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Neem: Role in leaf spot disease management: A review

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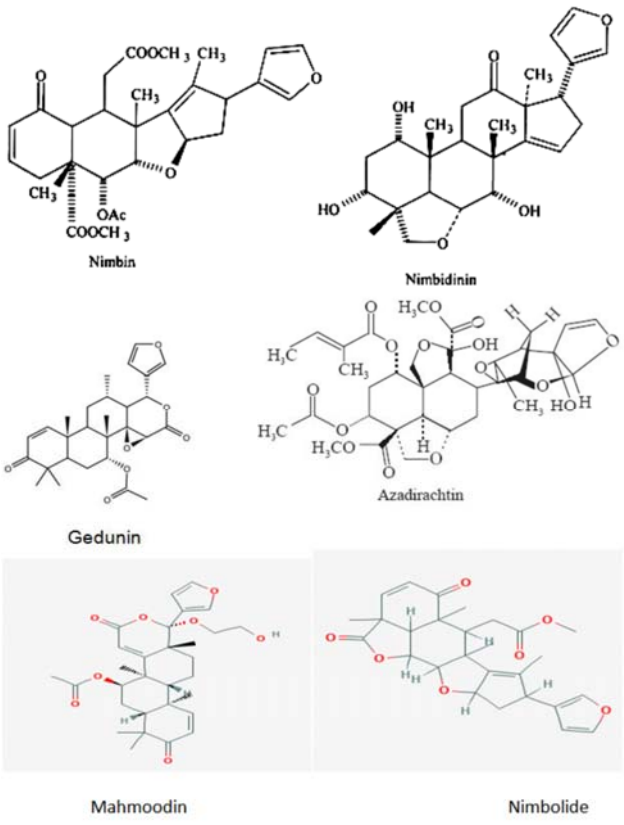
Abstract
Neem *Azadirachta indica* is an important plant in plant kingdom, which shows various applications for animal kingdom. Neem is one of the most powerful blood-purifiers, detoxifiers and immune system boosters known. Hundreds of diseases have been shown to respond favorably to neem. Neem leaf can be taken as tea or in capsules. Neem oil can be applied externally or a few drops can be put in an empty capsule and taken internally. It is also helpful to enhance the soil fertility. Neem oil is a unique source of various types of compounds with different chemical structure. As the era is now changing towards the use of nontoxic plant products having traditional medicinal use, development of modern drugs from neem should be emphasized for the control of various diseases. This is the time to use this novel product (neem oil) in medical field by the coordination of the knowledge gifted by the ancestors and modern approaches of drug development. As seed oil consists of so many beneficial properties to fight against several diseases, quite a significant amount of research has already been carried out during the past few decades in exploring the chemistry of different parts of neem. Several therapeutically and industrially useful preparations and compounds have also been marketed, but an extraordinary work should be done in the field of research and development to ensure the uses of neem seed oil and also other products of neem in a better and more effective way.

Keywords: botanicals, neem oil, leaf spot, management

Introduction
The neem plant is taxonomically classified as Kingdom-Plantae, Division- Tracheophyta, Class- Magnoliopsida, Order- Sapindles, Family- Meliaceae, Subfamily- Meloidae, Tribe- Melieae, Genus- *Azadirachta*, Species- *indica* (Girish and Shankara, 2008; Anon., 2011) [22, 6].
Botanicals are rich sources of biologically active secondary metabolites such as alkaloids, phenolics, and terpenoids (Esmaeili and Asgari, 2015) [20], using extraction methods employing aqueous or organic solvents or steam distillation. Their mechanisms of action can vary, especially when the effect is due to a combination of compounds (de Oliveira, 2011; Esmaeili and Asgari, 2015) [20].
The neem tree (*Azadirachta indica* A. Juss.) has emerged as the single most effective plant species possessing many pesticidal properties (Koul *et al.*,1990) [31], among several plant species that have been investigated. The bioactive ingredients of neem have been shown to be efficacious in controlling several crop diseases (Bhaskaran *et al.,* 1988; Badani *et al.,* 1987) [13, 11]. Neem oil contains at least 100 biologically active compounds. Among them, the major constituents are triterpenes known as limonoids, the most important being azadirachtin, which appears to cause 90% of the effect on most pests. The compound has a melting point of 160 °C and molecular weight of 720 g/mol. Other components present include meliantriol, nimbin, nimbidin, nimbin, nimbolide, fatty acids (oleic, stearic, and palmitic) and salannin. The main neem product is the oil extracted from the seeds by different techniques. The other parts of the neem tree contain less azadirachtin but are also used for oil extraction (Nicoletti *et al.,* 2012). It has been suggested that the content of azadirachtin in the seeds can be increased by artificial infection with arbuscular mycorrhiza (Venkateswarlu *et al.,* 2008) [23].
Among the botanical insecticides currently marketed, neem oil is one of the least toxic to humans and shows very low toxicity to beneficial organisms, so it is, therefore, very promising for the control of many pests. Target insect species include the following: *Anopheles stephensi* (Lucantoni*et al.,* 2006) [14], *A. culicifacies* (Chandramohan *et al.,* 2016) [26], *Ceraeochrysa claveri* (Scudeler *et al.,* 2013, 2014; Scudeler and dos Santos, 2013), *Cnaphalocrocis medinalis* (Senthil Nathan *et al.,* 2006) [12], *Diaphorina citri* (Weathersbee and McKenzie, 2005), *Helicoverpa armigera* (Ahmad *et al.,* 2015) [25], *Mamestra brassicae* (Seljåsen and Meadow, 2006), *Nilaparvata lugensStal* (Senthil-Nathan *et al.,* 2009) [17], *Pieris brassicae*

(Hasan and Shafiq Ansari, 2011), and *excavatum* (Abdel-Shafy and Zayed, 2002) and *Sarcoptes scabiei* var. cuniculi larvae (Xu *et al.,* 2010), *Spodoptera frugiperda* (Tavares *et al.,* 2010). Arachnid targets include *Hyalomma anatolicum.*

Neem products: *Azadirachta indica* L. (neem) shows therapeutics role in health management due to rich source of various types of ingredients. The most important active constituent is azadirachtin and the others are nimbolinin, nimbin, nimbidin, nimbidol, sodium nimbinate, gedunin, salannin, and quercetin. Leaves contain ingredients such as nimbin, nimbanene, 6-desacetylnimbinene, nimbandiol, nimbolide, ascorbic acid, n-hexacosanol and amino acid, 7-desacetyl-7-benzoylazadiradione, 7-desacetyl-7-benzoylgedunin, 17-hydroxyazadiradione, and nimbiol. Quercetin and ß sitosterol, polyphenolic flavonoids, were purified from neem fresh leaves and were known to have antibacterial and antifungal properties and seeds hold valuable constituents including gedunin and azadirachta (Mohammad A. Alzohairy).



Neem oil effect on leaf spot disease management: Management of these diseases through agro chemicals alone is neither cost effective nor environmentally safe. Therefore, an integrated disease management (IDM) approaches, using chemical, cultural and eco-friendly bio-agents are needed for sustainable chilli production (Pandey and Satpathy,2009; Lydia and Zacharia, 2012)

The inhibitory effect of neem extract on mycelial growth and sporulation of *C. capsici* was also reported by (Singh *et al*., 1997) [15], (Singh and Korpraditskul, 1999) [16], (Hegde *et al*.,2001) [7] and (Meera *et al*., 2004) [11],

Kadam (1997) observed that, garlic caused 89.96 per cent inhibition of *A. alternata* causing leaf spot of gerbera. Karade and Sawant (1999) also observed the efficacy of *Allium sativum* against *A. alternata*. Prasad and Naik (2003) assessed different plant extracts (onion bulb, garlic, Neem, Ocimum leaf extracts and Prosopis) in controlling the *Alternaria* spp. Neem oil is an effective and preventive fungicide used in the control of various diseases like leaf spot, *Alternaria* blight, downy and powdery mildews, rust, scab and flower, twig and tip blight, anthracnose and Botrytis blight (Kuepper, 2003). The poisoned food technique. Botanicals *viz.,* bulb extract of *Allium sativum* has been reported to effectively manage *Alternaria* blight of Indian mustard (Patni *et. al.,* 2006). Mamata and Yashoda (2006) also demonstrated efficacy of Tulsi extract against *A. alternata* causing leaf blight of turmeric. Curative application of ginger extracts suggests that it reduces the infection by 13-20%. Combined ginger spray when applied along with irrigation reduces the disease severity up to 44% (Hassanein *et. al.,* 2010). Two divided spray-doses of 3% neem oil at the on-set and fortnight later, retarded the development, spread and disease index of leaf blight of onion (*Alternaria alternata*); strongly improving the crop performance and yield (Ramjegathesh *et. al.,* 2011). Similar results on the efficacy of plant extracts against *Alternaria* spp. have been reported by (Baraka *et. al.,*2011) causing root rot of Date palm (Nashwa *et. al.,*2012) in purple blotch of onion, and Ravi kumar and Garampalli (2013) in early blight of tomato. Currently studies pertaining to the use of botanicals in management of leaf spot of maize is highly focused (Bisht *et. al.,* 2013). These are the evidences from the earlier work that plants possess the pesticidal activity that can play a pivotal role in the management of the plant disease which are cheap, locally available, and biodegradable and environment friendly.

Nature is a source of many different biocontrol agents, including the plant- growth promoting micro-organisms (PGPM) which promote plant growth by inducing a defense response (Akköprü and Demir 2005; Siddiqui, 2006). Natural plant extracts have latterly gained importance for crop protection against pests and pathogens because of their safety and target specificity. They have also been found effective against a wide range of pathogens (Manickam and Rajappan, 2001). Many reports have been published on non-chemical means to protect seed against plant pathogens. Among these means, plant extracts have proved effective in inhibiting seed-borne pathogens and in improving seed quality and the emergence of plant seeds (Nwachukwu and Umechuruba, 2001). Patil *et al*., (2001) found that neem leaf extract reduced disease incidence and increased fruit yield of tomato infected with *A. solani*, and Amadioha and Uchendu (2003) applied extracts from neem leaf to control *Fusarium solani* causing tomato fruit rot. Hosna *et al.,* (2003) reported that neem extract controlled *Alternaria* blight (*A. brassicicola* and *A. brassica*) of cauliflower seed. Surender and Hari (2004) found that pure neem leaf extract completely inhibited spore germination of the chickpea wilt agent *F. oxysporum*, and Aboellil (2007) reported that trilogy, a natural product from *A. indica*, significantly retarded growth of cucumber powdery mildew, and induced resistance in cucumber plants.

extracts from different parts of the neem tree, especially the bark, could be used by farmers to control the rot of tomato fruits caused by *F. solani* during storage. *In vitro* tests carried out by Chaudhary *et al.,* (2003) using different plant extracts, including those from *A. indica*, against *A. alternata* causing early blight of potato, revealed that extracts of *A. indica* gave the second highest inhibition of *A. alternata* (54%). Sanjeet *et al.* (2005) found that *A. indica* extracts provided good control of leaf spot of faba beans caused by *A. alternata* under both laboratory and field conditions.

There is at least some evidence that natural products such as essential oil and plants extracts may cause less deleterious effects than corresponding synthetic drugs (Tabassum and Vidyasagar, 2013; Tabassum *et al.*,2013).

Neem Applications: For centuries, neem has been used in folk medicine for the treatment of conditions such as malaria, ulcers, cardiovascular disease, and skin problems. Despite the limited existence of clinical trials to support therapeutic claims, the use of neem has expanded over time, and it is an important component of Ayurvedic medicine (medical knowledge developed in India about 7000 years ago. (Girish *et al.*, 2008; Ogbuewu *et al.*, 2011). In addition to its medical applications, neem has aroused interest in many other areas (Figure-1). In the cosmetics and hygiene sector, neem is used in the composition of face masks, lotions, sunscreens, soaps, and toothpastes (Mathur and Kachhwaha, 2015). Products derived from neem can contribute to sustainable development and the resolution of disease and pest control problems in agriculture (Lokanadhan *et al.*, 2012). These products benefit from the natural properties of neem as a powerful insect growth regulator (IGR) that also affects many other organisms (such as nematodes and fungi) and can act as a plant fertilizer (Brahmachari, 2004).

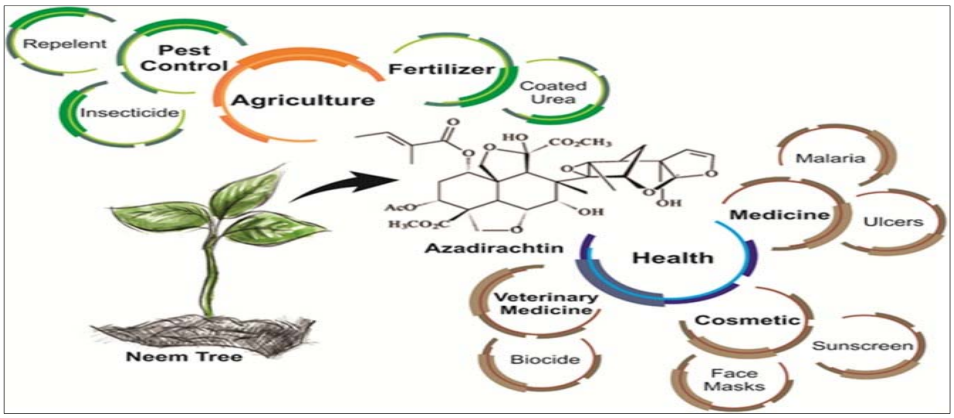


Fig 1: In addition to its medical applications, neem has aroused interest in many other areas

The use of neem in agriculture is not a new practice. In India, the traditional farming system employed neem extracts for pest management and to supply nutrients to plants (Mossini and Kemmelmeier, 2005; Sujarwo *et al.*, 2016). Scientific research has shown that neem is safe for workers, with no handling risks, and can be used throughout the entire crop production cycle (Boeke *et al.*, 2004).

Neem has proven use as a fertilizer, with the organic and inorganic compounds present in the plant material acting to improve soil quality and enhance the quality and quantity of crops. The waste remaining after extraction of the oil from neem seeds (neem seed cake) can be used as a biofertilizer, providing the macronutrients essential for plant growth (Ramachandran *et al.*, 2007; Lokanadhan *et al.*, 2012).

Nitrogen is one of the main nutrients required by plants for their development, and urea is the main source of nitrogen fertilizer used worldwide to supply the nitrogen demand of crops. The control of urea hydrolysis and nitrification is one of the principal strategies employed to avoid nitrogen losses in agriculture (Ni *et al.*, 2014). Neem has demonstrated activity as a nitrification inhibitor, helping to slow the bacterial activity that is responsible for denitrification, hence decreasing the loss of urea from the soil (Musalia *et al.*, 2000; Mohanty *et al.*, 2008).

Due to their compositional complexity, neem-based products can act as antifeedants, growth regulators, sterilants, anti-oviposition agents, and repellents (Gonzalez-Coloma *et al.*, 2013). Other factors that have stimulated the use of neem-based products for pest control in agriculture are ecological and toxicological aspects (low toxicity to non-target organisms), as well as economic aspects small amounts of the product can provide effective pest control (Ogbuewu *et al.*, 2011).

Neem oil is extracted from the seeds of the neem tree and has insecticidal and medicinal properties due to which it has been used in pest control in rice cultivation. Neem seed cake (residue of neem seeds after oil extraction) when used for soil amendment or added to soil, not only enriches the soil with organic matter but also lowers nitrogen losses by inhibiting nitrification. It also works as a nematicide. Neem leaves are used as green leaf manure and also in preparation of litter compost. Neem leaves are also used in storage of grains. Twigs of neem when tender is used as green manure after decomposing and widely incorporated in rice cultivation fields (Dubey *et al.*, 2010; Seufert *et al.*, 2012; Gahukar, 2014).

Neem bark and roots also have medicinal properties. Bark & roots in powdered form are also used to control fleas & sucking pests in rice cultivation. Neem has anti-bacterial, anti-fungal and anti-nematicidal properties and positive effect in combating several diseases in rice cultivation, and there are many active constituents of Neem which are still to be exploited.

Benefits of neem products: One of the most extensively used "natural" plant derived insecticides is neem, extracted from the plant *Azadirachta indica* (Ascher, K. R. S. (1993). (The neem oil extract had an toxic effect against *Anopheles stephensi*. aegypti larvae with median lethal concentrations (LC50) of 1.6, 1.8 and 1.7 ppm respectively. Recently, entomopathogenic fungi have been formulated in neem oil and tested against larval and adult. The results showed that the formulation of fungus and neem was more effective than neem alone for adults and larvae (Badani *et al.*, 1987). Like antibacterial and antimalarial properties of neem, the antifungal properties are also given great importance in the field of science. Neem Seed oil extracted from *Azadirachta indica* plant and formulated in Vanishing cream base was evaluated for repellent action against *Anopheles gambiae*. *Azadirachta indica* belongs to family meliaceae. B. Malik and M. Tufail, "Chickpea Production in Pakistan," in Ascochyta Blight and Winter Sowing of Chickpea (Saxean *et al.*, 1984)

Several pharmaceuticals, cosmetics, disinfectants, rubber, bio-pesticide and textile industries use neem oil (Jattan *et al.,* 1995). Many such neem-based commercial preparations are currently available (Koul *et al.,* 1990; Radwanski *et al.,* 1981) [31]. In India neem is highly exploited by many Ayurvedic drug industries. Neem oil and powdered neem leaves are employed in various cosmetic preparations such as face creams, nail polish, nail oils, shampoos, conditioners (Anonymous, 2006).

Conclusion

Neem being an ancient plant has various medicinal properties. Owing to its versatile characteristics neem is rightly called the 'Village pharmacy' or 'Doctor tree' or 'Wonder tree of India' or 'The bitter gem'. National Research Council (NRC), Washington, USA considers the neem, "One of the most promising of all plants and the fact is that it may eventually benefit every person on this plant. Probably no other plant yields as many strange and varied products or has as many exploitable byproducts" (Girish *et al.,* 2008) *Azadirachta indica* (Neem leaf extract) was taken to test its antifungal activity against three fungal species – *Alternaria alternata, Aspergillus flavus, Alternaria solani* and *Cladosporium*. Neem oil has been the cure for many fungal diseases caused by the above fungi.

There has recently been increased interest in the application of plant-based materials (botanical insecticides), such as neem oil, in pest control. Although these products are safer for the management of pests, compared to synthetic chemicals, their effects in IPM must be evaluated. Several studies have investigated the relationships between botanical insecticides and natural enemies of agricultural pests (Islam *et al.,* 2011; Mamoon-ur-Rashid *et al.,* 2011; Islam and Omar, 2012; Tunca *et al.,* 2012; Usman *et al.,* 2012). Sahayaraj *et al.* (2011) evaluated the use of different neem-based products in colonies of *Beauveria bassiana, Isaria fumosoroseus*, and *Lecanicillium lecanii*, and the results showed that these entomopathogenic fungi were compatible with most products tested. Raguraman and Kannan (2014) conducted a review in order to score the impact and safety of different botanical insecticides in the presence of parasitoids and predators (beneficial arthropods), with the aim of standardizing strategies and application methods to achieve better management of agricultural pests.

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