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Efficacy of Neem (*A. indica*) in plant protection

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Abstract
This paper gives an insight of neem products and an outline on its different uses and how it can provide cheapyet effective protection against various foreign element along with keeping environment in check against different pathogens.
Natural plant products has been usedfrom centuries for protection as well as preservation pf plants against diseases. In the last 2 decades scientists have laid their main focus on going green meaning less or minimum use of chemicals like insecticide and fertilizers in an effort to raise a healthy environment and society.
One such important need in today's world is neem. Scientists all over the world are using and researching on it since it has proved to be very beneficial since a long time. Neem plant has proved to be very beneficial against fungus, virus, viroid and other obnoxious elements that can cause disease to plants. Its seed extracts have shown a major success rate against microflora of cauliflower and it is highly effective againstthe inhabitation of growing spores as it makes them infertile. The neem is a kind of plant that provides protection against around 350 species of arthropods.
Other means can be done chemically but biologically neem has been the most consistent. Along with being anti- fungal, bacterial, viral neem has also been used to keep different pests out.

Keywords: Eco-friendly, fungus, virus, bacteria, disease, management, neem, products, pathogen, protection

Introduction
With the increasing population of human being, a large part of the productivity of food grains has hampered due to different crop diseases. Due to which humans are heavily dependent on the syntheticfertilizers. In turn leaving hazardous effects on human body and the spectrum in now being shifted towards organic methods. Organic agriculture has been defined, in practical terms as, "the cultivation that not only excludes the use of synthetic agents or agro-chemicals, but which maintains or even improves the fertility, organic quality and sustainability of the soil". In the case of a processed product, only non-synthetic and natural additives andnon-agricultural ingredients are permitted. (Facknath and Lailjee, 2008) [16] biologically active principles in neem. Helps to reduce pests, fungi and other micro bio spp. and there had been three international conferences just within a span of ten years, two in Germany (1980, 1983) and one held in Kenya (1990),devoted almost entirely to the understanding of the chemistry of the neem constituents and their influence on the whole problem of pest management (Tewari,1992) [57]. The word "neem" is derived from the Sanskrit word "Nimba" which means 'to bestow health' fragmentary reports of the use of neem products for control of plant pathogenic fungi, bacteria and viruses. Estimates of alternative medicine use today as primary care, are in the order of 80% for developing countries (Rupani & Chavez, 2018) [47], while in developed (or industrialized) countries, the use of alternative medicine continues togain steam as a not necessary but a vital way of care. An effect migration; more people are moving towardsthe developed countries and on the period of returning the people not only brings back their knowledge gain, their skill sets but their traditions and way of life (Deng *et al.*, 2013) [13]. A neem tree normally starts fruiting after 3-5 years. In about 10 years it becomes fully productive. From the tenth year onwards it can produce up to 50 Kg of fruits annually (Girish and Bhat, 2008) [19]. These properties of neem are now acting as base of many varieties as it has started picking up fire just like old days in used incosmetics, soaps, toothpaste, and pest repellents. moreover, by traditional ways of curing neem also emerged as a major player in the treatments for chickenpox, fever, headache, leprosy, jaundice, constipation, respiratory problems, rheumatism, and gastrointestinal disorders (Joshi *et al.*, 2010 Eid *et al.*, 2017, Heyman *et al*., 2017, Saleem *et al.*, 2018) [46, 14, 21, 49]. For a long period of time the properties and the complex chemicals of neem are studied very carefully with an aim to enhance the

properties and to mae the full use of the product. Results have found that many of theseherbs and plants contain several compounds mainly of the following families: flavonoids, catechins, anthocyanins, quercetins, saponins, tannins, limonoids, gallic acid and other minor polyphenols.

Taxonomy

(Girish and Bhatt, 2008) [19].

Table 1: Common name and neem

Common name	Neem
Scientific name	*Azadirachta indica*
Order	Rutales
Sub order	Retinae
Family	Meliaceae
Sub family	Melioideae
Tribe	Melieae
Genus	Azadirachta
Species	Indica

Fig 1: A neem tree, from LPU campus, Jalandhar

Fig 2: Neem leaves

Biochemicals present in neem

Approximately 135 different structural compounds have been sequestered and identified from different part of Neemtree.

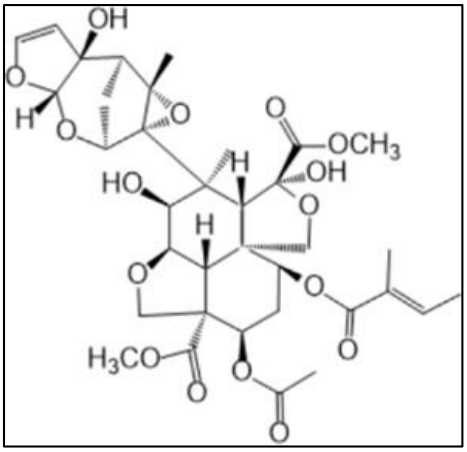
They are classified into

a. **Isoprenoids:** limonoids, protomeliacins, gedunin, azadirone, vilasinin and C- secomeliacins like salanin, nimbin and azadirachtin (Sarkar *et al.*,2007; Singh *et al.*,2009; Tiwari *et al.*, 2014) [50, 9].
b. **Non-isoprenoids:** amino acids, polysaccharides, polyphenolics like flavonoids, sulphurous compounds, dihydrochalcone, glycosides, tannins, coumarin and aliphatic compounds. (Brahmachari, 2004; Arora *et al.*,2008; Girish and Bhat, 2008; Atowadi and Atowadi 2009) [11, 4, 19].

Table 2: Efficacy of Neem compounds

Neem compound	Parts used	Efficacy of parts used
Nimbidin		Spermicidal (Rahman *et al.*, 2016) [43]. Antifungal (Biswas *et al.*, 2002) [8]. Antibacterial (Lakshmi *et al.*,2015) [29].
Nimbin	Seed oil	Spermicidal (Girish *et al.*,2008) [19].
Azadirachtin	Seed	Antimalarial (Uzamman, 2020)
		Nematicidal (Khalil,2 013) [74]
Nimbolide	Seed oil	Antibacterial Antimalarial (Agrawal, 2001) [2]
Gedunin	Seed oil	Antifungal Antimalarial (Girish *et al.*,2008) [19].
Mahmoodin	Seed oil	Antibacterial (Pandey *et al.*,2014) [39].
Margolone, margolonone and Isomargolonone	Bark	Antibacterial (Ghosh *et al.*,2016) [19].

Chemcal structure of azadirachtin



(Kraus *et al.*,1985) [27]

Various uses of Neem

Siddha Medical system which was defined as preventive against mortality was originated to mankind 10,000 BC to 4000 BC ago and it was theoldest medical system to human being, in this was the great sacred tree Neem by the Great Sage manuscript (Kumar *et al.*, 2013) [29]. In Puranas (600-700 AD) its medicinal uses have been mentioned. In Samhitas (ancient Indian literature) its various uses have been also mentioned. According to Charak decoction of its fine parts i.e. root, bark, flowers fruits and leaves were used to remove leprosy According to Susruta (800 BC) also reported its use as a remedy for leprosy. Neem which is a mother of all therapeutical plants has been used extensively many decades ago and stillusing for spritual and medicinal purpose. Some potential medicinal compounds had been isolated from A. indica like anti-plasmodial triterpenoids and snake venom

phospholipage A (Rakib and Hussain,2013) [46]. Neem is also known as wonder tree because every part of the tree is known to have it's unique medicinal value.

Neem and it's potential in agriculture

Neem is considered as renewable resource with the potential in solving agricultural, environmental and public health problems. The common properties of neem are its non-toxicity; so they are beneficial in plant conservation and management. Products derived from neem tree such as neem leaves, neem fruit, neem oil, neem seed cake and leaf extract usedas bio-pesticide, fungicide and bio manure has been applied because of their different mode of action to control the insects, plant pathogen, pest which have the resistance against chemical pesticides. Though the insect managing properties of neem have been known, but a real break through seems to have been made in early sixties when Pradhan *et al.*, (1962) firstreported the potential antifeedant properties of neemseed kernel against desert locust, Schistocerca gregaria. Studies say that neem can regulate around 300 species of insects (Nayak *et al.,* 2017). Azadirachtin is currently considered as neem's main agent for controlling insects. 'It appears to cause 90%of the effect on most pests. It does not kill insects - atleast not immediately - instead it both repels and disrupts their growth and reproduction. Neem can also be used for Soil Fertility and Fertilizer Management. Indian farmers have traditionally used de- oiled neem cake as a fertilizer in their fields. The dual activity of neem cake as fertilizer and pest repellent, has made it a favoured input. Neem seed cake can also reduce alkalinity in the soil by producing organic acids when mixed with the soil. (TNAU-2009-2014)

Neem products in the management of plant Pathogens and pests.

Fig 3: Pathogens repelled by neem leaves

Plant pathogens and pests

In general, a plant gets diseased when it is over and again being disturbed by obnoxious elements that are foreign and commonly known as 'pathogens' resulting in the abnormal physiological process which in turns causes an abnormality in its normal structure, growth, function, and other activities resulting in certain disorders that are generally not good and accepted. This interface with the obnoxiousforeign elements with its one function or more in plant's physiology or biochemical system reflects its physiological and pathological condition and is referred to condition or symptoms. Plant diseases are broadly classified according to the nature of their primary causal agents which generally falls under either infectious or non- infectious. The plant harmingor the infectious organisms are broadly mentioned in pathological organisms or pathogens that range underFungus, bacterium, mycoplasma, virus, viroid, nematodes and parasitic flower. An infectious causal agent is well seasoned enough to reproduced in or onits host resulting caused the changes and it can travel from one plant to another with ease that it finds suitable enough. Non- infectious plant diseases are caused mainly due to weather conditions as well as unfavourable growing conditions, such as extreme temperature, moisture oxygen imbalance, an excess loss of certain elements to name a few. It is generallydue to the face that n on infectious organisms are not capable of reproducing inside a host or does not needtransmission as they are not transmissible, but the unfavourable may very well help out the infectious organisms (Shurtleff *et al.*, 2021) [53]. Properties of neem have been reported to manage these diseases toa great extent. Neem products are effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, three viruses, and two species of snails and one crustacean species so far. The role of neem in management of these pathogens are discussed as follows:

Anti Fungal

There are various reports of neem oil cake being used against plant pathogenic fungal diseases. Singh (1968) [54] studied the incidence of black scurf on potatoes in oil cake amended soil. When the effect ofdifferent soil amendments on the rhizosphere mycoflora of cauliflower in the nursery beds was studied it was found that population and frequency offungi were low in the rhizosphere soil treated with neem (Prakash *et al,* 1979) [40]. Muthusamy *et al*. (1988) [34] evaluated the efficacy of neem products against rust disease of groundnut. The seed extract and oil were highly effective in inhibiting spore germination by 96.2% and 96.0% respectively, whereas the neem cake extract showed 87.6% inhibition. There are various reports of neem oil cake being used against plant pathogenic fungal diseases.The effect of aqueous leaf extract of *Azadirachta indica* on incidence of the foliar disease, caused by *Puccinia arachidis* and *Phaeoisariopsis personata* of groundnutwas later studied by Ghewande (1989) [18]. Neem was found to be quite effective in controlling both the diseases as well as in enhancement of yield. Bansal and Sobti (1990) [7] studied the effect of neem extract for the control of *Aspergillus niger* and *A. flavus* on groundnut. Overall, the neem extract showed far more effectiveness than well known anti-fungal chemicals. In a study conducted the efficacy of seed borne fungai diseases like Aspergillus, Rhizopus and chemical characterization were studied, The growth of both the fungal species was inhibited significantly ($p<0.01$) and controlled with both alcoholic and water extract of all ages and of the concentrations used. Therefore, *Azadirachta indica*, a common medicinal plant could be exploited as the source of a potent biocide that have immense fungi toxic effect to several fungal pathogens like Aspergilhts and Rhizopus. Singh *et al.,* (2010 b) [3] reported that the neem cake has ability to influence the secondary metabolites in soil borne phytopathogenic fungus *Sclerotium rolfsii* at 10% concentration, the maximum antifungal potential was observed with theextracts of *Azadiracta indica*, which revealed 57 percent inhibitory activity against *Rhizoctonia solani*,causing sheath blight of rice as concluded by Rahila *et al.*, 2020 [43]. Eisa *et al.*, 2017 [16] conducted an *in vitro* antifungal study of neem nano emulsion against *Rhizoctonia solani* and *Sclerotium rolfsii* was carriedout by poisoned food technique. Results showed that neem nano emulsion 10

(NNE10) was most active against *R. solani* (ED50 13.67 mg/L) and *S. rolfsii* (ED50 14.71 mg/L) resp. Singh *et al.*, (2010a) [56] reported that foliar spray of aqueous extract of neem cake show antifungal efficacy against powdery mildew of balsam. Ahmed *et al.*, 2020 concluded that 2% *A. indica* leaf amendment was the most useful concentration for management of collar rot disease of chickpea. Rawat *et al.*, 2018 [25] tested The ability of Neem oil to inhibit mycelia growth of *Schizophyllum commune*, *Fusarium oxysporum*, *Fusarium proliferatum*, *Coniophora puteana* and *Alternaria alternata* at different concentrations of 0.25, 0.50, 0.75, 1.0, 2.0, 4.0, 6.0, 8.0 and 10% where it was concluded that Neem oil concentrations above2% were significantly inhibitory to all the tested fungi. Neem products are also found to be the most effective against tomato seedlings damping off caused by *Fusarium oxysporum* f. sp. *lycopersici* and enhanced seed germination and plant growth asrecorded by Jiskani *et al.*, 2021.

Anti bacterial

The insect managing properties of neem have been known, but a real break through seems to have been made in early sixties when Pradhan *et al.*,1962 first reported the potential antifeedant properties of neem seed kernel against desert locust, Schistocerca *gregaria*. The antibacterial activity of neem seed oil against fourteen strains of pathogenic bacteria was assessed by Baswa *et al.*, 2001 [8]. Cyanobacteria nitrogen fixation and growth were estimated by acetylene reduction activity and chlorophyll measurement, respectively. Different strains respond differently to these phyto-extracts.

Anabaena spherica was observed to be the most sensitive strainswhile *Westiellopsis proiifica* was recorded as most resistant one. Among different phytoextracts, moringa ad least effect while gurich had maximum toxicity. The effect was recorded to be more toxic than fresh leaf extract. At 0 1% or 100 ppm, the phyto-extract proved to be stimulatory for all the strains in both types of preparation. These extracts were also tested for molluscicidal properties. Neem leaf aqueous extract induced changes in biomass accumulation, photosynthetic activity and status of reactive oxygen spesies, lipid peroxidation and enzymatic antioxidants in cyanobacterium *Plectonema boryanum* was studied by Prasad *et al.*, 2005. The antibacterial activity of neem extracts against 21 strains of food borne pathogens was determined by Hoque *et al.*, (2007) [31].

Neem extracts showed potential antimicrobial activity against Gram-positive bacteria compared to Gram- negative bacteria. Ghonmode W. N., Balsaraf O. D *et al.*, (2013) evaluated the antibacterial activity of the bark, leaf, seed and fruit extracts of *Azadirachta indica* (neem) on bacteria which was isolated from adult mouth and results showed that bark and leaf extracts of Neem showed antibacterial activity against test bacteria used. Also, seed and fruit extracts exhibited antibacterial activity only at higher concentrations.

Anti viral

Azadirachta indica (Bio pesticide), which reduced the number of thrips vector *viz*., nymphs and adults and also reduced the incidence of *TSWV* in tomato plants both in glasshouse and field conditions (Vasanthi *et al.*, 2017) [61]. Zeeshan and Kudada, 2019 evaluated Seven plant products *viz*., Neem (*Azadirachta indica L*.) oil 0.03% 5ml/lit. Neem (*Azadirachta indica L*.) Seed Kernel Extract (NSKE) 5%@ 5ml/lit. Karanj (*Pongamia pinnata L*.) oil@ 5ml/lit. Nimbicidine 0.03%@ 3ml/lit., Achook 0.03%@ 3ml/lit., Neem gold 0.15%@ 2ml/lit. and Nimactin 0.15%@ 2ml/lit. against vector activity to reduce the leaf curl disease incidence where the minimum disease incidence withhighest fruit yield was recorded in the treatment having two sprayings of NSKE 5%@ 5ml/lit. Abbas *et al.*, 2020 concluded that leaf extract of *Azadirachta indica* at 3% concentration may be used to minimize the whitefly population and to lower the disease incidence of cotton leaf curl virus disease.

Nematicidal

Apart from all other properties, Neem is also found to repel or reduce the feeding of many species of pest insects as well as some nematodes. The most devastating one is threadworm. These nematodes not only difficult to control but also use of synthetic nematicides is not desirable because of their toxicological residues and effects. Varous researchers have found neem products to be effective against these pests. Certain liminoid fractions from NSKE are providing active protection against these notorious root- knot nematodes'. Nematicidal properties are also found in water extracts of neem cake. Yadav *et al.*, 2018 [63] reported the Bio-nematicidaleffect of *Azadirachta indica* leaves @ 30 g/kg soil in improving plant growth and reducing the reproduction of root knot nematode in tomato. Neem cake also reported to reduce the root galls in chickpeaby 59% and gall index by 45% @0.5 t/ha.

Hence neem can be used for the management of *Meloidogyne species* in crops. Vyas *et al.*, 2012 while comparing the efficacy of Azadirachtin and carbofuran against the population of root galling, soil nematode population found that Azadirachtin 1500 ppm was more effective than that of carbofuran at 2kg ai/ha and neem cake at 1000kg/ha. Hence neem is also effective in controlling soil dwelling nematodes.

Insecticidal

The insecticidal properties of neem that are mentioned by Ascher *et al*., (1993) [65] includes antifeedent effect, delay in the development of immature stages after treatment of feeding and nonfeeding stages on instars, delay in post embryonic stages, effect on metamorphosis, oviposition deterrency, egg sterlity, shorter life span of male and female, decreased fittness of the insects. Some of the target pests of neem related to agriculture-

Insect-pests of field crops

Neem products are found to be effective against the orders of insects such as Orthoptera, Heteroptera, Homoptera, Thysanoptera (to some degree), Hymenoptera, Coleoptera, Lepidoptera, and Diptera (Schmutterer *et al*.,1981; Schmutterer *et al*.,1984; Jacobson 1986; Schmutterer *et al*.,1987; Schmutterer *et al*.,1989) [66, 67-69]. Neem is also found to be sensitive against the ostracod, *Heterocypris luzonensis* in paddy ecosystem as concluded by Grant and Schmutterer, 1987 [68]. Recently a study by Tulashie *et al*., (2021) [72] concluded that use of neem extracts against fall armyworm have great potential as a natural insecticide for which the obtained lethal dose was noted for neem seed oil extract (NSOE) were 1.78%, 0.97% and 0.68% and for methanolic neem leaf extract (MNLE) were 2.67%, 2.62% and 1.64% after 2, 6 and 12 hours respectively.

Insect pest of stored grains

Neem is found to be effective against a large range of of stored grain insects and pest since thousand years. Neem leaf powder treatment for stored grains is found to be utilized by almost every household in the Indian subcontinent. Neem oil at 1% as stated by Saxena *et al*., 2018 when applied to red gram seed as a surface protectant stopped the production of progeny by *C. chinensis* adults. Another study by Tesfaye *et al*.,(2021) while surveying on pests of stored sorghum concluded that efficacy of powdered neem seed (50.70%) found to have superior insecticidal effect against *S. oryzae* after 28th days of exposure and also the highest reduction of F1 was recorded in neem seed powder (73.14%), neem leaf powder (72.54%). Hence neem could be suggested to management of a various range of stored insects.

Conclusion

In a world that is being consumed by chemicals.Neem and its products are playing a key role in making up to the environment as they are in a world that is being consumed by chemicals.

Neem and its products are playing a key role in making up to the environment as they are environment friendly, are available in a huge number,provides protection against broad spectrum of fungi and bacteria, insects and nematodes as neem have shown its tendency to be an environment friendly, are available in a huge number,provides protection against broad spectrum of fungi and bacteria, as neem have shown its tendency to be a biological control agent as it effective against fungi, pests and insects as it provides a cheap solution for certain rusts and anti-bacterial. In the case of anti- fungal diseases, neem provides resistance against anthracnose, rust, black spot and mildew to name a few. Neem oil is an effective remedy and cure for many fungal diseases and also insects. Now it may not cure an already damaged plant but it surely can protect against a plant that is healthy. Its main function is by prevention of germination by preventing penetration of fungal spores in the neem tissue making neem an amazing product in terms of organic use. In case of its anti bacterial and insecticidal properties, neem leaf exctracts also contain polyphenols that treat oral surface and produce a long lasting synergic antioxidant properties and help the plant. Hence neem provides a cheap and easy to use products for farmers which help in many aspects of farming and protection against fungus, virus and bacteria meanwhile also keeping the product organic.

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