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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ABSTRACT

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 one of the most ten predominant plant pathogenic nematodes widely attacking economic and non-economic crops all over the world. The present review focuses 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). 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).

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.enaLsci.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/pubmed).
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 extract | Larval mortality | Citrus | Pakistan | Shakeel, (2000) |
| | Aqueous leaves extract | Nematode mortality | Laboratory | Pakistan | Ahmad *et al.*, (2004) |
| | Leaf extract | Larval mortality | Laboratory | Pakistan | Awan, (1992) |
| *M. incognita* | Root extract | 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. arborescens* 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 powder     | leaves | Nematode population | Mung-bean | Pakistan | Abid et al., (1995) |
|                 |                | Leaves | Juveniles   | Pigeon pea |                     | Upadhyay et al., (2007) |
| *M. javanica*   | Dry powder | leaves | Mortality- gal | Brinjal-Okra-Mung | Bean-Chickpea | Pakistan | Abid, (1996) |
|                 |                 | Leaves extracts | 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 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 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 extracts | Nematode population | Eggplant | India | Shah et al, (2018) |
| *M. javanica*   | Intercropping and dry leaves | Galling | Tomato | Kenya | Oduo-Owino (1993,2003b) |
|                 | Dried 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    | Moaazekho et al. (2020)       |
| Dried Leaves extracts     | Larval mortality and Egg hatching     | Laboratory    | Azarbaijan | 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)        |
| 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          | 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)        |
| Leaf 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 | Hadji-Sadok *et al.*, (2014) |
|                  | Plant extracts | Nematode control | Tomato | Bulgaria | Mateeva and Ivanova (2000) |
| *Xiphinema americanum* | Leaf, flower, root | Nematode immobility | Laboratory | Chile | Insunza *et al.*, (2001) |
| *Helicotylenchus multicinctus* | Plant extracts | Larval mortality | Laboratory | Pakistan | Qamar *et al.*, (1995) |
| *Rotylenchulus reniformis* | 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 leaf 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. innoxia*, *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 Moazeziko 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 48 hours 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 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 and 10% 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 was 33.9 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. Hadjisadok 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. inoxia*, *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. Moazeziko 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 glasshouse 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), recorded 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. metel 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≤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 give 100% juveniles’ mortality at 25% concentration after 24 and 48 hrs 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. metel* 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. metel* leaves extract enhanced the plant growth parameters of Eggplant inoculated 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, terpenoids 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 of alkaloids, 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 larvical or ovidicial 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 Nematicicides 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 ovidical or larvical 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 ovidical and larvical 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* leaf 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 studies suggested 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 primary physiological 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 mentioned as a component of nematocidal 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 prevents the 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 muscarinic acetylcholine receptors ability in different organs (Ahmad et al., 2004). The Anthraquiniones 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 composition of 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 inducing changes 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 while Ibrahim 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 valiabile 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.

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