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Harnessing the Nematicidal Potential of Non–Leguminous Plant Extracts for Sustainable Biocontrol

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Abstract: Extensive studies have been conducted to explore the nematicidal properties of different non-leguminous plants as for chemical nematicides. These plants have natural compounds that can effectively combat root-knot nematodes, destructive pests that threaten plant growth world wide. Extracts from plants like moringa, turmeric, cloves, and garlic have demonstrated powerful nematicidal properties. Phytochemical analysis has identified flavonoids, tannins, and phenolic compounds in these extracts, believed to be responsible for their effectiveness against nematodes. In laboratory tests, these plant extracts have been found to impede nematode egg hatching and movement, specifically targeting *Meloidogyne incognita* juveniles. The nematicidal effects of these plants arise from their ability to disrupt nematode cellular structures and functions, ultimately leading to their demise. Using these plant-based nematicides we can provide a sustainable and Eco-friendly alternative to synthetic chemicals which are known for their negative effects on human health and the environment. Further research is necessary to refine the extraction and application techniques for these plant-based nematicides, as well as to investigate their potential synergistic effects when combined.The aim of this review article is to investigate the potential of nematicidal plants and their extracts as eco-friendly and sustainable alternatives to synthetic nematicides for managing plant-parasitic nematodes in agricultural systems.

Keywords: Nematicidal Potential, Non-Leguminous Plant Extracts, Sustainable Biocontrol, Phytochemicals, *Meloidogyne incognita*, Eco-friendly, Botanicals, Pest management, Soil Health, Crop protection

Introduction:

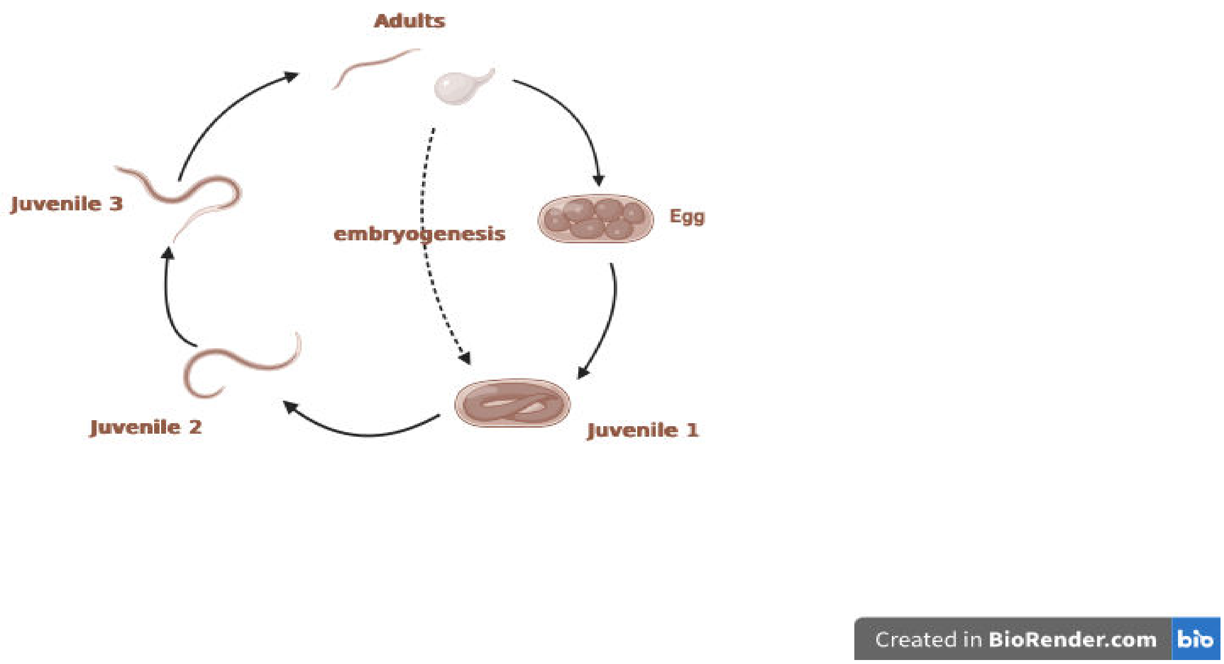
Nematodes, prevalent and widespread organisms, have a significant economic impact through substantial crop losses. These organisms account for approximately 90% of all multicellular species (Çetintaş et al., 2017). Nematodes belong to the extensive phylum Nematoda, consisting of unsegmented roundworms. They are ubiquitous, thriving in various environments worldwide. Nematodes can thrive in a wide range of temperatures, from cold regions to hot desert areas. PPNs are categorized into ectoparasites and endoparasites based on their feeding habits and lifestyles. Ectoparasites feed by inserting their stylet into root cells from the outside on the root surface,while endoparasites penetrate host cells to feed from within (Escobar et al., 2015). Phytoparasitic nematodes can be found in a wide variety of plants and crops worldwide, resulting in significant economic damage. The American Society of phytopathology (APS) estimates that nematodes cause agricultural losses amounting to approximately 14% of global crop yields, totaling nearly $125 billion annually (Chitwood, 2003). Many studies have indicated that at the forefront of the rankings are root-knot nematodes (*Meloidogyne spp*.). Root-knot nematodes (*Meloidogyne spp.*) include more than 100 species, with *M. arenaria*, *M. incognita*, *M. javanica*, and *M. hapla* posing the biggest risk to agricultural crop output (Postnikova et al., 2015). The negative effects of pesticides and synthetic fertilizers on the environment and food safety and quality have raised concerns among the public. Growing awareness of the dangers of pesticides and contamination of the environment has sparked global interest in pest control methods that are derived from plants and are safe, environmentally-friendly, and biodegradable. The use of organic materials can help enhance the population of beneficial organisms in the soil. Various organic products sourced from plants, such as oil-seed cakes, chopped plant parts, and seed dressing with plant extracts, have been utilized as agents for nematode control (Alam 1976); Akhtar and Alam 1993). Botanical extracts are natural substances with a wide range of uses in pest management, known for their safety, effectiveness, and ease of use. Historically, local plant materials have been commonly utilized to safeguard plants from insect damage. One key benefit of botanicals is that they can be easily cultivated by farmers, are more affordable, and pose fewer risks compared to chemical insecticides (Golob and Webly 1980). Current trends in the use of botanical nematicides show that most allelopathic compounds are effective in preventing the hatching egg's, disrupting reproductive processes, and reducing gut movement in nematodes. Plant extract's with nematicidal properties are primarily derived from plant families such as Meliaceae, Fabaceae, Lamiaceae, Brassicaceae, Verbenance, and Euphorbiaceae (Mwamula et al., 2022). The positive impacts of specific plant-based substances and microorganisms in soil are believed to lead to a reduction in the numbers of nematodes that harm plants (Pinkerton et al., 2000).

Plant Parasitic nematodes:

Plant parasitic nematodes, referred to as PPNs, have been documented to encompass approximately 4,300 species, making up 7% of the phylum Nematoda (Decraemer and Hunt 2006). PPNs are tiny worm-like creatures with bilateral symmetry, transparent bodies, and multicellular structure. They can be found living freely in various environments or parasitizing on other organisms, displaying predatory behavior, and residing in both aquatic and terrestrial habitats. Some PPNs are entomopathogenic, ectoparasitic, endoparasitic, or semi-endoparasitic like *Tylenchulus semipenetrans* (Shah and Mahamood 2017). Additional research has indicated that 15% of all recognized nematode species have a significant impact on agriculture. These economically important species primarily attack the roots of major crops, hindering their ability to absorb water and nutrients. This ultimately leads to decreased agricultural productivity, quality, and yields. Nematodes belonging to the Tylenchida order are known to be harmful to plants, invertebrates, and fungi, making them some of the most significant agricultural pests (Sasser and Freckman 1987). Researchers have discovered that nematodes which feed on plants are known as plant-parasitic nematodes because they obtain their nutrients from plants. These nematodes have a slender, needle-like organ known as a stylet, which enables them to puncture the cell walls of plants and access the nutritious substances inside that they consume (Bernard et al., 2017). To date, more than 4100 species of plant-parasitic nematodes have been identified. Some genera are recognized as major plant pathogens, while others target a smaller variety of crops, all of which have a significant impact on economically important crops. The global projected yield loss due to plant nematodes is estimated to be 12.3%, equivalent to $157 billion (Singh et al., 2015).

Life cycle of Plant Parasitic Nematodes:

Meloidogyne spp., being endoparasites, have a lifecycle that can range from three weeks to multiple months, influenced by factors like temperature, moisture levels, and the presence of an appropriate host (Taylor and Sasser 1978) Roberts and McKenry (1985) provided an explanation of the life cycle of root knot and cyst nematodes (Kavithal et al., 2011) Female nematodes deposit their eggs on the root surface, with some eggs being found within galls or plant tissue, typically in large numbers of up to 1000. The first-stage juvenile (J1) undergoes molting within the egg to become the infective second-stage juvenile (J2) upon hatching. The hatching of *Meloidogyne incognita* is primarily influenced by adequate moisture and temperature conditions, as they are able to infect a wide range of host plants without requiring any stimulus from the host. In certain situations, the root diffusates and hatching response may be affected by the generation number of the nematodes (Curtis et al., 2009). In the second part of their lifecycle, the infective juveniles (J2) enter the host plant's roots by piercing them with their stylet. Once inside, these juveniles release secretions that cause the roots to form feeding cells with multiple nuclei. The J2 juveniles then settle down, feed, and go through three molts before becoming adults. Occasionally, worm-like males emerge from the roots, while the females stay in place and have a round or pear-like shape. The females feed, lay eggs in a jelly like substance, and the development of the embryos begins inside the eggs. After the first molt, the second stage juveniles (J2) break out of the eggs (Abad et al., 2009).



Life cycle of plant parasitic nematodes

Non leguminous plant extracts as bionematicides:

The popularity of using plant extracts to combat root knot nematodes is increasing due to the increasing concerns about environmental pollution caused by persistent pesticides. Some dangerous nematicides have been removed from registration. Farmers are facing greater demands to adopt environmentally-friendly pest control methods that do not involve chemicals (Nagdi et al., 2013). Certain plants, materials, and microorganisms found in soil have been shown to decrease the population of plant-parasitic nematodes, resulting in positive impacts (Pinkertonet al., 2000). Botanical insecticides are typically believed to break down quickly in the field due to exposure to light, oxygen, and microorganisms, leading to the formation of less harmful substances. Consequently, there should be no trace of residues on the products or in the surrounding environment (Ujvary 2001). Using organic material can help support the growth of helpful organisms in the soil. Various plant-based organic substances, such as oil-seed cakes, chopped plant pieces, and seed coatings containing plant extracts, have been utilized to manage nematodes (Alam 1976; Muller and Gooch 1982; Tiyagi et al., 2009a; Tiyagi et al., 2009b). Certain plants extracts are utilized to manage specific nematodes due to environmental concerns and the high costs associated with nematicides. This leads to exploration of alternative control methods, such as using antagonistic plants in conjunction with or interspersed among crop plants (Jeyaprakash et al., 2011). Currently, farmers are dealing with a challenge of seedling failure caused by nematodes in the field. This has created a demand for the creation of nematicides that occur naturally, which are less harmful to humans and animals but still as effective against nematodes in different crops as synthetic ones. Several studies have shown that the root extracts of various plants exhibit toxicity towards nematodes (Onifade and Egunjobi 1994; Adegbite and Adesiyan, 2005).

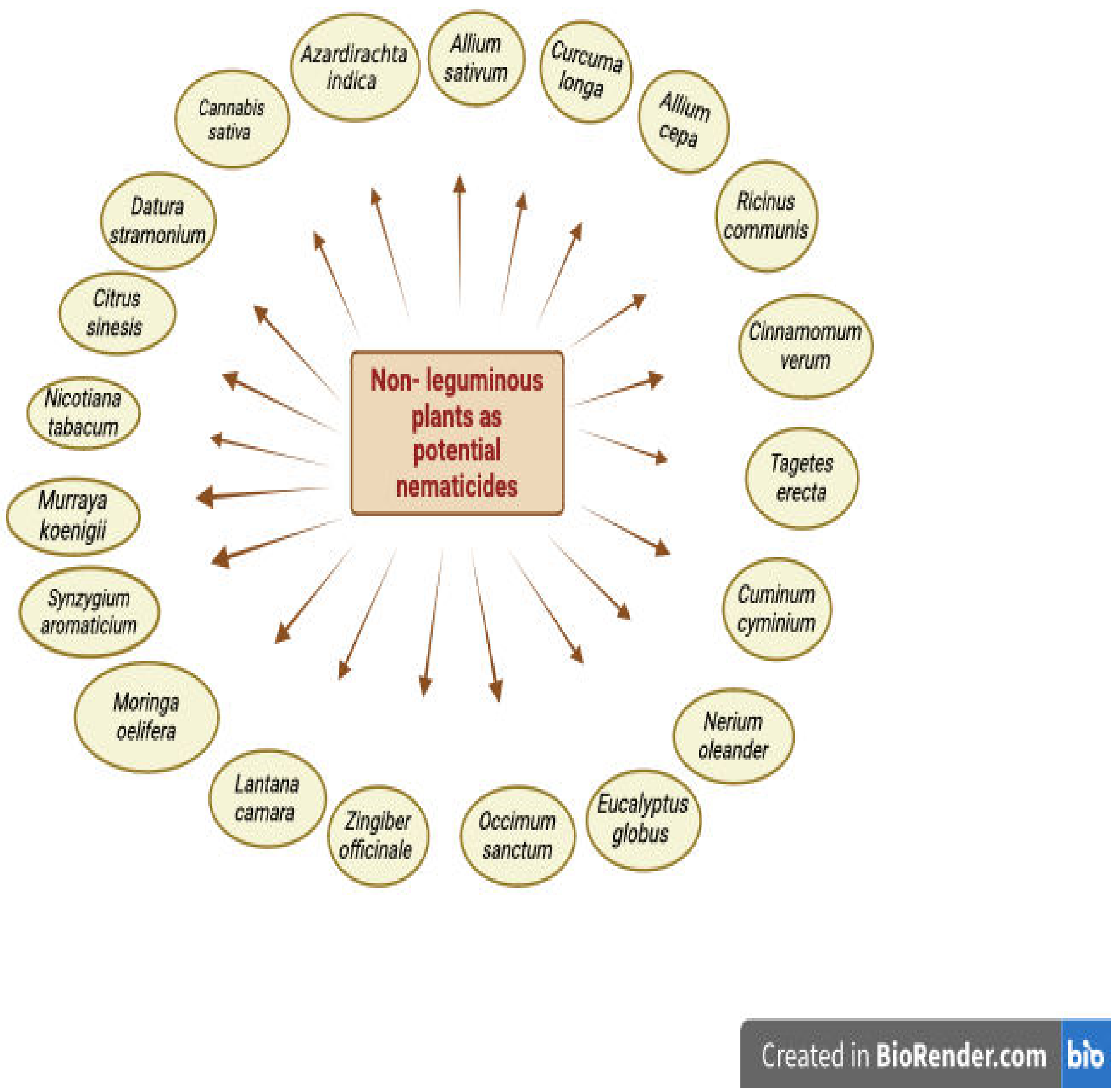
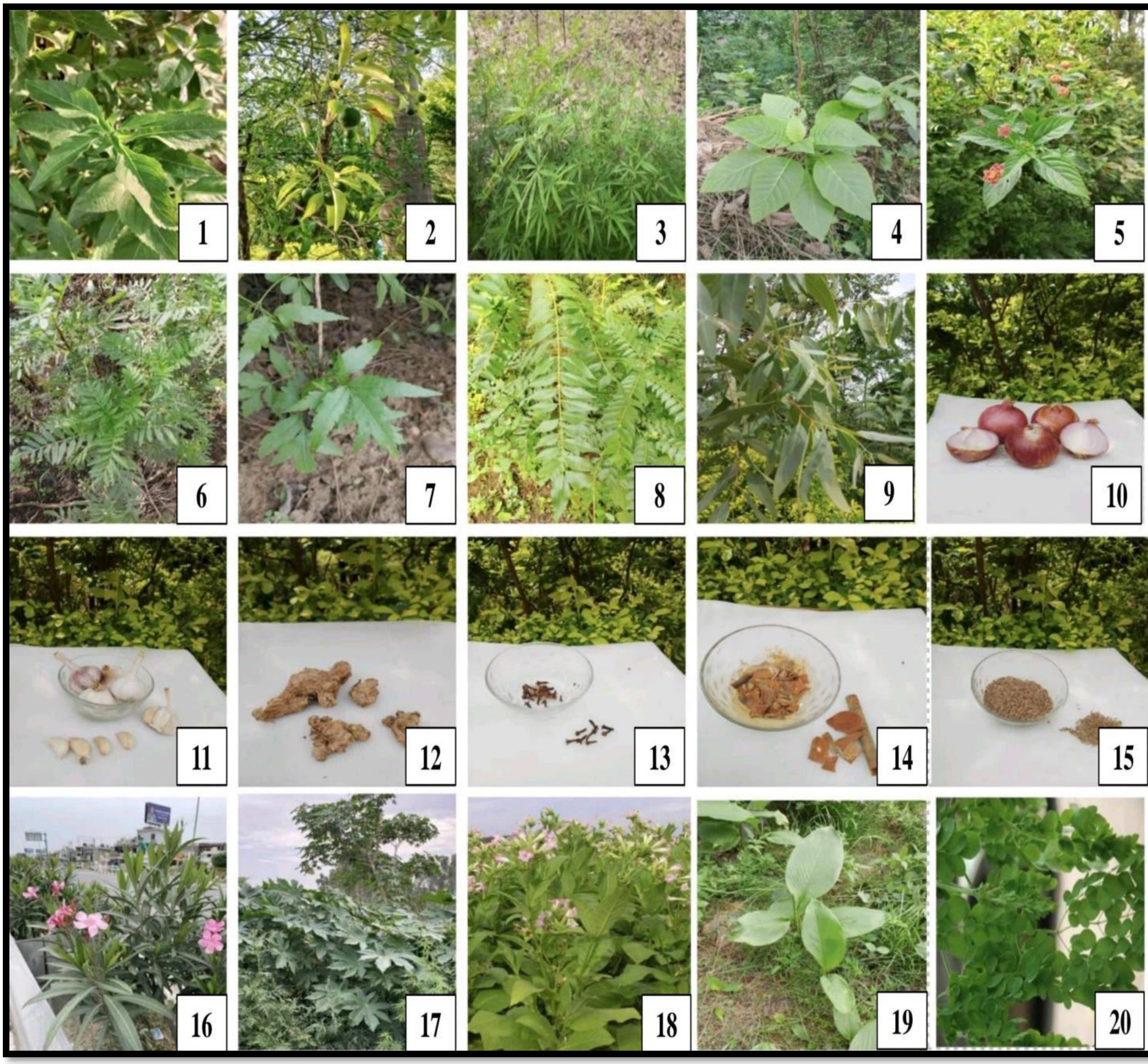


Chart of the Diffrent Non – Leguminous Plants



1.Occimum sanctum 2. Citrus sinesis 3. Cannabis sativa 4. Datura stramonium 5. Lantana camara 6. Tagetes erecta 7. Azardirachta indica 8. Murrayakoenigii 9. Eucalyptus globus 10. Allium cepa 11. Allium sativum 12. Zingiber officinale 13. Syzyngiumaromaticium 14. Cinnamomum vermum 15. Cuminum cyminum 16. Nerium oleander 17. Ricinus communis 18. Nicotiana tabacum 19. Curcuma longa 20. Moringa oelifera

***1. Allium sativum* (Garlic):**

Garlic, scientifically referred to as *Allium sativum*, belongs to the Alliaceae family, which also includes onions, shallots, and leeks. Among the cultivated *Allium* crops, garlic ranks as the second most popular spice globally, after onions (Hectars et al., 2012). Garlic is predominantly grown for consumption in its fresh form or used in dehydrated form as a key ingredient in food processing, essential oils, oil infusions, and powders. It contains substantial levels of essential elements like calcium, phosphorus, and potassium, with its leaves being a good source of proteins, vitamins, and natural antibiotics such as garlicin and allistatin (Diriba-Shiferaw 2016). The *Allium* genus holds economic significance due to its variety of valuable vegetable crops, such as onions and garlic, along with numerous decorative species. Among these, garlic stands out as the second most significant *Allium* species, cultivated globally for its importance as a spice and medicinal herb. The bulb, made up of a varying number of cloves, serves as the primary economic component. Additionally, the fresh leaves, pseudostems, and bulbils are commonly used for consumption (Friesen et. al., 2006). Several studies have shown that garlic, belonging to the Amaryllidaceae family and scientifically known as ***Allium sativum L.***, has been studied for its various biological effects. These effects include antibacterial, antifungal, and nematicidal activities, which are linked to the presence of a diverse range of organosulfur compounds (Anwar, et al., 2017; Munchberg et al., 2007).

***2. Azardirachta indica* (Neem):**

The neem tree, also known as *Azadirachta indica*, is a perennial tree that grows in tropical regions and belongs to the Meliaceae family. This tree is originally from East India and Burma, but it can now be seen in various in Southeast Asia and West Africa. Recently, some neem trees have been planted in the Caribbean and Central America, including Mexico (Roshan and Verma 2015). Numerous research studies have been conducted to investigate the potential use of neem as a natural method for controlling pests and diseases, as an alternative to synthetic chemicals that can have harmful effects over time. The abundance of scientific information available on neem and its derived products like biopesticides and biofungicides is currently disorganized. Therefore, this review seeks to compile and highlight the accomplishments achieved through the use of neem in managing plant pests and diseases. The primary focus of this study is to examine neem's effectiveness as a fumigant, pesticide, and disease prevention agent for plants, along with its chemical composition (Advsei and Azupio, 2022). Additionally, it has been documented that the seed extract of the neem plant possesses insect killing capabilities. Moreover, research has revealed that various components of the neem tree can be effective in combating plant parasites and nematodes, thereby decreasing root knot infections in tea plants (Vitarana, 2023).

***3. Curcuma longa*(Turmeric):**

Turmeric, a spice with a yellow hue, is extracted from the underground stem of the *Curcuma longa* plant and has a history of medicinal use dating back to ancient times in China and India (Ammon and Wahl (1991). Turmeric cultivation in India covers 60% of the total land used for growing spices and condiments and belongs to the Zingiberaceae family. This plant is commonly grown in India and Southeast Asia, known by various names like kunyit in Indonesian and Malay, besar in Nepali, and haldi or pasupu in other Asian countries. There are approximately 70 different species of turmeric, with 30 of them being found in India. Turmeric is sourced from the rhizome of the *Curcuma longa* plant, which makes up 96% of the total yield of this variety in India (Chattopadhyay et al., 2004). Several research reports indicate that the *curcuma* extract has shown effectiveness in managing pests and diseases, particularly those caused by fungi and bacteria. It is possible that similar results can be achieved when applied to NPAs. To further investigate, a study was carried out to assess the efficacy of various vegetable extracts in inhibiting the activity of the root-knot nematode, *Meloidogyne spp.* (Ulfa, et al., 2021).

4. *Tagetes erecta* (African marigold):

The Asteraceae family includes 56 different species of the marigold genus *Tagetes*, with only a total of six annuals and three perennials being grown commercially at present (Ferraz, Grassi de Freitas 2024). Marigold or *Tagetes erecta L.* is commonly referred to as the death flower. This plant is valued for both its medicinal and decorative qualities, as well as its effectiveness as a nematocide. Additionally, marigold is utilized for its cosmetic benefits and medicinal properties (Dharmagadda et al., 2005, Farjana et al., 2009).*T. erecta L* plant has been discovered to have quercetagetin, a type of glucoside, as well as phenolics, syringic acid, methyl-3,5-dihydroxy-4-methoxybenzoate, quercetin, thienyl, and ethyl gallate (Farjana et. al., 2009; Ferraz and Grassi de Freitas, 2004). The majority of findings suggest that *Tagetes spp.* Are highly effective in controlling nematodes, particularly *Pratylenchus* and *Meloidogyne species*. It has been observed that various species and types of *Tagetes* may exhibit varying responses to the same nematode species. Additionally, different populations of nematodes may react differently when confronted with various *Tagetes* varieties (Farjana et al., 2009; Ghani 2003).

***5. Moringa oleifera* (Drumstick)**:

The term *Moringa* originates from the Tamil word ‘muringa’ which means ‘twisted pods’. The genus name is derived from the Latin words ‘oleum’ for ‘oil’ and ‘ferre’ for 'to bear'. In French, it is referred to as acacia blanc, ben oléifère, moringa ailé, Moringa oleifère, Mouroungue, while in German it is known as behenbaum, Behennussbaum, Meerrettichbaum. Various other names are used in different countries such ,mlonge, mlongo, mronge, shagara al rauwaq in Egypt, la mu in China, quiabo-da-quina in Brazil, mzunze in Kenya, alim, bagaruwar maka, samarin, zogale, chigban wawa, idagbo monoye, koraukin zaila, zogalla-gandi, danga, halim, rimin turawa, okwe oyibo, rimin nacara in Nigeria and so on (Orwa et al., 2009). According to a study by Youssef and El-Nagdi in 2015, the use of moringa dry leaf extract in water resulted in a decrease in galling and reproduction of root-knot nematodes on sugar beet plants, ultimate leading to better vegetative growth (El Nagdi et al., 2015; Youseef, et al., 2015).

6. Zingiber officinale (Ginger) :

Ginger, also known as *Zingiber officinale Roscoe*, is a plant that typically grows for two years andd produces fragrant roots that do not have stems. In both British and Indian Pharmacopoeia, ginger has been recognized as a potent treatment for different illnesses. Studies have shown that ginger can lead to central motor paralysis in frogs when injected subcutaneously (Watt et al., 1962). *Z. officinal*e is a type of plant with medicinal properties, and research has demonstrated the effectiveness of its components. Additional research indicates that these plant extracts, as well as their main or minor compounds, could be useful as nematicides. More studies are necessary to explore their potential In managing nematode populations in agriculture (Youssef et al., 2015). In their study, Youssef and colleagues (2015) found that applying ginger as a soil drench at different concentrations led to a decrease in nematode-related issues in eggplant, such as the numb of galls, egg masses, and hatched juveniles in roots and soil infected with *M. incognita* the effectiveness of cinnamon ethyl acetate in controlling *M. incognita* in tomatoes may be attributed to its alkaloids, flavonoids, phenols, steroids, terpenoids, glycosides, and tannins content (Youssef et al., 2015).

7. Lantana camara (*Lantana*):

Lantana camara L. (Verbenaceae) is a perennial plant that is frequently seen in the dry regions of the Indian subcontinent. It is considered to be among the top 10 most troublesome weeds globally and poses a significant challenge for 14 different crops across 47 nations (Holm et al., 1979). Begum and colleagues (2000) recently found and extracted four distinct substances, namely lantanoside, linoroside, camarinic acid, and lantanone, from the uppermost portions of the *L. camara* plant. These substances have displayed nematicidal properties against *Meloidogyne incognita*, with the first three exhibiting significant effectiveness (Begum et al., 2000). Subsequent research showed that the breakdown of *L.*

camara leaves resulted in significant alterations to the soil's fungal community structure, particularly within the endorhiza. This led to the dominance of fungal species with potent nematicidal and hatch-inhibiting properties (Shaukat and Siddiquic 2001a). Phenolic compounds were identified in previous studies as having a significant impact on controlling *M. javanica* and influencing the survival of mycorrhizae species such as *Glomus mosseae* and *Glomus intraradices*(Calvet et.al., 2001: Shaukat and Siddique 2001a).

8.*Synzygium aromaticum* (Cloves):

The clove tree, known as *Syzygium aromaticum,* is originally from Indonesia and is popular worldwide for its flavor and scent. In Tanzania, cloves are cultivated in the East Usambara Mountains, which have a warm and humid climate (Baietto, 2014). The compound eugenol found in cloves possesses antioxidant qualities that help prevent food from becoming rancid. Eugenol esters are utilized as a flavoring agent. With its strong and spicy flavor, cloves are commonly used to enhance the taste of meats and baked goods. Cloves can complement both sweet and savory dishes with their unique flavor. Thanks to its antioxidant properties, cloves can also act as a preservative. They are commonly added to products like pan masala, betel nuts, and chewing gums. Cloves have various reported actions including antiseptic, analgesic, antipperspirant, antibacterial, anesthetic, antiparasitic, stomachic, antioxidant, digestive deodorant, carmative, rubfacient, stimulant, and antidotal properties (Bhat 2009; Delaquis et al., 2002).

***9. Ricinus communis* (Castor):**

The Castor plant, known scientifically as *Ricinus communis L.* is a type of flowering plant belonging to the Euphorbiaceae family. This family consists of numerous plants, predominantly found in tropical regions (Moshkin 1986). Many farmers have easy access to castor oil, which is a commonly used plant-based insecticide. With a high ricin content of over 87.7%, it proves to be a powerful and proficient insecticide (N'guessan et al., 2019). The authors (Kouakou et al., 2023; Kouakou et al., 2017) claim that using certain products in a single application can help decrease the numbers of *M. javanica* and *P. coffeae*in soil, yam roots, and tubers. It can also help prevent the development of symptoms caused by nematodes on yam tubers. However, they also observed an increase in the number of nematodes three months after yam seeds were planted. This increase in nematodes could be because the castor leaf products used in the soil may have been depleted. This depletion could be a threat to the growth of tubers. Therefore, the purpose of the study is to assess how the number of applications of dried castor leaf products affects the pathological activities and population dynamics of *M. javanica* and *P. coffeae*on water yam.

***10. Cinnamomum verum* (Cinnamon):**

The plant group known as *Cinnamomum* is a part of the Lauraceae family and includes approximately 110 different types of perennial trees and bushes (Purseglove et al.,1969). The nematicidal properties of cinnamon essential oils have been demonstrated, indicating the potential for these botanicals to serve as alternatives to synthetic insecticides (Paranagama et al., 2003; Kong et al., 2007). Cinnamon is derived from the bark of the Cinnamon tree. The bark contains 1% essential oil, which consists of active compounds like cineole, cinnamaldehyde, and eugenol. It is commonly used in the preparation of garam masala powder and is known for its antioxidant properties due to the presence of methyl hydroxyl chalcone polymer. Cinnamon, apart from that, is packed with essential chemical components like, cinnamate, cinnamic acid, and cinamaldehyde cinnamate, which offer various health benefits including , immunity-boosting, anti-diabetic, antioxidant, anti-microbial, anti-inflammatory, and protective effects against cancer and heart disease (Khan et al., 2013; Bajpai et al., 2005).

***11. Ocimum sanctum* (Tulsi):**

Tulsi, also known as *Ocimum sanctum*, is a fragrant herb used in Ayurvedic medicine. It belongs to the Labiatae family, it is cultivated in various tropical and subtropical regions around the world (Trivedi2009). There are many differences in the way *Ocimum* plants grow, how they look, and the chemicals they contain. They can thrive in various types of soil and climates. Essential oils extracted from plants have medicinal benefits such as fighting against microbes, preventing oxidation, treating fungal infections, and reducing inflammation. Among the 150 species of *Ocimum*, *Ocimumbasilicum L.* is chosen for research due to its significance in agriculture, cooking, and medicine. This particular species, also known as sweet basil or bhabri, is highly valued for its pleasant scent and is often referred to as the king of herbs (Grieve, 1931). Tulsi is made up of natural compounds that can act as insecticides and repel insects. The extracts from *Ocimumtenuiflorum*have been shown to inhibit the growth of *M. incognita* (Priya and Pandyan 2019; Bharadwaj and Sharma 2007; Popovic et al. 2006).

12. Datura stramonium :

D. stramonium a common annual plant belonging to the Solanaceae family, is widely recognized as a traditional medicinal herb. This wild plant, known for its beautiful flowers, has been studied as a potential natural source for tropane alkaloids that contain a nitrogen atom with a methyl group (N-CH3), including the medications atropine and scopolamine, which have anti-cholinergic effects (Das and Basu 2012). According to Ayurveda, Datura is utilized for treating a variety of human conditions like painful menstruation, nerve pain, swelling, injuries, infections, high body temperature, and difficulty breathing. In India, poisoning from datura is widespread because the seeds are misused as a drug in criminal activities. It is referred to as a dangerous substance found on roadsides and can show symptoms of poisoning such as false perceptions, convulsions, memory impairment, and confusion. Exercise caution when using datura as it can offer medicinal advantages but also carries toxic risks due to its harmful properties. The seeds that have fully developed contain the greatest number of poisonous alkaloids (Miraldi et al., 2001). *Datura stramonium* is known for its ability to control nematodes in plants. Research has explained the effectiveness of *Datura stramonium* extracts in combating plant-parasitic nematodes, particularly those belonging to the *Meloidogyne species* (Oplos et al. 2018).

13. Nerium oleander :

Nerium oleander is known for its ability to withstand dry conditions and is classified under the Apocynaceae family. The leaves of this plant typically measure between 5 and 20 cm in length, and are pointed, short-stemmed, slender, and have a tough dark green surface (Pagen 1988). *Nerium oleander's* toxic nature has been known for a long time. Every part of the plant, particularly the seeds and roots, contains cardiac glycosides. These cardiac glycosides have a structure resembling digitoxin found in foxglove plants. Numerous research studies have suggested that *N. oleander* could potentially be used as insecticides, pesticides, rodenticides, and antimicrobial agents. Ingesting just five leaves of *N. oleander* can result in fatal poisoning (Bandara et al., 2010). Bakr et al., 2015 explained that plant extracts from *Nerium oleander* were found to be extremely poisonous to nematodes when tested in a controlled laboratory setting. The hatching of *Meloidogyne incognita* eggs was significantly impacted in these laboratory conditions.

14. *Eucalyptus globulus:*

The southern blue gum, also known as ***Eucalyptus globulus,*** is a massive and resilient tree that was first discovered on Tasmania island in 1792. Belonging to the large Myrtaceae family, there are around 900 species of eucalyptus, mostly found in Australia. Introduced in India in 1843 for fuel purposes, Eucalyptus is a prominent tree in the country. Research suggests that *Eucalyptus globulus* is a complex species consisting of four unique subspecies: ***Eucalyptus maidenii, Eucalyptus globulus, Eucalyptus pseudoglobulus,*** and ***Eucalyptus bicostata*** (Gupta, et al., 2018). Based on research conducted by (Sharma et al., 2023), it has been found that Eucalyptus species have a range of pharmacological effects. These include pain-relieving, anti-fungal, anti-inflammatory, bacteria-fighting, diabetes-controlling, antioxidant, antiviral, tumor-fighting, allergy-relieving, cancer-fighting, enzyme-inhibiting, and liver-protecting properties. According to the study of (Shakyal and Yadav, 2020)

Eucalyptus leaf extract, after being applied for 6 days, was found to inhibit the egg hatching during the incubation period. The inhibitory effect was observed to increase with higher concentrations of the leaf extract. The number of juveniles significantly decreased when treated with a 20% concentration of the leaf extract.

15. Cuminum cyminum:

Cumin, also called *Cuminum cyminum L.* is part of the Apiaceae family and has various scientific names such as *Cuminum hispanicum Bunge* and *Cuminia cyminum J.F. Gmel.* Additionally, it is known as *CuminumodorumSalisb* and *Ligusticumcuminum L. Crantz* (Jirovetz et al., 2005). The cumin seeds possess traits that induce abortions, relieve spasms, increase urination, regulate menstruation, aid digestion, and support stomach health. Extracts from the seeds are frequently used in various foods such as crackers, sauces, meat dishes, and sausages. The seeds' strong and distinctive scent is what makes them popular as both culinary spices and for medicinal purposes. This fragnance is mainly attributed to cuminol, which makes up 2.5 – 4.0% of the seed. The essential oils present in cumin seeds consist mostly of aldehydes and hydrocarbons (Kanani et al., 2019). In the research conducted by (Bettaiebet al., 2011) they identified bornyl acetate, terpinene, and terpinene as components with antioxidant properties in cumin oils derived from different parts of the plant. Their study also demonstrated that *C. cyminum* and *N. sativa* have promising abilities to control root-knot nematode (*M. javanica)*. These findings suggest that these plants have significant potential for pesticide synthesis to safeguard plant crops (Bettaieb et al. 2011).

16. ***Cannabis sativa:***

Cannabis sativa L. is a plant with herbaceous properties that falls under the Cannabaceae family. It is commonly referred to by various names such as marijuana and hemp, and is recognized by many. Even though its origins lie in Central Asia, its ability to thrive in various climates has enabled it to become widespread globally (McPartland et al., 2019). The mixture comprises a variety of bioactive substances, including alkaloids, amides, sugars, phenolic compounds, plant sterols, fatty acids and their derivatives, flavonoids, and terpenoids, as well as cannabinoids (Andre et al., 2016; ElSohly 2002). Research has demonstrated the effective nematicidal properties of *A. indica* and *C. sativa* in combating *M. incognita,* with C. sativa exhibiting marginally higher toxicity compared to *A. indica.* It is widely known that *C. sativa* has displayed insect and mite repellent qualities, and even the ability to eliminate them. Furthermore, *C. sativa* has been noted for its fungicidal and bactericidal effects against various plant pathogens (Mukhtar et al., 2013 and Kayani et al., 2012).

17. *Allium cepa:*

Onion, scientifically known as *Allium cepa L.,* is a popular vegetable that is cultivated on a large scale around the world. The plant belongs to the Alliaceae family and is commonly consumed in various cultures around the world. This vegetable is highly valued for its versatility, as it can be consumed in various forms including raw, cooked, or as a seasoning (Mahanthesh etal., 2008). Onions are rich in several essential vitamins, such as B2, C, and B1, as well as minerals like selenium and potassium. They have been found to have potential therapeutic benefits in conditions such as diabetes mellitus, cardiovascular diseases, and stomach cancer. The compounds found in onion peel have been shown to possess biological properties that are effective in preventing hypertrophic scars and keloids. Research suggests that extracts derived from onions have the ability to treat hypertrophic wounds (Foo and Tristani-Firouzi, 2019). In a study conducted by Joshi et al., 2013 it was documented that onion extract has the ability to destroy eggs and larvae and kill the second larval stage of *Meloidogyne incognita*. Moreover, the substantial nematicidal effectiveness of water extracts from onion and garlic observed in laboratory experiments led to the confirmation of their nematicidal properties in live organisms.

18. ***Murraya koenigii:***

Curry leaf, scientifically known as *Murraya koenigii,* is a plant found in the Rutaceae family with numerous genera and species, commonly referred to as karipatta in various Indian languages (Satyavati et al., 1987). *Murraya koenigii* is a well-established medicinal herb. Among its components are various essential oils, such as trans-caryophyllene (9.02%), sabinene (13.3%), and α-pinene (39.93%). The presence of trans-caryophyllene (9.02%) is known to exhibit antibacterial properties against various bacteria, including *Bacillus subtilis,Corynebacterium pyogenes, a*nd *Proteus vulgaris* (Kumar et al., 1999). Findings from experiments conducted in laboratory conditions and in potted plants showed that certain plants have the ability to kill nematodes. These plants include *M koenigii, J gandurosa, R.serpentina, J sambac, Zjujuba.H. rosachinensis, and C.aurantifolia*. Additionally, adding dried leaves of these plants to the soil at a concentration of 3% by weight reduced nematode infections and promoted the growth of tomato plants (Padhi and Behera, 2000).

19. *Nicotiana tabacum*

Nicotiana tabacum L. is a plant from the Solanaceae Juss family. It is a herbaceous plant that can grow as an annual or perennial and typically thrives at altitudes ranging from sea level to 500 meters (Hunziker, 2001). *Nicotiana* plants contain a number of natural components, such as pyridine alkaloids, flavonoids, aromatic compounds, and isoprenoids. One well-known compound found in these plants is nicotine. Additionally, they also contain volatile compounds and recently discovered diterpene glycosides (Yan et al., 2019; Moghbel et al., 2017; Jassbi et al.,2017). In a study conducted by Isman, in 2005, it was found that tobacco extract is extremely toxic to nematodes. However, due to its high toxicity towards mammals, including humans, it may not be the most suitable option for practical application.

20. *Citrus sinesis:*

Citrus is a family of fruits under the Rutaceae family, being the largest genus in the fruit kingdom. It is the most widely traded horticultural product worldwide. The Lime, lemon sour orange, tangerine, sweet orange, shaddock, grapefruit, and citron play a significant role in the economy as important species of this genus. Among these, the sweet orange is the primary fruit crop, making up approximately 70% of global citrus production (Ladaniya, 2008). One of the most frequently used components in Traditional Chinese Medicine is derived from different parts of the plant, including the mature fruit young fruit, peel, flower, and other tissues. These components are processed for use in food items in China and are commonly included in Chinese remedies because they contain significant phytochemicals like flavonoids, vitamins, and phenolic acids, suggesting a shared origin between food and medicine (Zhang et al., 2007). According to Akhtar et al., 2019, it was found that the level of inhibition seen was closely linked to the amount of the extracts used. *Capsicum annuum,Citrus sinensis*, and *Manilkara zapota* displayed the highest level of inhibition against *Meloidogyne javanica* egg hatching, showing strong activity across all concentrations.

Phytochemical constituents of the different plant extracts:

1. ***Allium sativum:***

   Researchers believed that S-allyl cysteine sulphoxide is an organosulfur compound, also known as allicin, that is considered a key component responsible for various activities of garlic, including its antibiotic, antimicrobial, and antifungal properties. Garlic is known to contain several organosulfur compounds such as vinyldithiins, Diallyltrisulfide (DATS), diallyltetrasulfide (DATTS) diallyldisulfide (DADS), and diallysulfide (DAS). These compounds have been identified as phytoprotectants and environmentally friendly pesticides (Jacob 2006).
2. ***Cinnamomum verum:***

   The active compounds found in Cinnamon oil are responsible for its biological effects. Cinnamon essential oil contains significant components such as methyl eugenol, trans-cinnamaldehyde, and 3-methoxy-2-propanediol. Previous research has showcased the antifungal and antioxidant properties of these compounds (Anaissie 2010). In their study, Yap et al., in 2015discovered that the essential oil of *Cinnamomum verum* is mainly composed of eugenol (6.57%) benzyl alcohol (12.5%), and trans-cinnamaldehyde (72.81%), (6.57%) according to Gas-MS spectrometry analysis (Yap et al., 2015).

3. ***Azardirachta indica:***
   Phytochemicals like nimbolinin, nimbin, and nimbidin have been found to be effective against various pathogens. Other compounds in leaves, such as ascorbic acid, n-hexacosanol, and amino acids, also contribute to their medicinal properties. Additionally, ingredients like gedunin, quercetin, and salannin play a role in the leaves' ability to combat diseases (Kokate, Purohit, and Gokhale, 2010; Ali, 1993, and Hossain, Shah & Sakari, 2011).
4. ***Curcuma longa:***
   Turmeric includes an extensive range of plant chemicals such as turmeronols, tetrahydrocurcumin, curcumenol, curcumol, eugenol, triethylcurcumin, zingiberene, turmerin, turmerones, and different forms of curcumin like demethoxycurcumin and bisdemethoxycurcumin (Chattopadhyay et al., 2004).
5. ***Tagetes erecta:***
   Research on the plant's various parts has led to the discovery of different chemical compounds including triterpenoids, carotenoids, flavonoids and thiophenes. *Tagetes erecta* has been found to have vinyl and ethyl gallate, quercetagetin glucoside, phenolics, syringic acid, and various other compounds. Lutein, a type of oxycarotenoid, is a prominent component of *Tagetes erecta*, and it contains a C-40 isoprenoid structure and two cyclic end groups. It is also considered the primary pigment of the plant (Dixit et al., 2013).
6. ***Moringa oleifera:***
   Phytochemicals are natural plant compounds that do not provide nutrition but have the ability to protect against diseases. The Moringa family contains a mix of phytochemicals including β-sitosterol, quercetin, kaempferol, caffeoylquinic acid, Isoquercitrin, kaempferitrin, rhamnetin, zeatin, rhamnose, as well as a specific set of compounds known as glucosinolates and isothiocyanate (Fahey 2005).
7. ***Zingiber officinale:***
   The ginger root has two groups of compounds within it: the essential oils responsible for its scent, and the main spicy elements known as gingerols. Within ginger, there is around 5-8% resin, 1-2% starch, volatile oil, and mucilage. The oil extracted from ginger is made up of more than 24 different substances, including monoterpenes like borneol, cineolc, carnphene, citral, phellandrene and borneol, as well as sesquiterpenes like bisabolene and

zingiberine (Connell 1969). Polyphenol compounds found in ginger extracts, specifically 6-gingerol and its derivatives, are known for their powerful antioxidant properties. These antioxidants are derived from various phytochemicals like coumarin, isoflavones, anthocyanin, flavonoids, lignans, flavones, catechins, and isocatechins (Kumar et al., 2014).

8. ***Lantana camara:***

Various compounds including alkaloids, flavonoids, proteins, and tannins can be found in different components of *L. camara* such as the leaves, stems, and roots. Other components like saponins, catechins, steroids, anthraquinone, and tri-terpenoids are also present along with reducing sugars. These plant materials contain important phyto molecules like linaroside, verbascoside, ursolic acid, and phytol. Additionally, umuhengerin, carminic acid, caprylic acid, and lanatoside are also among the compounds present. It is these compounds that contribute to the diverse range of biological activities associated with *L. camara* (Sharma et al., 2007; Satish et al., 2011; Begum et al., 2014; Sousa et al., 2012).

9. ***Synzygium aromaticum:***

Clove buds have an essential oil content of 15-20%, with the main components being eugenol (70-85%), eugenyl acetate (15%), and β-caryophyllene (5-12%). In addition to these, clove oil also contains flavonoids, crategolic acid, tannins, gallotannic acid, and several other compounds including eugenitin, eugenin, methyl salicylate, rhamnetin, vanillin, kaempferol, and triterpenoids like oleanolic acid. The oil also includes chavicol, α and β-humulene, benzaldehyde, β-ylangene, and minor constituents like methyl amyl ketone, which contribute to the pleasant scent associated with cloves (Gopalakrishnan et al., 1984).

10. ***Ricinus communis:***

Castor plant has become a subject of worldwide interest because of its important phytochemicals and economic importance. Key bioactive components consist of castor oil, ricinoleic acid, 11-amino-undecanoic acid, ricinoleyl-sulfate, and lithium grease (lithium hydroxystearate) (McKeon et al., 2016). Phytochemical researchers have put in significant effort to identify the chemical components found in various areas of the *Ricinus communis* plant. Vermeer et al., 2003 extracted homologous long chain 1,3-alkanediols and 3-hydroxyaldehydes from the leaf cuticular waxes of this plant. Additionally, the cuticular waxes contain triterpenoids, aldehydes, fatty acids, primary alcohols, and alkanes (Vermeer et al., 2003).

11. ***Ocimum sanctum***

The extraction of fresh leaves and stems from *Ocimum sanctum* resulted in the presence of phenolic compounds, including antioxidants like apigenin, circimaritin, isothymusin, rosameric acid, and cirsilineol, as well as a significant amount of eugenol. The leaves of *Ocimum sanctum* contain volatile oil making up 0.7% of the plant, with eugenol accounting for around 71% and methyl eugenol for 20%. This oil also includes carvacrol and the sesquiterpene hydrocarbon caryophyllene (Devi 2001).

12. *Datura stramonium*

Scopolamine andHyoscyamine are the main tropane alkaloids found in Datura species, along with a few other minor tropane alkaloids. Some of the less common alkaloids in *D. stramonium* include Scopolamine N-oxide, 7-hydroxyhyoscyamine, Hyoscyamine N-oxide, and apoatropin. Additionally, compounds like 6â-ditigloyloxytropane, tigloidin, and aposcopolamine have been identified in this species for the first time (Das and Basu 2012).

13. Nerium oleander:

The initial inspection of plant chemicals, it was discovered that there were steroids alkaloids, flavonoids, sugars, triterpenes, phenols, soap-like compounds, cardiac glycosides, pregnanes, cardenolides, triterpenes, and tannins (Chaudhary et al., 2015; Baljan et al., 2018).

14. *Eucalyptus globulus :*

The essential oils extracted from different parts of *Eucalyptus globulus* contain valuable chemical compounds. These oils can be obtained from the leaves, branches, buds, and fruits of the plant. Research has shown that the levels of 1,8-cineole in the oils extracted from the leaves vary widely, ranging from 4.10% to 50.30%. The amount of this compound is influenced by factors such as the maturity of the leaves and the location where they are collected. In addition to 1,8-cineole, other primary constituents found in the oils from the leaves are cryptone (0.00–17.80%), spathulenol (0.12–17.00%), p-cymene (trace-27.22%), and α-pinene (0.05–17.85%) (Suganya et al., 2023).

15. Cuminum cyminum:

In a study conducted by Ravi et al., in 2013, the presence of mint sulfide as a minor component was identified in the seed oil of *C. cyminum.* Cumin essential oil was found to have a volatile content of over 90%, with terpene hydrocarbons such as aldehydes, p-cymene, γ-terpinene, and ß-pinene contributing significantly to its composition, including cuminal aldehydes (Ravi et al., 2013).

16. Cannabis sativa:

The Cannabis plant and its derivatives contain a wide range of chemicals, with some of the 483 compounds identified being exclusive to Cannabis. This includes over 60 cannabinoids such as Cannabitriol, Cannabichromene, Cannabigerol, Cannabidiol, '9-Tetrahydrocannabinol, '8-THC, Cannabicyclol, Cannabielsoin, Cannabinol, and Cannabinodiol. On the other hand, the terpenes, which are the most common class with around 140 members, are found throughout the plant kingdom. The term "cannabinoids" refers to a group of C21 terpenophenolic compounds that have so far only been discovered in *Cannabis sativa L.* (Mechoulam and Gaoni, 1967).

17. Allium cepa:

Onions contain a variety of organosulfur compounds, with four main diallyl sulfides being the most prominent: diallyldisulfide, diallyltrisulfide, diallylmonosulfide, and diallyltetrasulfide. When the volatile fraction of onions is steam distilled, di- and trisulfides are the main compounds that are extracted. The primary sulfur-containing elements in onions are S-alk(en)yl-L-cysteine sulfoxides (Lancaster et al., 1989).

18. Murraya koenigii

The *MurrayaKoenijii* plant contains alkaloids such as koenine, koenidine, isomahanimbine, mahanimbine, koenimbine, mahanimbidine, koenimbine, koenigine, and muconicine, which possess bioactive properties including anticancer, antidiabetic, antioxidative, and anti-ulcer effects. The alkaloids in the leaves have bioactive functions such as anticancer, antidiabetic, antioxidative and antiulcer properties. The leaves also contain various free amino acids such as histidine, phenylalanine, glycine, serine, aspartic acid, glutamic acid, theonine, alanine, proline, tyrosine, tryptophan, amino butyric acid, theonine leucine, isoleucine, and small amounts of ornithine, lysine, arginine, and asparagin. Extracts from spices, aromatic herbs, and medicinal plants are highly beneficial natural products that are commonly used in food products, pharmaceuticals, and cosmetics due to their strong flavors, medicinal benefits, and antiseptic properties (Strehle et al., 2005).

19. Nicotiana tabacum

The tobacco leaf is composed of numerous pyridine alkaloids, with nicotine being the primary liquid alkaloid present. Other alkaloids found in the leaf include anatalline, nicotimine, and nornicotine, as well as anabaine. Additionally, the tobacco leaf contains a significant amount of organic acids. Within the leaves one can also find oxalic acids, tahacinin, iso-caffeic, quercitrin, tahacilin, 1-quinic, chlorogenic, and various glucosides. Furthermore, terpenic and carcinogenic substances can also be found in tobacco leaves (Shaligram et al., 2004).

20. Citrus sinesis

The composition contains elements such as linalyl acetate, citral, and geranyl acetate alongside other compounds like n-nonanal, n-decanal, and n-dodecanal. They are also found to include anthranilic acid, sinesal, and citronellal, as well as a high concentration of D-limonene (90%) and methyl ester (Milind and Dev 2012). Phytochemical components are abundant in citrus fruits. These fruits, categorized under the rutaceae family, are a popular choice for fruit tree cultivation globally. The sweet orange, also known as *Citrus sinensis,* is the most prominent fruit in this category, making up approximately 70% of citrus production (Okwu 2008).

Table showing the different phytochemical constituents' present in the non leguminous plants:

Scientific name	Common name	Phytochemical constituents	References
Allium sativum	**Garlic**	Vinyldithiins, Diallyltrisulfide, Diallytetra sulphide, diallyldisulfide and diallysulfide.	Anaya et al., 2006
Cinnamomum verum	**Cinnamon**	Eugenol, transcinnmaaldehyde and 3-methoxy-2propanediol; Eugenol, benzyl alcohol and transcinnmaaldehyde	Abbas et al., 2009
Azardirachtaindica	**Neem**	Nimbolinnin, nimbin and nimbidin	Kokate, Purohit and Gokhale, 2010; Ali, 1993, and Hossain, Shah& Sakari, 2011
Curcuma longa	**Turmeric**	Turmeronols, tetrahydrocurcumin, curcumenol, curcumol, eugenol, triethylcurcumin, zingiberene, turmerin, and turmerones	Chattopadhyay et al., 2004
Tagetes erecta	**Marigold**	Vinyl and ethyl gallate, quercetagetin glucoside, phenolics, syringic acid	Dixit et al., 2014
Moringa oleifera	**Moringa**	B-sitosterol, quercetin, kaempferol, caffeoylquinic acid, Isoquercitrin, kaempferitrin, rhamnetin, zeatin, rhamnose	Fahey 2005
Zingiber officinale	**Ginger**	E-coumarin, isoflavones, anthocyanin, flavonoids, lignans, flavones, catechins, and isocatechins	Conell 1969

Lantana camara	**Lantana**	Linaroside, verbascoside, ursolic acid, and phytol. Additionally, umuhengerin, carminic acid, caprylic acid, and lanatoside	Sharma et al., 2006; Satish et al., 2011; Begum et al., 2014; Sousa et al. 2012
Synzygium aromaticum	**Cloves**	Clove buds have an essential oil content of 15-20%, with the main components being eugenol (70-85%), eugenyl acetate (15%), and β-caryophyllene (5-12%).	Gopalkrishna et al., 1984
Ricinus communis	**Castor**	Ricinoleic acid, 11-amino-undecanoic acid, ricinoleyl-sulfate, and lithium grease (lithium hydroxystearate)	Mckeon et al., 2016
Ocimum sanctum	**Tulsi**	Apigenin, circimaritin, isothymusin, rosameric acid, and cirsilineol	Devi P. 2001
Datura stramonium	**Thorn apple**	7-hydroxyhyoscyamine, apoatropin, hyoscyamine N-oxide, and scopolamine N-oxide.	Das, Kumar P, Basu 2012
Nerium oleander	**Rose bay**	Cardenolides, cardiac glycosides, pregnanes, triterpenoids, triterpenes, and steroids(	Chaudhary et al., 2015; Baljan et al., 2018
Eucalyptus globulus	**Blue gum**	8-cineole, other primary constituents found in the oils from the leaves are cryptone (0.00–17.80%), spathulenol (0.12–17.00%), p-cymene (trace-27.22%), and α-pinene (0.05–17.85%)	Suganya et al., 2023
Cuminum cyminum	**Jeera**	Aldehydes, p-cymene, γ-terpinene, and ß-pinene	Ravi et al., 2013
Cannabis sativa	**Hemp**	Cannabitriol, Cannabichromene, Cannabigerol, Cannabidiol, '9-Tetrahydrocannabinol, '8-	Mechoulam and Gaoni, 1967

		THC, Cannabicyclol, Cannabielsoin, Cannabinol, and Cannabinodiol	
Allium cepa	**Onion**	Diallyldisulfide, diallyltrisulfide, diallylmonosulfide, and diallyltetrasulfide.	Lancaster et al., 1989
Murraya koenigii	**Curry leaves**	Koenine, koenidine, isomahanimbine, mahanimbine, koenimbine, mahanimbidine, koenimbine, koenigine, and muconicine.	Strehle et al., 2005
Nicotiana tabacum	**Tobacco**	Anatalline, nicotimine, and nornicotine, as well as anabaine.	Shaligram, et al., 2004
Citrus sinesis	**Sweet orange**	Linalyl acetate, citral, and geranyl acetate alongside other compounds like n-nonanal, n-decanal, and n-dodecanal.	Milind and Dev 2012

Effects of plant extracts on Plant Parasitic Nematodes:

1. Allium sativum :

Various research has indicated that the extract derived from garlic (*Alliumsativum*) as well as other plants in the *Allium* genus exhibit antibacterial, antifungal, and nematicidal properties (BlockE, 2010). Plant chemicals have the potential to alter the development and reproductive processes of nematodes, thereby changing their physical make-up. This can happen through various mechanisms like influencing the absorption of ions, changing the permeability of membranes, impacting enzymatic functions, altering cell division, and affecting electron transport within the nematodes. Consequently, this could result in the paralysis and eventual death of the nematodes (Anaya et al., 2006).

2. *Azardirachta indica:*

Haroon et al. 2018 have determined in their recent study that the leaf extract of *Azardirachtaindica* can completely hinder the hatching of root-knot nematode eggs. This discovery is crucial for finding new methods to control nematodes in the roots. Further research is necessary to segregate and identify the key compounds involved. The study shows that petroleum ether fractions of *Azadirachta indica* contain nematicidal compounds that can prevent nematode egg hatching, particularly at concentrations of 4000ppm.

3. ***Curcuma longa :***

Turmeric extract using various solvents was shown to effectively hinder the hatching and entry of *Meloidogynespp*. into roots, although it did not have a vital impact on the growth and reproduction of the pests. Therefore, the extract of turmeric is successful in supressing he activity of *Meloidogynespp*. in the roots. The reduced activity of *M. spp.* over the roots is evident in the decrease in hatched eggs and the penetration of the pests into roots with the treatment of vegetable extracts (Ulfa et al., 2021).

4. ***Tagetes erecta*:**

As per study by Hanawi, 2016 the consequences of various treatments on *M. javanica* showed a notable decrease in galling of roots and egg numbers in comparison to the control, whether used individually or in combination. However, combining treatments proved to be have greater efficacy in suppressing nematode development. The combination of *T. erecta, P. lilacinus,* and *T. hamatum* resulted in the lowest galls and egg numbers on the plants. When used individually, *P. lilacinus* treatment showed the lowest galls and egg numbers (Hanawi, 2016).

5. ***Moringa oleifera*** :

The ability of Neem and Moringa leaf extract to control *M. incognita* may be attributed to the various natural compounds they contain, such as reducing sugars, triterpenoids, alkaloids, steroids, flavonoids, saponins, and tannins. Some of these components, including saponins, flavonoids, and tannins, have been found to disturb cell membranes in organisms, allowing harmful substances to enter and harm the organism (Olajidei, 2018; Izuogu et al., 2013; Chin et al., 2018).

6. Zingiber officinale:

As per the study by Bawa et al., 2014, Neem (*Azadirachta indica*), African locust bean *(Parkia biglobosa)*, ginger *(Zingiber officinale)*, and red-bell pepper *(Capsicum annuum*) were effective in preventing root-knot nematodes from hatching and attacking at 1,000ppm concentrations. These plants also successfully destroyed root-knot nematode juveniles at concentrations of 10% and higher (Bawa, et al., 2014).

7. Lantana camara:

According to Qamar et al., 2005 and Ahmad et al., 2010, the impacts of *L. camara* leaf extracts on paralyzing of *M. incognita* second stage juveniles(J2)observed using vital staining techniques. It was determined that the leaf extract of *L. camara* did not function as a potent nematicide, as it only paralyzed the juveniles without killing them. Therefore, the impact of *L. camara* leaf extract may be classified as a nematostatic effect.(Qamar et al., 2005 ; Ahmad et al., 2010).

8. *Synzygium aromaticum:*

Essential oil extracted from cloves has been proven to prevent the development of eggs and completely kill juvenile nematodes, whether they are free or in egg clusters. In a different research study, it was discovered that clove extracts were more successful in eradicating *M. incognita* compared to synthetic pesticides like deltamethrin, carbosulfan, and chlorpyrifos deltamethrin, with a significantly lower effective concentration EC50 (Taniwiryono et al., 2009).

9. *Ricinuscommunis*:

In a study conducted by Katoll et al., 2010, an alcohol-based extract from the leaves and seeds of the castor bean plant was employed to combat *M. incognita* on cucumber plants. This treatment led to a decrease in the quantity of galls and array of nematodes in the soil, as well as promoting the vertical expansion of the cucumber plants (Katoll et al., 2010).

10. *Cinnamomum verum*:

In a study conducted by Abbas and colleagues in 2009, it was found that *Cinnamomum tamala*had a negative impact on the hatching rate and survival of *M. javanica*. The essential oil of this plant is similar to cinnamon leaf oil and contains phellandrene and 78% eugenol. The use of spices for their nematicidal properties has proven to be effective in managing root knot nematodes, particularly *M. javanica* (Abbas et al, 2009).

11. Ocimum sanctum:

In a study by Gill et al., 2001 it was found that all *M. incognita* juveniles died when exposed to *O. sanctum* essential oil from India at a concentration of 200 mg/L. Compareable outcomes were found by Kodjo et al., 2019. Based on the research conducted by Tsonchumi et al. in 2018, it was found that the plant extracts used in the study led to a notable rise in the mortality rate of hatching J2. Out of the nine plants examined, all showed effectiveness in hindering the egg hatching of *Meloidogyne incognita* compared to the experimental group. But on the other hand there were variations in the ability of the different botanicals to reduce the hatching of the juvenile nematodes. After 24 hours of exposure, all nine plant extracts led to a rise in the inability of *M. incognita* juveniles to move although *Ocimumtenuiflorum*stood out as significantly more effective in this regard compared to the control group.

12. Datura stramonium:

A comprehensive report exists on the effectiveness of various Datura species in controlling PPNs. According to Kamau et al., 2020, the leaf extracts of *Datura metal* at a concentration of 10% were found to decrease the egg hatching of *M. incognita*. The death of the nematodes could be a result of the nematicidal substances found in the leaf extracts. Research by Oplos et al. (2018) suggests that *D. stramonium* contains scopolamine. The increased mortality of

Radopholussimilis when exposed to *D. stramonium* because ofthe presence of allelochemicals, particularly tropane alkaloids. Elisanteet al. (2014) also indicate that these compounds, along with other nematicidal substances, contribute to the higher mortality rates.

13. Nerium oleander

Bakr et al., 2015 found in their recent study that extracts from the *N. oleander* plant were very effective in killing nematodes during lab tests. The hatching of *Meloidogyne incognita* eggs was significantly impacted in laboratory settings. The petroleum ether extract from oleander showed the highest efficacy in causing larvae death when used at a concentration of 3%. This could be due to the high amount of acidic compounds, their derivatives, amino acids, and their derivatives present in the extract. Elbadriet al., 2008 and Zasada et al., 2002 also found similar results in their studies.

14. *Eucalyptus globulus:*

Shakya and Yadav's 2020 research found that different levels of leaf extract effectively prevented *Meloidogyne javanica* eggs from hatching.To confirm these findings, mortality studies were conducted on *M. javanica* juveniles (J2). The mortality rate for *Eucalyptus* was determined to be 40.9%. Studies have indicated that extracts from Eucalyptus species have the potential to cause a substantial decrease in the number of *M. javanica*, (second stage juveniles) J2s. However, conflicting results have been reported in other research studies, showing no impact on mortality rates (Ahmed et al., 2010).

15. *Cuminum cyminum:*

According to Haroun, et al., 2022, they discovered that cumin extracts had the ability to hinder the hatching process of 39.5-59.3% of eggs, paralyze 12.5-22.9% of J2s, and eliminate 8.5-16.4% of second stage juveniles (Haroun, et al., 2022). An additional study by Pardavella et al., 2020 explored the effects of hydrosol and essential oil extracted from seeds of cumin on the movement, ability to survive and hatching of second stage juveniles (J2) belonging to *M. javanica* and *M. incognita* (Pardavella et al., 2020). In their 2016 study, Faria et al. discovered that Essential Oils obtained from 56 plant samples showed promising results, particularly those containing γ-terpinene, ascaridol, p-cymene, methyl salicylate, and 2-undecanone carvacrol. While a direct comparison is difficult due to variations in constituents, it appears that C. cyminum essential oils contains potent nematicidal compounds, contributing to its effectiveness against *M. javanica* and *M. incognita* J2s in the tested extract (Faria et al., 2016).

16. *Cannabis sativa*:

Reports indicate that cannabis extracts have been effective in decreasing populations of various organisms such as weeds, protozoans, fungi, insects, mites, bacteria, and nematodes. In addition, Cannabis derivatives have demonstrated the ability to eliminate or hinder the growth of insects, fungi, and bacteria (McPartland 1997). Cannabis has chemicals which are involved in various biological processes of both hosts and pathogens either separately or together. These chemical compounds are also found to have properties that can impede or reduce the multiplication of nematodes, affecting their various activities such as egg hatching, invasion, reproduction, movement, and attraction/repulsion (Chitwood, 2002).

17. Allium cepa:

According to Kouamé et al., 2021, sulfur compounds found in Alliaceae extracts, such as dimethyl-dipropyl and dimethyl-disulfide, have the potential to impact nematode development and reproduction. These compounds may alter the physiology of nematodes by influencing ion absorption, changing permeability of the membrane, affecting activity of enzymes, disrupting cellular division, and interfering with transportation of electrons. Ultimately, this could result in paralysis and eventual death of the nematodes (Kouamé et al., 2021). In his research, Bakr (2018) demonstrated the effectiveness of onion extract as a larvicide by decreasing the population of second-stage larvae of *Meloidogyne incognita.*

18. Murrayakoenigii :

According to a study conducted by Padhi and Behera in 2000, it was observed that test plants such as *M. latifolia,M. Koenigii, R. serpentina, M. latifolia, sambac, G. arboria, Caurantifolia, and C. lanceolatus* exhibited higher efficacy, leading to 100% mortality when exposed to standard extract concentrations for 24 hours. The interactions between leaf extracts of different plant species, concentrations, exposure periods, as well as the combination of concentrations and exposure periods were found to have significant statistical relevance. The mortality of juveniles was attributed to the toxic effects of chemicals found in the leaf extracts from the plants being tested(Vijaylakshmi et al., 1979).

19. Nicotiana tabacum:

Wiratno and colleagues (2009) evaluated the effectiveness of nematicides derived from 17 different plant species. In laboratory experiments, they found that extracts from *N. tabacum* leaves caused a mortality rate of 94% among 150 J2 of *M. incognita* to doses of 5 mg·mL. The nematodes after being left in the open for a full day study found that extracts of betelvine, tobacco, and clove,were the most potent in eliminating the nematode, with an EC50 significantly lower than that of chemical pesticides such as chlorpyrifos, carbosulfan, and deltamethrin. At 5 mg extract/ml water, betelvine, tobacco, and clove, were extremely lethal to the nematodes, causing mortality rates of over 80% (Wiratno, et al., 2009).

20. Citrus sinesis:

According to Abidel et al., (1995) the efficacity of different plant extracts aimed to reduce the number of nematodes residing in the roots and soil, leading to less damage in the crops they tested. They found that using citrus peel extract resulted in inhibiting egg hatching and causing high mortality in nematode juveniles, which was comparable to using a synthetic nematicide like carbofuran. They believed that the lethal effects of the peel extract on nematodes were due to the presence of certain chemicals that are harmful to both eggs of *M. incognita* and their J_2 stage (second stage juveniles). The peel contains saponins, flavonoids, and tannins, which may be the reason for its toxicity to *M. incognita* (Abidel et al., 1995). Previous studies by Barry et al (1986), Alam et al (1978) and Daveral (1972) have also highlighted the role of these compounds in decreasing *M. incognita* population and preventing egg hatching in their research experiments.

Conclusion and future prospective

The worldwide nematicide industry is projected to keep expanding, and as the push to restrict or eliminate the use of harmful synthetic nematicides grows, botanical nematicides are emerging as top alternatives. There is a rising desire for organic foods free of synthetic chemicals, and the general public views botanical pesticides favorably (Caboni and Ntalli, 2014). Exploring the potential of non-leguminous plants like marigold, ginger, lantana, castor, garlic, cannabis, nicotine, curry leaves, onion, cumin, eucalyptus, *Nerium oleander*, datura, tulsi, cinnamon, cloves, turmeric, neem, and citrus for their ability to control nematodes could offer promising solutions for agricultural pest management in the future. Recent research has shown that plant extracts and essential oils from these plants are effective in reducing root-knot nematodes, especially ***Meloidogyne incognita***, which is known for causing extensive damage to crops. The different phytochemicals found in these plants, such as saponins, alkaloids, and terpenes, have nematicidal properties that disrupt the nematode's life cycle, providing a sustainable alternative to chemical nematicides. Studies have shown that including these plants in pest control methods can benefit soil quality and the variety of organisms living in it, which in turn supports long-term farming methods. One example is using leftover plant material in the soil, which not only lowers the number of nematodes but also increases the amount of nutrients available for crops. Moreover, the idea of using these plants as natural fumigants is becoming more popular, as when they break down, they release substances that can effectively reduce nematode populations. Studies have shown that the effectiveness of these plants comes from their secondary compounds, which work by stopping eggs from hatching, driving away nematodes, and killing young ones. Extracts from these plants have been proven to drastically reduce nematode populations and boost plant well-being, hinting at their potential as safe alternatives to chemical nematicides. To sum up, utilizing the nematode-killing abilities of non-leguminous plants not only presents a sustainable method for nematode control but also helps increase crop output and soil quality. Ongoing exploration into the unique compounds and mechanisms of these plants will be vital in creating efficient natural nematicides for farming purposes.

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References:

- A.R. Jassbi, S. Zare, M. Asadollahi, M.C. Schuman, (2017) Ecological roles and biological Activities of specialized metabolites from the genus Nicotiana, Chem. Rev. 117 (19) (2017) 12227–12280.
- Abad, P., Gouzy, J., Aury, J-M., Castagnone-Sereno, P., Danchin, E. G. J., Deleury, E., Perfus-Barbeoch, L., Anthouard, V., Artiguenave, F., Blok, V. C., Caillaud, M-C., Coutinho, P. M., Dasilva, C., De Luca, F., Deau, F., Esquibet, M., Flutre, T., Goldstone, J. V., Hamamouch, N., Hewezi, T., Jaillon, O., Jubin,nC., Leonetti, P., Magliano, M., Maier, T. R., Markov, G. V., McVeigh, P., Pesole, G., Poulain, P., Robinson-Rechavi, M., Sallet, E., Se´gurens, B., Steinbach, D., Tytgat, T., Ugarte, E., Ghelder, C. V., Veronico, P., Baum, T. J., Blaxter, M., Bleve-Zacheo, T., Davis, E. L., Ewbank, J. J., Favery, B., Grenier, E., Henrissat, B., Jones, J. T., Laudet, V., Maule, A. G., Quesneville, H., Rosso, M-N., Schiex, T., Smant, G., Weissenbach, J. and Wincker, P.(2008). Genome sequence of the metazoan plant-parasitic nematode Meloidogyne incognita. Nature Biotechnology. 26 (8): 909-915.
- Abid, M: M, A. Zaki and M.A M.AMagbool (1995): Effect of bare root dip treatment in oil-cake and neem leaf extract on root development and growth of tomato and Eggplant. Nematol. 9 (1) 13-16.
- Adegbite AA, Adesiyan SO (2005). Root extracts of plants to control root-knot nematode on edible soybean. World J. Agric. Sci. (1):18-21.
- Ahmad, F.; Rather, M.A.; Siddiqui, M.A. (2010), Influence of organic additives on the incidence of root-knot nematode, Meloidogyne javanica in roots of tomato plants. Archives of Phytopathology and Plant Protection, 43, 168-173.
- Ahmed Z M, Dawar S, Tariq M & Zaki M J (2010). Effect of local tree seeds in the control of root knot nematode Meloidogyne javanicana(Treub.) Chitwood and growth promotion of chickpea (Cicer arietinum L.) and mung bean (Vigna radiata L.). Acta Agrobotanica 63(1): 197-203.
- Akhtar M, Alam MM (1993) Utilization of waste materials in nematodes control: a review. Biores Technol 45: 1–7 .
- Alam MM (1976) Organic Amendments in Relation to Nematodes. PhD Thesis, Aligarh Muslim University, Aligarh; Muller R, Gooch PS (1982) Organic amendments in nematode control. An examination of the literature. Nematropica 12: 319–326.

- Alam MM (1976) Organic Amendments in Relation to Nematodes. PhD Thesis, Aligarh Muslim University, Aligarh.
- Alam, M.M.M, Ahmed and A.M Ahan (1989). Effect of organic amendment on the growth and chemical composition of tomato, eggplant and chilli and their susceptibility to attack by Meloidogyne incognita. Plant and soil 57:231-236.
- Ali,A. (1993). Textbook of Pharmacognosy, Publication and information Directorate, New Delhi, India.
- Ammon HP and Wahl MA (1991). Pharmacology of Curcuma longa. Planta Med. 57(1): 1–7.
- Anaya, A. L. (2006). Allelopathic organisms and molecules: promising Bioregulators for the control of plant Diseases, weeds, and other pests, in Allelochemicals: biological control of Plant pathogens and diseases Springer.
- Andre CM, Hausman JF, Guerriero G.(2016) Cannabis sativa: the plant of the thousand and one molecules. Front Plant Sci (2016) ; 7:19.
- Anwar, A.; Gould, E.; Tinson, R.; Groom, M.; Hamilton, C.J. (2017) Think yellow and keep green–role of sulfanes from garlic in Agriculture. Antioxidants, 6, 3.
- Assiri Patrice Kouamé, Yadom Yao François Regis Kouakou, Kafondja Estelle Coulibaly, KoutouaSéka, Fatoumatou Fofana and Hortense Atta Diallo(2021) Effectiveness of Garlic and Onion Aqueous Extracts on Tomato Root-Knot Nematodes (Meloidogyne sp.) in the Autonomous District of Yamoussoukro in Central Côte d'Ivoire, ISSN: 2582 – 2845 Ind. J. Pure App. Biosci. (2021) 9(1), 24-35.
- Baietto, M. (2014). Bud fall induction in Clove (Syzygium aromaticum). Academic Research International. 5(4): 23-29.
- Bajpai M, Pande A, Tewari SK, Prakash D. (2005). Phenolic contents and Antioxidant activity of some food and Medicinal plants. International Journal of Food Science and Nutrition. 2005; 56 (4): 287-291.
- Bakr R.A.; M.E. Mahdy; E.M. Mousa and M.A.Salem, (2015). Efficacy of Nerium oleander Leaves extract on controlling Meloidogyne incognita in-Vitro and in-Vivo ; Egyptian Journal of Crop Protection, Vol., (10), No. (1): 1 13, 2015 © Egyptian Society of Plant Protection 2015.
- Balkan IA, Doğan H, Zengin G, Colak N, Ayaz FA, Gören A, Kırmızıbekmez H, YeşiladaE.(2018). Enzyme inhibitory and antioxidant Activities of Nerium oleander L.flower extracts and activity Guided isolation of the active components. Industrial Crops and Products. 2018; 112:24-31.
- Bandara V, Weinstein SA, White J, et al. (2010). A review of the natural history, toxicology, diagnosis and clinical management of Nerium oleander

(common oleander) and Thevetiaperuviana (yellow oleander) poisoning. Toxicon 2010; 56(3): 273–281.

- Barry, T.N, T.R. Manly and S.J Duncan (1986): The role of condensed tannins in nutritional value of lotus penducalatus for sheep-sites of carbohydrate and protein digestion as influenced by dietry reactive tannins concentration. Brit. J. Nutri. 55:123-127.
- Begum S, Ayub A, Zehra SQ, Siddiqui BS, Chaudhary MI. (2014) Leishmanial triterpenes from Lantana camara. Chem Biodiverse 2014; 11:709-18.
- Begum S., Wahab A., Siddiqui B. S. and Qamar F., (2000) Nematicidal constituents of the aerial parts of Lantana camara. Journal of Natural Products, 63: 76.
- Bernard, G.C., Egnin, M., Bonsi, C., (2017) The impact of plant-parasitic nematodes on agriculture and methods of control, in: Nematology – Concepts, Diagnosis and Control. BoD–Books on Demand, pp. 121-151.
- Bettaieb, I., Bourgou, S., Sriti, J., Msaada, K., Limam, F., and Marzouk, B., (2011). Essential oils and fatty acids composition of Tunisian and Indian cumin (Cuminum cyminum L.) seeds: A comparative study. J. Sci. Food Agric., 91: 2100–2107.
- Bharadwaj, A. and Sharma, S., (2007) Effect of some plant extracts on the hatch of Meloidogyne incognita eggs. Int. J. Bot., 3 (3): 312 – 316.
- Bhat KS, Vivek K. (2009) Biocidal potential of clove oils against Aede albopictus – A Comparative study. African Journal of Biotechnology. 2009; 8 (24):6933-6937, 15.
- Block E (2010) Garlic and other Allium: The lore and the science (Cambridge, United Kingdom: The Royal Society of Chemistry)
- C. Zhang, P. Buccheli, X. Liang, Y. Lu, (2007) Citrus flavonoids in fruit and traditional chinese medicinal food ingredients in China, Glob. Sci. Book 1 (2) (2007) 287-196.
- Caboni P, Ntalli NG. Botanical nematicides, recent findings. In: Gross AD, Coats JR, Duke SO, Seiber JN, editors. Biopesticides: state of the art and future opportunities. American Chemical Society; Washington, DC, USA: 2014. Pp. 145–157
- Calvet C., A. Camprubí, V. Estaún and R. Rodríguez-Kába- Na (2001). Evaluation of natural chemical compounds against root-lesion and root-knot nematodes and side effects on the infectivity of arbuscular mycorrhizal fungi. European Journal of Plant Pathology 107, 601–605.
- Çetintaş, R., Kareem, K. H., Nassar, H. A. (2017): Diagnosis of Nematode Populations found in Chard, Barley and Onion Grown in North of Iraq and South of Turkey. – Doga BilimleriDergisi 20: 28.

- Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee RK. (2004) Turmeric and curcumin: Biological Actions and medicinal applications. Current Science of India. 2004; 87:44-53.
- Chaudhary K, Prasad D, Sandhu B. (2015) Preliminary pharmacognostic and phytochemical studies on Nerium oleander Linn. (White Cultivar). Journal of Pharmacognosy and Phytochemistry. 2015;4(1):185-188.
- Chin, S., Abehm, C.A., and Mathesius, U., (2018). Functions of flavonoids in plant nematode Interactions. Plants, 7(4): 85.
- Chitwood, D.J. (2002) Phytochemicals based strategies for nematode control. Annu. Rev. Phytopathol.40:221-249.
- Chitwood, D.J. (2003) Research on plant-parasitic nematode biology conducted by the United States Department of Agriculture-Agricultural Research Service. Pest Manag. Sci. 2003, 59, 748–753.
- Connell DW. (1969) The pungent principles of ginger and their importance in certain ginger products. Food Tech 1969; 21:570-5.
- Curtis, R. H., Robinson, A. F., & Perry, R. N. (2009). Hatch and host location. Root-knot nematodes, 139-162.
- Das S, Kumar P, Basu SP. (2012) Review article on phytoconstituents and therapeutic potentials of Datura stramonium linn. J Drug Del Therap. 2012;2(3):4–7.
- Daverall, B.J (1972). In phytochemical ecology ed. Harbon J.B Academic Press. London pp. 217-234.
- Decraemer, W., and Hunt, D. J. (2006). "Structure and classification," in Plant nematology, eds R. N. Perry and M. Moens (Oxfordshire: CABI1), 3–32.
- Delaquis PJ, Stanich K, Girard B, Mazza G. (2002) Antimicrobial activity of Individual and mixed fractions of dill, Cilantro, coriander and eucalyptus Essential oils. International Journal of Food Microbiology. 2002; 74(1–2): 101-109.
- Dharmagadda V, Naik SN, Mittal PK, Vasudevan P. (2005) Larvicidal activity of Tagetes patula essential oil against three mosquito species. BioresourTechnol 2005; 96: 1235-40.
- Diriba-Shiferaw, G. (2016) Review of management strategies of constraints in garlic (Alliumsativum L.) production. J. Agric. Sci. 2016, 11, 186–207.
- Dixit P, Tripathi S, Verma NK (2013). A brief study on Marigold. International Research Journal of Pharmacy, 4, 43-48.
- Elbadri , G.A.A.; Dong Woon Lee , Jung Chan Park , Hwang Bin Yu and Ho Yul Choo (2008). Evaluation of various plant extracts for their nematicidalefficaies against juveniles of Meloidogyne incognita. Journal of Asia-Pacific Entomology, 11: 99– 102.

- Elisante, F &Ndakidemi, P.A (2014). Allelopathic effect of Datura stramonium on the survival of grass and legume species in the conservation areas. American Journal of Research Communication. 2(1).
- El-Nagdi, Wafaa M, A, and Youssef, M.M.A. (2015). Nematicidal effect of some aqueous extracts of botanicals and a commercial bacterial byproduct for biocontrolling root knot nematode, Meloidogyne incognita infecting sugar beet. Sci. Agric 10 (2): 55-58.
- ElSohly MA. Chemical constituents of cannabis. Haworth Press. New York 2002.
- Escobar, C., Barcala, M., Cabrera, J., &Fenoll, C. (2015). Overview of root-knot nematodes and giant cells. In Advances in botanical research (Vol. 73, pp. 1-32). Academic Press.
- Fahey, J.W., (2005) Moringa oleifera: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal 1.
- Faria, J.M.S.; Sena, I.; Ribeiro, B.; Rodrigues, A.M.; Maleita, C.M.N.; Abrantes, I.; Bennett, R.; Mota, M.; Figueiredo, A.C.S. (2016) First report on Meloidogyne chitwoodi hatching inhibition activity of essential oils and essential oils fractions. J. Pest Sci. 2016, 89, 207–217.
- Farjana N, Rowshanul HM, Zahangir AS, Rezaul MK, Apurba KR, Shahriar Z. (2009) Toxicological evaluation of chloroform fraction of flower of Tagetes erecta Linn on rats. Int J Drug Dev & Res 2009; 1: 1: 161-165.
- Ferraz S., Grassi de Freitas L. (2004). Use of antagonistic plants and Natural products. In: Nematology-Advances and perspectives; Volume II, Nematode Management and Utilisation (Chen Z. X., Chen S. Y., Dickson D. W., eds), CABI Publishing, Wallingford, UK, pp. 931-977
- Foo C. W., Tristani-Firouzi P. (2011) Topical modalities for treatment and prevention of postsurgical hypertrophic scars. Facial Plastic Surgery Clinics of North America. 2011;19(3):551–557.
- Friesen N., Fritsch R.M., Blattner F.R., (2006) Phylogeny and new intrageneric classification of Allium L. (Alliaceae) based on nuclear ribosomal DNA ITS sequences. Aliso, 22: 372–395.
- Ghani A. (2003) Medicinal plants of Bangladesh: Chemical constituents and uses, 2nd edition, Dhaka, India. Asiatic Society of Bangladesh,2003.
- Gill K, Mehta S, Malik M, Malik O, Walia R. (2001) Toxicity of methanolic leaf extracts and essential oil from various plants to the root-knot nematode Meloidogyne incognita. NematolMediterr. 29:219–222.
- Golob, P. and Webly, D. J. (1980) The use of plants and minerals as traditional protectants of stored products. Insect Sci. Application.12(1\2\3): 103-109 and

Saxena, K. B.; Lateef, S. S.; Ariyaratne, H. P.; Fenseka, H. H. D. and Dharmasena, C. M. D.. 1996. Maruca, testulalis damage in determinate and intermidiate lines of pigeonpea. Int. Pigeonpea. 14:190-193.

- Gopalakrishnan M, Narayanan CS, Mathew AG.(1984) Sesquiterpene Hydrocarbons from clove oil. J Lebensmittel-Wissenschaft U Technologie B 1984;17:42-3.
- Grieve M. A Modern Herbal. Jonathan Cape LTD. Bedford Square, London. 1931; 30:86-87.
- Hector S, Espino F. and Olivio HH. (2012). Agronomic and biotechnological strategies for breeding Cultivated garlic in mexico.
- Hissein Mahamad HAROUN2 Gökhan AYDINLI3 Sevilhan MENNAN2* creening of the nematicidal potential of some spice extracts against root-knot nematode, Meloidogyne arenaria (Neal, 1889) Chitwood, 1949 (Tylenchida: Meloidogynidae)1 Türk. Entomol. Derg., 2022, 46 (3): 275-288.
- Holm L., J.V. Pancho, J.P. Herberger and D.L. Plucknett, (1979). A geographical Atlas of World Weeds. John Wiley, New York, NY, USA, 136 pp.
- Hossain,M. A. Shah,M. D. and Sakari,M. (2011). Gas chromatography–mass spectrometry analysis of various organic extracts of Merremiaborneensis from Sabah. Asian pacific Journal of Tropical Medicine. 4(8), 637–641.
- Hunziker, A.T. (2001) Genera Solanacearum. The Genera of Solanaceae Illustrated, Arrange according to a New System; John Wiley and Sons: Hoboken, NJ, USA, 2001; pp. 1–500.
- Jacob C (2006) A scent of therapy: pharmacological implications of natural products containing redox -active sulfur atoms Natural Product Reports 23 851-863.
- Jeyaprakash K, Ayyanar M, Geetha KN, et al. (2011) Traditional uses of medicinal Plants among the tribal people in Theni district (Western Ghats), South india. Asian Pacific Journal of Tropical Biomedicine. 2011;1(1): S20–25.
- Jibia Abdulhadi BAWA *1, Iliya MOHAMMED 1, Sanusi LIADI 2 ; (2014) Nematicidal Effect of some Plants Extracts on Root-Knot Nematodes (Meloidogyne incognita) of Tomato (Lycopersicon esculentum), ISSN 2249-0574 World J Life Sci. and Medical Research 2014;3(3):81
- Jirovetz L, Buchbauer G, Stoyanova AS, Georgiev EV, Damianova ST. (2005) Composition, quality control and antimicrobial activity of the essential oil of cumin (Cuminum cyminum L.) seeds from Bulgaria that had been stored for up to 36 years. International Journal of Food Science and Technology 2005; 40: 305-310.

- Joshi, G., Subhash, B., & Sharma, M. (2013). Effect of plant extracts on hatching and mortality of root-knot nematode, Meloidogyne incognita larvae (in Vitro). Indian Journal of Nematology, 43(2), 200-202.
- Kanani P, Shukla YM, Modi AR, Subhash N, Kumar S. (2019) Standardization of an efficient protocol for isolation of RNA from Cuminum cyminum. Journal of King Saud University – science. 2019;31(4):1202–1207.
- Kayani, M.Z., T. Mukhtar and M.A. Hussain. (2012). Evaluation of nematicidal effects of Cannabis sativa L. and Zanthoxylum alatumRoxb. Against root-knot Nematodes, Meloidogyne incognita. Crop Prot. 39:52-56.
- Kesharwani, Gupta, Kushwaha, Kesharwani, KM Patel. (2018) A review on therapeutic application of eucalyptus oil.International Journal of Herbal Medicine. 2018;6(6): 110-115.
- Khan A, Safdar M, Khan AMM, Khattak KN, Anderson RA. (2013) Cinnamon improves glucose and lipids of people with type 2 diabetes. Diabetes Care. 2013; 26 (12): 215- 218.
- Khan, A., Asif, M., Tariq, M. and Rehman, B. (2017). Phytochemical investigation of Nematostatic and nmaticidal potential of weed extracts against Meloidogyne incognita in vitro. Asian Journal of Biological sciences, 10 (2):38 – 46.
- Kodjo Eloh, Kafui Kpegba, Nicola Sasanelli, Honoré Kossi Koumaglo& Pierluigi Caboni Nematicidal activity of some essential plant oil from tropical West Africa. ISSN: 0967-0874 (Print) 1366-5863.
- Kokate,C.Purohit,A. P. and Gokhale, S.B.(2010). Pharmacognosy. NiraliPrakashan, Maharashtra, india.
- Kong, J.O.; Lee, S.M. S.M.; M oon, Y.S.; Lee, S.G. nd Ahn, Y.J. (2007). Nematicidal activity of Cassia and cinnamon oil compounds and Related compounds toward BursaphelenchusXylophilus (Nematoda: Parasitaphelenchidae). J. Nematol., 39(1): 31-36.
- Kumar NV, Murthy PS, Manjunatha JR, Bettadaiah BK. (2014) Synthesis and Quorum sensing inhibitory activity of key phenolic compounds of ginger and their derivatives. Food Chem. 2014; 159:451–457.
- Kumar, V.S., Sharma, A., Tiwari, R., Kumar, S. (1999). Murraya koenigii: A review. Journal of Medicinal and Aromatic Plant Science, 2(1), 1139- 1141.
- Ladaniya, M. S. (2008). Citrus fruit: Biology, technology and evaluation. Academic Press.
- Lancaster JE, Shaw ML. (1989) γ-Glutamyl peptides in the biosynthesis of S-alk (en) yl-L-cysteine Sulphoxides (flavour precursors) in Allium. Phytochemistry. 1989;28(2):455-60.

- Mahanthesh, B., M.R.P. Sajjan, M. Harshavardhan, S. Vishnuvardhana and G. Janardhan (2008). Evaluation of different onion (Allium cepa L.) genotypes for yield and processing quality parameters in Kharif season under irigated condition. Asian J. Hortic., 3: 5-9.
- Maria Ulfa, Toto Himawan and Hagus Tarno. (2021) Nematicidal Activity of Turmeric Extract against Nematodes Meloidogyne spp. Research Journal of Life Science APRIL-2021 Volume 8 NO. 1 (48-56).
- McKeon TA, Hayes DG, Hildebrand DF, Randall J, Weselake RJ (2016). Industrial Crops. 2016 – Academic Press. 474.
- McPartland J.M., Hegman W., Long T. (2019) Cannabis in Asia: Its center of origin and early cultivation, based on a synthesis of subfossil pollen and archaeobotanical studies. Veg. Hist. Archaeobot. 2019; 28:691–702.
- McPartland, J.M., (1997). Cannabis as repellent and pesticide. J. Int. Hemp Assoc. 4, 87–92.
- Mechoulam R and Gaoni Y. Recent advances in the chemistry of hashish. Fortschr. Chem. Org. Naturst. 1967; 25, 175–213.
- Miraldi E, Masti A, Ferri S, Barni Comparini I (2001). Distribution of hyoscyamine and scopolamine in Datura stramonium. Fitoterap., 72: 644-648.
- Mohammed Jubair Hanawi (2016), Tagetes erecta With Native Isolates OfPaecilomyceslilacinus and Trichodermahamatum In Controlling Root Knot Nematode Meloidogyne javanica On Tomato Volume 5, Issue 1, January 2016 ISSN 2319 – 4847.
- Mukhtar, T., M.Z. Kayani and M.A. Hussain. (2013). Nematicidal activities of Cannabissativa L. and Zanthoxylum alatumRoxb. Against Meloidogyne incognita. Ind. Crops Prod. 42:447-453.
- Muller R, Gooch PS (1982) Organic amendments in nematode Control. An examination of the literature. Nematropica 12: 319–326.
- Münchberg, U.; Anwar, A.; Mecklenburg, S.; Jacob, C. (2017) Polysulfides as biologically active ingredients of garlic. Org. Biomol. Chem. 2007, 5, 1505–1518.
- Mwamula, A.O.; Kabir, M.F.; Lee, D. (2022) A Review of the Potency of Plant Extracts and Compounds from Key Families as an alternative to Synthetic Nematicides: History, Efficacy, and Current Developments. Plant Pathol. J. 2022, 38, 53–77.
- N. Moghbel, B. Ryu, A. Ratsch, K.J. Steadman, (2017). Nicotine alkaloid levels, and Nicotine to nornicotine conversion, in Australian Nicotiana species used as chewing tobacco, Heliyon 3 (11) (2017) 00469.

- N. Yan, Y. Du, X. Liu, H. Zhang, Y. Liu, Z. Zhang, (2019). Study progress of radiomics with machine learning for precision medicine in bladder cancer management, Front. Oncol. 9 (1) (2019) 1296.
- N.N. Padhi and Gunanidhi Behera(2000). Evaluation of nematicidal potential in ten indigenous plant species against Meloidogyne incognita; Indian Phytopath. 53 (I) : 28-31 (2000).
- N'guessan et al.,(2019) Effect of the corn- Cowpea association on the organic Carbon dynamics of the soils of two plots In real culture in northern Côte d'Ivoire; 2019.
- Nabin Sharma*, Meenakshi Kandwal and S. M. Patil (2023). A Review On Medicinal Property Of Euclapytus Plant; World Journal Of Pharmaceutical And Medical Research; wjpmr, 2023,9(6), 88-94.
- Okwu, D. E. (2008). Citrus fruits: a rich Source of phytochemicals and their roles In human health. Int. J. Chem. Sci.: 6 (2), 2008, 451-471.
- Olajidei, M.C., Izuogui, N.B., Apalowoi, R.A., and Baba, H.S., (2018). Evaluation of the nematicidal and antifungal activity of aqueous extract of Moringa oleifera leaves and seed in cucumber Field. Cercet. Agron. Mol., LI 4 (176): 47-59. Izuogu, N.B., Badmos, A.A., and Raji, S.O., 2013.
- Onifade AK, Egunjobi OA (1994). Suppression of Meloidogyne incognita population with water hyacinth and water lettuce in Nigeria. Afroasian J. Nematol. 4:96-100.
- Oplos, C., Eloh, K., Spirondi, U. M., Pierluigic, C &Ntalli, N. (2018). Nematicidal weeds, Solanum nigrum and Datura stramonium. J Nematol. 50(3).
- Orwa C, Mutua A, Roeland K, Jamnadass R, Simons A. Agroforestree database: A tree reference and selection guide. World Agroforestry Centre. 2009.
- P.G. Kavithal, E.I. Jonathan and S. Nakkeeran, (2011). Life Cycle, Histopathology and Yield Loss Caused by root Knot Nematode, Meloidogyneincognita on Noni, Madras Agric. J., 98 (10-12): 386-389, December 2011.
- Pagen FJJ (1988) Series of revisions of Apocynaceae. XX. Oleanders: Nerium L. and the oleander cultivars. Agricultural University Wageningen Papers 87(2): 1–113.
- Paranagama, P.A.; Abeysekera, T.; Nugaliyadde, L. and Abeywickrema, K.P. (2003). Effect of the Essential oils of Cymbopogon citratus, C. Nardus and Cinnamomum zeylanicum on Pest incidence and grain quality of rough rice (paddy) stored in an enclosed seed box. Ann. Sri Lanka Food Agric. Environ., 1(2): 134-136.

- Pardavella, I., D. Daferera, T. Tselios, P. Skiada & I. Giannakou, (2020). The use of essential oil and hydrosol extracted from Cuminum cyminum seeds for the control of Meloidogyne incognita and Meloidogyne javanica. Plants-Basel, 10 (1): 46 (1-14).
- Pinkerton JN, Ivors KL, Miller ML, Moore LW (2000) Effect of solarization and Cover crops on population of selected soil borne plant pathogens in Western Oregon. Plant Disease 84: 952- 960.
- POPOVIC, Z., KOSTIC, M., POPOVIC, S. AND SKORIC, S., (2006), Bioactivities of essential oils from basil and sage to Stophilus oryzae L. Biotechnol. Equip., 20 : 36 – 40.
- Postnikova O, Hult M, Shao J, Skantar A, Nemchinov L. Transcriptome analysis of resistant and susceptible alfalfa cultivars infected with root-knot nematode Meloidogyneincognita. PloS One. 2015;10:e0118269.
- PRIYA, M. S. AND PANDIYAN, M., (2019), Efficacy of botanical Extracts on hatching of Meloidogyne incognita Egg Under in vitro Study. Int. J. Curr. Microbiol. App. Sci., 8 (1) : 2664 – 2668.
- Purseglove, J. W. (1969). Lauraceae. In Tropical Crops: Dicotyledons. Vol. 2, 2nd ed. Purseglove J. W. (ed), Longmans Green and Co. ltd. London, U.K. pp. 187-192.
- Qamar, F.; Begum, S.; Raza, S.M.; Wahab, A.; Siddiqui, B.S. (2005), Nematicidal natural products from the aerial parts of Lantana camara L. Natural Product Research, 19, 609-613. L
- Ravi, R., Prakash, M., & Bhat, K. K. (2013). Characterization of aroma active compounds of cumin (Cuminum cyminum L.) by GC-MS, E-Nose, and sensory techniques. International Journal of Food Properties, 16(5), 1048–1058.
- Roshan and N. K. Verma, (2015) "A brief study on neem (Azarrdirachta indica A.) and its application-a review," research Journal of Phytomedicine, vol. 1, no. 1, pp. 1–3, 2015.
- S. Suganya1, S. VijayanandAnd K. Vanmathiselvi (2023) Photochemistry and Therapeutic Applications of Eucalyptus – An Overview ; Int.J.Curr.Microbiol.App.Sci (2023) 12(07): 204-210.
- S.L Vitarana,(2003). Feasibility of using Neem in the form of raw material and formulations in tea in Sri Lanka, conference Proceedings of the Science and Application of Neem, Glasgow, 2003.
- Sanaa A Haroon, Baraa AA Hassan, Fatma MI Hamad, Mostafa M Rady, (2018). The efficiency of some natural alternatives in root- knot nematode control; Volume 8 Issue 4 – 2018.The potency of Moringaoleifera and Jatropha curcasleaf extracts as control for root- knot nematode in maize (Zea mays). Int. J. Phytofuels Allied Sci., pp. 116-124.

- Sasser J, Freckman D. (1987). A world perspective on nematology: The role of the society. In: Veech J, Dickson D, editors. Vistas on Nematology; Society of Nematologists, Inc.: Hyattsville, MD .pp.7-14
- Satish R, Vyawahare B, Natarajan K. (2011). Antiulcerogenic activity of Lantana camara leaves on gastric and duodenal ulcers in experimental Rats. J Ethnopharmacol2011;134:195-7.
- Satyavati GV, Gupta AK, Tendon N, (1987) Medicinal Plants of India, Vol-2, Indian council of medical research, New Delhi India, 1987,289-299.
- Shah, M. M., & Mahamood, M. (2017). Introductory chapter: nematodes- a lesser known group of organisms. Nematology- Concepts, Diagnosis and Control.
- Sharma OP, Sharma S, Pattabhi V, Mahato SB, Sharma PD (2007). A review of the hepatotoxic plant Lantana camara. Crit Rev Toxicol 2007; 37:313-52.
- Shaukat S.S. and I.A. Siddiqui, (2001a)Effect of some phenolic compounds on survival, infectivity and population density of Meloidogyne javanica in mungbean. NematologiaMediterranea 29, 123–126.
- ShilpyShakyal, Bindhya Chal Yadav (2020); Screening of anti-nematode potential through inhibition of egg hatching in Plant-parasitic nematode Meloidogyne Javanica ; Current Botany 2020, 11: 93-98.Doi: 10.25081/cb. 2020.v11.6172
- Singh, S., Singh, B., and Singh, A. P. (2015). Nematodes: a threat to sustainability Of agriculture. Procedia Environ. Sci. 29, 215–216.
- Sousa EO, Almeida TS, Menezes IR, Rodrigues FF, Campus AR, Lima SG, et al.(2012) Chemical composition of essential oils of Lantana camara L. (Verbenaceae) and synergistic effect of the aminoglycosidesnGentamicin and amikacin. Rec Nat Prod 2012; 6:144-50.
- Stephen Adusei and Samuel Azupio(2022) Neem: A Novel Biocide for Pest and Disease Control of PlantsJournal of Chemistry Volume 2022.
- Taylor, A. L. and Sasser, J. N. (1978). Biology, identification and control of Root-knot nematodes (Meloidogyne species). Raleigh, NC, USA, North Carolina State University Graphics. 111 p.
- Tiyagi SA, Mahmood I, Rizvi R (2009a) Application of some latex bearing plants for the management of phytonematodes Infecting tomato and eggplant. Thai J Agric Sci 42: 183–189.
- Tiyagi SA, Mahmood I, Rizvi R, Dev RT (2009b) Utilization of medicinal plants for the management of root-knot and reniform nematodes infecting tomato and chilli. Trends in Biosci 2: 47–49.
- Trivedi PC. (2007): Ethno medical plants of India published by Avishkar publisher's distributors Jaipur (Raj.)

- Tsonchumiodyuo, Sobita Simon and Abhilasha A Lal. (2018). Effect of selected botanical extracts againstCurvularia Sp. And Meloidogyne incognita (J2). Journal of Pharmacognosy and Phytochemistry7(3): 2331-2336.
- Ujvary, I.(2001) Pest Control Agents from Natural Products, Handbook of Pesticide Toxicology. 2nd ed.; Academic Press: San Diego.
- Uma Devi P. (2001) Radioprotective, anticarcinogenic and antioxidant properties of the Indian holy basil, Ocimum sanctum (Tulasi). Indian J Exp Biol. 2001; 39:185-190.
- Vermeer, C.P.; Nastold, P.; Jetter. R. (2003): Homologous very long-chain 1, 3-alkanediols in leaf Cuticular waxes of Ricinus communis. Phytochem. 62 433-438.
- Vijayalakshmi, K., Mishra, S.B. and Parasad, S.K. (1979). Nematicidal properties of some indigenous plant materials against second stage juveniles of Meloidogyne incognita (Kofoid and White) Chitwood. Indian 1. Entomol. 41: 326-331.
- VL Shaligram, S Nighantubhushanam. Krishnadas Khemraj Prakashan Mumbai.,4, 2004:908.
- Wafaa Mohamed Abd-Elhameed El-Nagdi, Mahmoud Mohamed Ahmed Youssef (2013) Comparative efficacy of garlic clove and castor seed aqueous extracts against the root-knot nematode, Meloidogyne incognita infecting tomato plants Journal of Plant Protection Research Vol. 53, No. 3.
- Watt, J.M. and Breyer-Brandwijk, M.G. (1962): The Medicinal and Poisonous Plants of Southern and Eastern Africa. 2ndEdn., E and S Liningstone Ltd., London, UK., Pages: 1457.
- WiratnoTaniwiryiono D, Van den Berg H, Riksen JAG, Rietjens IMCM, Djiwanti SR, Kammenga JE, Murk AJ (2009). Nematicidal Activity of Plant Extracts against the Root-Knot Nematode. The Open Natural aproducts Journal 2:77-85.
- Yap PS, Krishnan T, Chan KG, Lim SH. (2015). Antibacterial mode of action of Cinnamomum verum bark essential oil, alone and in combination with piperacillin, against a multi-drug-resistant Escherichia coli strain. J MicrobiolBiotechnol. 2015;25(8):1299-1306.
- Youssef, M.M.A.; El-Nagdi, Wafaa M.A. and Dawood, Mona G. (2015). Population density of root-knot nematode, Meloidogyne incognita infecting eggplant as affected by medicinal plant aqueous extracts. Appl. Sci. Reptr. 10(1):8-11.
- Zasada, I. A., H. Ferris and L. Zheng (2002). Plant Sources of Chinese Herbal Remedies: Laboratory Efficacy, suppression of Meloidogyne javanica in Soil, and Phytotoxicity Assays. Journal of Nematology, 34(2):124– 129