions as source of alkaloids, oil and protein under Mediterranean conditions. Industrial Crops, 121: 187-194.

Umar, I. and P. A. Ngwamdai. 2015. Evaluation of Leaf Powder and Extract of *Datura Stramonium* in Controlling Root Knot Nematode [*Meloidogyne Javanica* (Chitwood) 1949] on Sweet Melon in Yola, Adamawa State. International Journal of Chemical, Environmental & Biological Sciences, 3: 96-100.

Upadhyay, K.D., K. Dwivedi and S. K. Uttam. 2007. Role of Plant Parts and Their Extracts in the Management of *Meloidogyne incognita* Infecting Pigeonpea. Indian Journal of Nematology, 37: 197-98.

Verma, A.C. and M. N. Khan. 2004. Potentiality of botanicals for managing *Meloidogyne incognita* in *Ocimum canum*. Annals of Plant Protection Sciences, 12: 464-465.

Wen, Y., S. L. Meyer, E. P. Masler, F. Zhang, Ji. Liao, X. Wei and D. J. Chitwood. 2013. Nematotoxicity of drupacine and a cephalotaxus alkaloid preparation against the plant-parasitic nematodes *Meloidogyne incognita* and *Bursaphelenchus xylophilus*. Pest Management Science, 69: 1026-1033.

Youssef, M.M.A. and A.M.S. Lashein. 2013. Efficacy of different medicinal plants as green and dry leaves and extracts of leaves on root knot nematode, *Meloidogyne incognita* infecting Eggplant. Eurasian Journal of Agricultural and Environmental Medicine, 2: 10-14.

Zarina, B. 2007. Management of root-knot nematode (*Meloidogyne javanica*) on Banana plantation in Sindh, Pakistan. Pakistan Journal of Nematology, 25: 73-78.

Zarina, B., A. Ghaffar and M.A. Maqbool. 2006. Effect of plant extracts in the control of *Meloidogyne javanica* root-knot nematode on Okra (*Abelmoschus esculentus* (L.) Moench). Pakistan Journal of Nematology,24: 199–203.

Zarina, B., A. Ghaffar and M.A. Maqbool.2003. Effect of plant extracts in the control of *Meloidogyne javanica* root-knot nematode on Brinjal. Pakistan Journal of Nematology, 21: 31-35.

Contribution of Authors:		
Ramadan A. Bakr	:	Conceptualized the study, developed, implemented, draw graphs and writing of original manuscript, read, edit, and approved the final manuscript.