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Prospects, Utilization and Challenges of Botanical Pesticides in Sustainable Agriculture

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ABSTRACT

Botanical pesticides can be recommended as an ecochemical and sustainable strategy in the management of agricultural pests. Because of their biodegradable nature, systemicity after application, capacity to alter the behavior of target pests and favorable safety profile, it is hoped that plant-based pesticides play a significant role in achieving evergreen revolution. Azadirachta indica is widely grown all over the tropic and is the most useful traditional medicinal plant in India. Each and every part of it has diverse applications due to presence of many biologically active ingredients such as Nimbidin, Nimbin, Nimbolide, Gedunin, azadirachtin, mahmoodin, gallic acid etc. Different neem products containing different neem compounds are having various applications including antialergic, anti-inflammatory, insecticidal, nematicidal, spermatocidal, antidermatic, antiviral, antifungal, anti AIDS, anticancer, antimalerial, antipyretic and many other biological activities. Therefore, this review gives clear idea about agricultural applications of botanicals.

Key words: Pesticides, Challenges, Botanical, Agriculture, Pests

INTRODUCTION

Sustainable agriculture aims at reducing the incidence of pests and diseases to such a degree that they do not seriously damage crops without upsetting nature’s balance. Although both synthetic and natural pesticides are used extensively in the agricultural fields to control crop pests, it is well known that natural pesticides are eco- friendly and are safe to the nontarget organisms (Debashri and Tamal, 2012). One of the aims of sustainable agriculture is to rediscover and develop strategies whose cost and ecological side-effects are minimal. The use of synthetic pesticides has undoubtedly resulted in achievement of green revolution in different countries through increased crop production. Agriculture in a tropical country like India, owing to its climatic conditions and environmental pollution suffers severe losses due to pests. In Andhra Pradesh and Karnataka complete absence of actinomycetes were due to indiscriminate use of synthetic chemical fertilizers and pesticides therefore, after a severe setback arising from the use of these chemical on living systems and on the environment, the use of eco-friendly biopesticide is gaining momentum. When botanical pesticides were incorporated into integrated pest management programs, decrease the use of conventional pesticides. Further, in rotation or in combination with other insecticides, botanicals potentially lessening the overall pesticide dosages applied and thereby mitigating or delaying the development of resistance in pest populations. Therefore, the farmers of the world are in need of effective and alternative tools to fight against insect pests (Khater, 2012). However, in recent years there has been considerable pressure on consumers and farmers to reduce or eliminate synthetic pesticides in agriculture. This concern has encouraged researchers to look for better alternatives to synthetic pesticides. One important of them is *azadiracthtin* that deters insects, e.g. locusts, from feeding and interferes with the normal life cycle of insects, including feeding, molting, mating, and egg laying (Beaulieu, 2013).

Though India has a rich source of plants that could be harnessed as botanical pesticides, which effectively replace the chemical pesticides. Botanical pesticides are eco-friendly, economic, target-specific and biodegradable, called as Phytopesticides ranged from whole fresh plant to purely isolate bioactive phytochemical or their formulations which are effective against pests and pathogens (Prakash and Rao, 1996). For example, neem-based botanical pesticides have been used traditionally for many years. Nowadays pesticides from *A. indica* become very much popular because of their biodegradability, least persistence and least toxic to non-target organisms, economic and easy availability. In India, neem products are effective against various pests of both crop fields as well as stored grains like rice, wheat, corn, legumes, potato, tomato, etc (Debashri and Tamal, 2012).

CURRENT STATUS OF BOTANICAL PESTICIDES

The *Bible* and other early literature mention plant diseases such as rusts, mildews, blights and blast and the use of available plants in the control of pests and diseases was an ancient technology in many parts of the world. Some plants, viz. *Derris*, *Nicotiana* and *Ryania* were used to combat agricultural pests during pre-historic period. Until 1940s, such botanical pesticides were partly substituted by synthetic pesticides which seemed easy to handle and lasted for a long time. Higher plants harbour numerous compounds which provide them resistance to pathogenic organisms and pests. During course of evolution, the selection pressure caused by pathogens and herbivores has probably been highly acute and intense and resulted in a vast chemical diversity in higher plants. Unlike synthetic compounds, secondary metabolites from plants are virtually guaranteed to have biological activity, protecting the plant from pathogen, herbivore or competitor and in general, plant secondary metabolites are considered to have co-evolved with herb-ivory. Knowledge of the pests to which the secondary compounds produced in the plants are resistant may leads in predicting which pests may be controlled by compounds from a particular plant species. This approach has led to the discovery of different botanical pesticides important among them is neem (*Azadirachtin*).

Neem is a versatile tree having many good and useful qualities belonging to the order rutales and family mellaceae. The genus *azadirachta indica* was described by Juss in 1830. Neem based pesticides do not leave any residue on the crop and also work as systemic pesticide, absorbed into the plant, transported to all the tissues and are ingested by plant feeding insects and is considered nontoxic to mammals, fish and pollinators, having low mammalian toxicity (LD_{50} of >5000 mg/kg). It is felt that none of the synthetic pesticides developed so far has the excellent virtues of neem in pest management programme. The neem and its products are used in seed treatment, manurial application, increasing nutrient efficiency by which the grain yield in rice and other economic crop is enhanced (Lokanadhan *et al.*, 2012). Both leaves and fruit of neem plant are known to have bitter taste having fungicidal, insecticidal and nematicidal properties (Bajwa and Ahmad, 2012)**.** Pyrethrum, another old and safe insecticide, extracted from the dried flower buds of *Chrysanthemum* sp. was used in the early 19th century to control body lice during the Napoleonic wars. It is a mixture of four compounds: pyrethrins I and II and cinerins I and II. Pyrethrum is nontoxic to most mammals, making it one of the safest insecticides in use. Sabadilla, also known as ‘cevadilla’ is derived from the seeds of the sabadilla lily (*Schoenocaulon officinale*), a tropical lily that grows in Central and South America. The active ingredient in it is an alkaloid known as veratrine which is commonly sold under the trade names ‘Red Devil’ and ‘Natural Guard’. Sabadilla is considered as the least toxic botanical insecticide, with an oral LD_{50} of 4000 to 5000 mg/kg. Carvone, a monoterpene of the essential oil of *Carum carvi*, is a nontoxic botanical pesticide with the trade name TALENT, inhibits sprouting of potato tubers during storage and protects them from bacterial rotting without exhibiting mammalian toxicity. Thus, it enhances the shelf life of stored fruits and vegetables and inhibits microbial deterioration without altering the taste and odour of the fruits. Such plant based chemicals can improve shelf life, quality and nutritional value of stored food commodities. Different crude extracts and plant materials rich in polyphenolics are becoming increasingly important in food industry because of their antifungal, anti-aflatoxigenic and antioxidant activity. Many aromatic plants commonly used as culinary herbs and spices and their essential oils have attracted the attention of scientists regarding their exploitation as botanical pesticides against storage losses of food commodities.

BIORATIONAL APPROACH

Some plant secondary metabolites have altered the behaviour and life cycle of insect pests without killing them. Such chemicals are termed as semiochemicals which act by modifying the behaviour of pest species rather than killing them and are target specific. Some of the essential oils and their components show chemosterilant activity e.g. asarone extracted from rhizomes of *Acorus calamus* possesses antigonadial activity, causing complete inhibition of ovarian development of different insects. The products showing chemosterilant activity are highly required in integrated pest management programmes to limit the chances of physiological (resistant) race development by insects. Repellents and attractants modify the behavioral response of insects. This is the basis for the principle of behavioral insect control, whereby a given species is either attracted to a bait, or pheromone; or repelled from a host plant by a repulsive agent. Pesticidal compounds of plant origin are effective against pests, mostly through diverse modes of action and can express several properties such as growth retardation, feeding deterrent, oviposition deterrent and reduction in fertility. Most of the essential oils of higher plant origin act in biorational mode of action interrupting the function of octapamine receptors found in insects but absent in mammalian system. Hence, their exploitation in pest management would be an ideal ecochemical approach. A push-pull or stimulo-deterrent is employed for control of maize stem borer and *Heliothis* species in cotton fields. Plant flowers like marigold and certain kinds of vegetables help to control pests in or around the main crop. Such a strategy is sometimes also called 'companion planting' in pest management.

Botanicals are materials or products of plants origin valued for their pesticidal, medicinal or therapeutic properties. These natural pesticides are renewable and could be prepared as fresh dried products, liquid extracts, powders, cakes or in miniporous bags. Farmers of most countries including India are resource poor ones and have been using botanicals success-fully for protecting their crops against insect pests, nematode, fungal and bacterial diseases either on the field or in the store. Several scientists and farmers have reported the use of crude or formulated bioactive plant compounds against the insect pests (Tsado and Tanko, 2000; Tang'an *et al*., 2002, Anjorin *et al*., 2004). The bioactivity of crude or commercial pesticides from the seeds, twigs and stem barks of neem trees against over 700 pests and disease pathogens has been reported and the pesticidal or microbicidal property was attributed to their secondary metabolites which are triterpenoids and non-terpenoids (Finar, 1986; Hellpap and Dryer, 1995).The use of plant derivatives (Table 1) for pest control was common in the tropics before the advent of synthetic pesticides (Saxena, 1987).

Table 1: Trees as a source of botanicals.

S.N	Tree species	Common name	Plant part/product	Active principle	Activity
1	*Albizia lebbeck*	Wild Sirissa	Seed, leaf, pod, bark and root	Caffeic acid, alkaloids and quercetin	insecticidal
2	*Anacardium occidentale*	Cashew nut	Shell oil	Phenolic compounds	insecticidal
3	*Anona sequamosa*	Custard apple	Stem, leaf and semi-ripe fruit	Anonine	insecticidal

4	*Azadrachta indica*	Neem	Seed and fruit oil	Azadirachtin, nimidin, salanin, meliantrol and terpenoids	Antifeedant, oviposition deterrent, IGR and insecticidal
5	*Butea monosperma*	Flame of forest	Flower extract	Chalcones and aurones	termiticidal
6	*Madhuca indica*	Butter	Seed and seed oil	saponins	Repellent and insecticidal
7	*Melia azadaracha*	Common bead	Fruit and seed	meliacin	Antifeedant and insecticidal
8	*Pongama pinnata*	Indian beech	Seed and seed oil	karanjin	Repellent and insecticidal

Neem (*Azadirachta indica* A. Juss Fam. Meliaceae) has a wide range of uses in the control of crop and household pests, for medicinal purposes and as shade trees. It is also a raw material for soap, charcoal production and for protection of crops and homes against pests and pathogens in an area is linked to their tradition. As neem products are used for human consumption and medication (Table 2), exposure to neem in the process of treating plants with neem oil poses no threat to humans or other higher animals. Moreover, neem is not a contact poison so does little harm to beneficial insects.

Table 2: Medicinal value of Neem in Ayurveda

Plant part	Medicinal value
Leaf	Leprosy, skin problems, skin ulcers, intestine worms, anorexia, eye problems, epistaxis, biliousness
Bark	Analgesic, curative of fever
Flower	Elimination of intestine worms, phlegm, bile suppression,
Fruit	Diabetes, eye problem, piles, intestine worms, urinary disorder, wounds, leprosy, epistaxis
Twig	Asthma, cough, piles, intestine worms, obstinate urinary disorder, phantom tumor, spermatorrhoea
Gum	Scabies, wounds, ulcer, skin diseases
Seed	Intestine worms and leprosy
Oil	Intestine worms, skin diseases and leprosy
Root	Refrigerant, diuretic

Neem kernel oil and derivatives had a very important role in daily life because of the specific physical and chemical characteristics given in Table 3.

Table 3: Specifications for neem kernel oil

S.No	Characteristic	Requirement
1	Maximum moisture and insoluble impurities Lovibond colour (1/4 in cell), expressed as Y + 5R, not deeper than	0.3 per cent by weight
2	Refractive index at 40 0C	1.4615-1.4705
3	Specific gravity,	0.908-0.934
4	Saponification value	180-205
5	Maximum acid value	15
6	Maximum unsaponifiable matter	2% by weight
7	Minimum titre	36^{0}C
8	Iodine value (Wij's method)	65-80

(Singh *et al.*, 2012)

NEEM IN PLANT PROTECTION

In India, neem products are effective against various pests of both crop fields as well as stored grains like rice, wheat, corn, legumes, potato, tomato, etc. Several organic compounds are found in the neem tree viz., Azadirachtin, Maliantriol, Nimbin, Nimbidin etc. Neem has miraculous powers and may be used as insecticidal, larvicidal, antimalarial, antifeedant, antifungal, antitubercular, antiviral, antialergic, antidermatic, antigingvitic, anti-inflammatory, anti-periodontitic, antipyrrhoeic, anti-seborrhoeic, antifuruncular, bactericide, nematicidal, piscicidal, amoebicidal, diuretic, spermicidal (contraceptive) etc. (Singh *et al.*, 2012). The fish exhibited respiratory distress (such as gasping air), loss of balance and erratic swimming prior to mortality. The toxicity tests indicate that the applications of neem gold bio-pesticides for the control of unwanted organisms in agricultural farms are much safer and more environmental friendly than synthetic pesticides (Davoodi and Gholamreza 2012).This put light on the use and efficacy of *A. indica* based pesticides against various pests of both crop fields as well as stored grains of India (Debashri and Tamal 2012). Different molecular techniques have been used to determine the effect of *azadirachtin* at cellular and molecular level. It has been shown that azadirachtin acts on the mitotic cells and blocks the microtubule polymerization. It has been revealed that the anti-proliferating effect of azadirachtin is due to blocking of cell cycle and induction of apoptosis (Huang *et al.*, 2011). In addition to this, nuclear DNA is directly damaged by *azadirachtin* and also binds to a large protein complex including heat shock proteins (Robertson *et al*., 2007). It has been suggested that azadirachtin is highly reactive and have many cellular molecules as target in cytoplasm as well as in nucleus. Certain activities of genes and proteins are also altered by *azadiracthtin* (Lynn *et al*., 2012). Plant extracts constitute a rich source of bioactive chemicals with a potential for development as successful pest control agent (Rahman and Schmidt, 1999) which can affect insects in several ways: disrupt major metabolic pathways and cause rapid death, retard or accelerate development or interfere with the life cycle of the insects (Rimpi *et al.,* 2010). Limonoid from the neem tree acts as a strong antifeedant, IGR as an elicitor of reproductive effects at cellular level. Antifeedancy varies markedly between species with Lepidoptera being particularly sensitive to *azadirachtin*. The physiological effects on the growth, moulting and reproduction are more consistent between species although cuticle or gut may provide barrier to bioavailability in some species. The mode of action of azadiractin lies in

1. Effect on deterrent and other chemoreceptors resulting in Antifeedancy
2. Effect on ecdysteroid (moulting hormone) and juvenile hormone titters through a blockage of morphogenetic peptide hormone release and
3. Direct effect on most other tissues studied resulting in an overall loss of fitness of the insect.

In spite of high selectivity, neem derivatives affect 400 to 500 species of insects belonging to Blattodea, Caelifers, Dermaptera, Diptera, Ensifera, Hetroptera, Hymenoptera, Isoptera, Lepidoptera, Phasmida, Phthiraptera, Siphonoptera and Thysanoptera, one species of ostracad, several species of mites, and nematodes and even noxious snails and fungi, including aflatoxin-producing *Aspergillus flavus*. Interaction of neem extract concentrations on fecundity of *T. castaneum* at 27, 35 and 42 days after exposure showed that beetle laid significantly less number of eggs as compared to control.

As a biopesticide Azadirachtin is known to have very little effect on non-targeted organisms for example pollinators (Mordue *et al.*, 2005). It is completely non-toxic to vertebrates. Azadirachtin may not be effective against all pest insects (Salehzadeh *et al.*, 2002) and its effectiveness is dependent on used concentration.

Fig 1: Comparison of larval/pupal duration and survival in different concentrations of neem biopesticide

Neem biopesticide has proved lethal to survival of larvae and pupae of *T. casataneum* at all three concentrations as compared to control. Khalequzzaman and Khanam (2006) reported the efficacy of neem extracts compared with cypermethrin and methyl parathion against the stored grain insect pests and observed that neem extracts gave highest mortality of *T. castaneum,* this supports neem biopesticide especially which gave less survival and highest mortality of the beetle

ADVANTAGES OF NEEM

Salako, (2002) stated that the use of neem has obvious advantages. It includes

- All the neem products are commercially very important. If temperature is above 70 C^{o}, the kernel loose oil reduction, properties, medicinal properties and azadiracthtin quality. It is therefore important that neem seeds should be dried on floor or polythene sheet or by hot air blowers. The kernel contains the insecticidal properties; antifeedant properties etc. The neem cake is used in the agriculture as fertilizer, to reduce the nematode infestation in soils and also for nitrogen conservation. Lately the cake water solution is also used to control insects.

- It is relatively cheap and easily available
- It is complex mixture of active ingredients which function differently on various systems of the insect's life cycle, digestion, nerve conduction and makes it difficult for pests to develop resistance to it.
- It is systemic, thereby protecting the plant from within. This has resulted in wheat, barley, rice, sugar cane, tomatoes, cotton etc being protected from damaging insects for up to ten (10) weeks. Further Khalid and Shad (2002) reported that the toxic effect is normally of an ephemeral nature disappearing within 14 - 21days.
- It parades a wide spectrum of pesticidal activity. Insects controlled by neem include migratory locust, army worms, whitefly and even head lice. About 50 neem products are being manufactured for the control of pests and nematodes. The pathogens it controls include *Meloidogyne* root-knot nematode, *Rhizoctonia* root- rot fungus and Rice stunt virus (Anjorin *et al*., 2004); and
- It is found to be safe to earthworms.

DISADVANTAGES

When sun light is exposed to the neem products it loses its effectiveness. It is therefore necessary to have sun screen to avoid spoilage. These products when sprayed on the plant remain effective for 2 to 3 weeks if stored at low temperature.

- Neem has very short viability hence it is difficult to introduce the seeds in any new location.
- The neem tree and its products are very sensitive to frost and it can be grown in tropical and subtropical regions.
- Although there is no hazards in the use of neem products but no systematic work have so for been made to know the residue and its side effect on the humans and other mammals.
- Another setback which come to the notice is that by using neem products, we do get damage to some type of crops, as potato plant do not take up azadiracthtin, whereas bean do accept.
- Time of application is very important factor but in general the extracts are very effective if spraying is done in morning and evening. The neem products have a little slow action as compared to the chemical pesticides. Prolonged exposure time by neem is most effective to control red flour beetle in stored wheat (Hameed *et al*., 2011).
- Further, it is also observed that registration of neem products is very difficult as authorities are psychologically not sound to accept the products an alternative to pesticides.

NEEM USED AS RAW MATERIAL FOR PEST CONTROL.

Neem oil insecticide is unique in that it does not immediately kill the insects it affects. Instead, for reasons not yet understood by scientists, neem oil insecticide causes a pest to be unable to maintain hydration, which in turn kills it. Some pests are also repelled by neem oil insecticide, which means that they stay away from the plant neem oil is sprayed on (Rhoades 2013). Raw leaf and leaf powder were used by formers in the store of farm produce, in spite of organic solvent neem extract, neem oil, neem seed cake and commercial formulations, which were used only by agro-allied personnel (~33.40%) for laboratory or field experimental research work. Neem oil has been reported to store for a longer time than either the extracts or the cake, but they could be phytotoxic if used in high concentration (Child *et al.*, 2000).

Neem seed kernel extracts (NSKE).

NSKE were found to reduce seed rot-index and increases germination percentage (85% cowpea) and seedling vigor index, while as neem leaf extracts reduce severity-index of brown Bloch disease significantly from 3.6 to 2.1 without any sign of scorching (Mohammed, 2005). Botanical pesticides are unique in that the content of the active substances vary with season, growing conditions, age at harvest, differences in extraction methods and storage conditions thus posing difficulties in dosage standardizing. Jazzar and Hammad (2003) suggested that the efficacy of the Melia extract could be enhanced by using a more proficient extraction procedure, because the quantity of the biologically active compounds varies with the extraction method.

Neem leaf powder.

Neem leaf powder plus ash, neem leaf powder slurry, neem seed powder, neem seed powder slurry and neem leaf powder plus groundnut oil control scale insect of yam and reduced scale insect score by 0.6 to 2 points (Ezekiel *et al*, 2008). Furthermore, Neem leaf extract (NLE) and mahogany bark extract (MBE) control the groundnut leaf spot. Liquid formulations are more effective than dust formulation.

CONSTRAINTS

The use of botanical pesticides such as neem materials has some constraints. Jaryum *et al.* (2000) observed residual bitter taste on the grains treated with neem seed powder. It was therefore reported that neem products are most suitable for seed protection than on stored farm produce for consumption. Anjorin (2006) also reported the constraints of using botanical pesticides because it is laborious and time consuming processing such as grinding of bark or leaves of neem tree into powder and the usage of crude and household materials like pestle, mortar and containers which often become stained, tasty and contaminated. Majority of the neem users (83.3%) indicated insufficient supply of commercial neem formulation as their main constraints to the use of neem pesticides. Next constraints are inadequate modern processing facilities (Okwete 2006) which are necessary for efficient isolation, purification and compounding of natural products into pesticides and drugs. The process of simplification and purification of the active ingredients are often slow and cumbersome and may lead to loss of activity. Dayan *et al.* (1992) found that it is often difficult to standardize their dosages due to variation in their diverse growing conditions, varietal differences, age of sample at harvest, extraction methods and storage conditions.

CHALLENGES AND IMPROVEMENT OF NEEM BIOPESTICIDE UTILIZATION

Establishment of quality standards for neem products involves numerous interwoven practical, scientific and legal issues. Infrastructures such as specialized research laboratory and storage facilities for neem raw materials and products are inadequate. There is need for collaboration with the Government agencies such as National Agency for Food and Drug Administration (NAFDAC), Standard Organization of country and the farmers. Standard formula of extraction technique of crude, semi-purified or purified neem pesticidal products should be originated and introduced in order to produce a more consistent botanical pesticide in the country. Proper identification of neem products used as biopesticide is imperative. Economics is an important factor, as the cost of these standards is often prohibitive (Hameed *et al.*, 2011).

CHARACTERS OF NEEM BASED PESTICIDES

Neem leaf extracts are less effective than seed extracts due to lower azadirachtin content. Neem materials should be efficiently and quickly dried after harvest (Hellpap and Dreyer, 1995) so that they can be stored ready for use during off season period. Neem based pesticide preparations are to be kept away from sunlight to avoid photodegradation of active ingredients by UV light. Formulations are better applied at dusk when sun is weak. Sun screens such as Para Amino Benzoic Acid (PABA) could be added to reduce the photo-oxidation of azadirachtin by UV light. Further organic solvent such as methanol and ethanol have been found to extract the active ingredients better than water. Gahukaar (2006) reported that limnoids is highly soluble in alcohol such as methanol or ethanol. Worldwide, there are over 100 commercial neem formulations (Yaradua, 2007).

FUTURE PROSPECTS

Biotechnology facilitie scientific laboratories and National Pharmaceutical Research Institute (NIPR) and the science & technological-oriented Universities are necessary to be explored and exploited, so as to boost the neem products research and utilization. It is imperative that commercial neem formulations should be produced and made available for use instead of the current crude neem preparation. Crude formulations often degrade rapidly and therefore applied frequently and precisely. Certified commercial neem pesticides on the long run involve minimum labour requirements and can be formulated for stability under ultraviolet rays. Care is however be taken to ensure its even distribution, unrestricted availability and high quality so that it will get to the farmers at the most affordable rate. To enhance utilization of neem for crop protection the following recommendation should be noted:

Two or more plant parts or species should be combined for neem formulation in order to boost the bioefficacy of neem, grant it broader spectrum and check the risk of resistance developing.

Commercial preparation of some botanical pesticides should include synergist such as piperonyl butoxide to increase the effectiveness of the pesticide.

Relevant institutions should increase awareness of the economic significance of neem especially its pesticidal potential amongst farmers and to provide technical support for plant pesticide researchers. The most effective means of ensuring identity of neem pesticides by experienced and competent personnel is simply by subjecting them to organoleptic (sensory) assessments and microscopic examination of diagnostic anatomical and histological characteristics. There should be professional educational programs such as organic pesticide education and training and also in related fields such as biochemistry and natural products is necessary. Government and NGOs should initiate programmes that encourage the growing of plants with pesticidal potentials on the farms. Fundamental political and financial support is needed to establish the infrastructure and to conduct the necessary research and development of neem biopesticide. There should be an organizational infrastructure to plan, foster, facilitate and coordinate research so that the current gap or imbalance in scientific research findings in neem biopesticide development and utilization could be consciously bridged.

SUMMERY AND CONCLUSION

The botanical pesticides are cheap, easy to prepare, eco- friendly and low-cost alternatives to agrochemicals. The extracts of *A. indica* have been compared with commercial pesticides on various crop pests where they have been found to be efficacious, and equally or more cost effective. However, the *A. indica* is not being exploited to its full potential by farmers of south and south-east Asia. There appears to be a number of reasons for this, including a lack of knowledge surrounding *A. indica's* role in crop protection. Despite the setback to the traditional pest control uses of *A. indica* due to the advent and popularization of synthetic insecticides, new interest in the pest control potential of *A. indica* has grown worldwide since the past decade. However, if full benefits are to be achieved, then further patronage is needed from governments, policy makers, administrators, public and private organizations, national and international programs, and the donor community.

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REFERENCES

[1] Anjorin, S.T. 2006. A survey of crop seed protection with botanicals in the FCT-Abuja. *J. Sustainable Trop. Agric.Res.* Vol. 24: 35- 40.

[2] Anjorin, S.T; Salako, E.A and Ndana, R.W. 2004. *In vitro* assessment of some plants leaf extracts for the control of *Meloidogyn*e spp. and *Rhizoctonia solani.* Zuma. *J.Pure. Appl. Sci.* **7**(1): 23-28.

[3] Bajwa, A. A. I. and Ahmad, A. 2012. Potential applications of Neem based products as Biopesticides. *The Health*. **3**(4): 116- 120.

[4] Beaulieu, D. 2013.Neem Oil as Organic Insecticide. *Landscaping Newsletter*. **Pp** 1-2.

[5] Childs, F.J; Chamberlain, J.R and Daniel, J. 2000. Improvement of neem and its potential benefits to poor farmers in developing countries. *Proceedings of Pune Workshop*; 2-5 April, 2013. HDRA, Coventry, UK.

[6] Dayan, F.G; Tellez, A. and Duke, S. 1992. Managing weeds with natural products. *Pesticide Outlook*: 185 -188.

[7] Debashri, M. and Tamal, M. 2012. A Review on efficacy of *Azadirachta indica* A. Juss based biopesticides: An Indian perspective. *Research Journal of Recent Sciences.* Vol. **1**(3). 94- 99.

[8] Davoodi, R. and Gholamreza, A. 2012. Comparative Study on the Acute Toxicity of Synthetic Pesticides, Permethrin 25% and Monocrotophos 36%, and Neem-Based Pesticide, Neem Gold EC 0.03%, to *Juvenile Cyprinus carpio* Linn. *J. BIOL. ENVIRON. SCI.* 6(16). 105- 108.

[9] Ezekiel, A.S; Samuel, T. A; Charity, D. G. and Ezekiel, B.O.2008. A review of neem biopesticide utilization and challenges in Central Northern Nigeria. *African Journal of Biotechnology.* Vol. **7** (25). **pp**. 4758-4764

[10] Finar, I.L. 1986. Stereochemistry and the chemistry of natural products. Organic chemistry. Vol. 2. *Longman Publishers England*. **pp**. 696-761.

[11] Gahukaar, R.O. 2006. Formulation of neem-based products and pesticides. *Neem Foundation*, Mumbai, Indian. Gunasena HPM: 12-13.

[12] Hameed1, A; Shoaib, F; Altaf, H; Muhammad, I; Mussurat, H; Muhammad, N; Asif, S; Hammad, H; Muhammad, A. and Abdul, L. T. 2012. Toxicological effects of neem (*Azadirachta indica*), Kanair (*Nerium oleander*) and spinosad on the red flour beetle (*Tribolium castaneum*) (Herbst.). *African Journal of Agricultural Research.* Vol.7 (4). **pp**. 555-560.

[13] Hellpap, S. and Dreyer, M. 1995. The smallholders' neem products in the neem tree: Source of unique natural products for Integrated Pest Management, Medicine, Industry and other purposes; H. Schmutterer Weinhein, Germany: **pp.** 3-6

[14] Huang, J.F; Shui, K.J; Li, H.Y; Hu, Y. and Zhong, G.H. 2011. Antiproliferative effect of azadirachtin on *Spodoptera litura* S_l-1 cell line through cell cycle arrest and apoptosis induced by up-regulation. *Pestic Biochem Physiol.* 99: 16-24.

[15] Jaryrum, A. I; Salako, E. A; Valenica, E. A. and Oyabanji, O. 2001.*The Technical Buletin Sasakawa Global*. The Federal Agricultural Coordinating Units, Abuja, **pp**. 1-12

[16] Jazzar, C. and Hammad, E.A.F. 2003. The efficacy of enhanced aqueous extracts of Melia azedarach leaves and fruits integrated with the Camptotylus reuteri releases against the sweetpotato whitefly nymphs. *Bull. Insectol.* **56** (2): 269-275.

[17] Khalequzzaman, M. and Khanom, M. 2006. Effects of cypermethrin alone and in combination with leaf and seed extracts of neem against adult Tribolium castaneum (Herbst). *Univ. J. Zool. Rajshahi Univ*. **25**: 45-49.

[18] Khalid, S. and Shad, R.A. 2002. Potential advantage of recent allelochemicals discoveries and agro cosystems. *Prog. Farm.* **11**: 30-35.

[19] Khater, H. F. 2012. Prospects of botanical biopesticides in insect pest Management. *Journal of applied pharmaceutical science*. **2** (05): 244-259

[20] Lynn, O. M; Kim, J.E and Lee, K.Y. 2012. Effect of azadirachtin on development and gene expression of 5th instar larvae of Indian meal moth, *Plodia interpunctella*. *J Asia-Pacific Entomology*. **15**: 101-5.

[21] Lokanadhan, S; Muthukrishnan, P. and Jeyaraman, S. 2012. Neem products and their agricultural applications. *J. Biopest.* **5**: 72-76

[22] Mohammed, B. 2005. Interactive effect of different fertilizer rate, application of neem leaf extract and benomyl on yield and diseases of cowpea. PGD Crop Production Thesis. Federal University of Technology, Minna, Niger State, **pp**. 21-30.

[23] Mordue, A.J; Morgan, E.D; Nisbet, A. J and Azadirachtin. K. 2005. A natural product in insect control. In: Gilbert, L.I., Iatrou, K., Gill, S.S. (Eds.).*Comprehensive Molecular Science. Elsevier*, Oxford, **pp**. **6**: 117-35.

[24] Okwete, S.K. 2006. Use of organic bioactive substances from plants for use in agriculture and Medicine: Natural Products Chemistry. *The 5th Inaugural Lecture at University of Abuja*.

[25] Prakash, A. and Rao, J. 1996. Botanical Pesticides in Agriculture. CRC Press New Delhi, Indian. *(http://factbotanicals.htm; http://www.cplbookshop.com)*.

[26] Rahman, M. M. and Schmidt, G. H. 1999. Effect of *Acorus calamus* (L.) (Araceae) essential oil vapours from various origins on *Callosobruchus phaseoli* (Gyllenhal) (Coleoptra: Bruchidae). *J. Stored Prod. Res*. **35**: 285-295.

[27] Rhaoides, D.2013.Helping Your Plants With Neem Oil Foliar Spray. Gardening know how. **pp** 1-2

[28] Rimpi, D; Chutia, B. C; Sarmah, M. and Rahman, A. 2010. Effect of neem kernel aqueous extract (NKAE) on growth and development of red slug caterpillar, *Eterusia magnifica* but in tea in North-East India, *India. Journal of Biopesticides*. **3**(2): 489 - 494

[29] Robertson, S.L; Ni, W. Dhadialla, T.S; Nisbet, A.J and McCusker, C. 2007. Identification of a putative azadirachtin-binding complex from Drosophila Kc167 cells. *Arch Insect Biochem Physiol***.** **64**:2-8.

[30] Salako, E.A. 2002. Plant protection for the resource-poor farmers. A keynote address at Nigerian Society for Plant Protection. *30th Annual conference. UNAAB.* Abeokuta.1-4.

[31] Salehzadeh, A; Jabbar, A. Jennens, L; Ley, S.V. and Annadurai, R.S. 2002. The effects of phytochemical pesticides on the growth of cultured invertebrate and vertebrate cells. *Pest Manag Sci*. **58**: 268-76.

[32] Saxena, K. 1987. Indigenous crop Protection practices in sub-Saharan East Africa. In: Database of Natural Crop Protectant Chemicals (DNCPC).*http:www.ipmafrica.htpm*

[33] Singh, S.K; Chauhan, I; Singh, G. and Rashmi, S.2012. Adoption of Neem as a Pesticide in Agriculture: An Experimental Study. *Indian Res. J. Ext. Edu*. **12** (3): 97-101

[34] Tang'an, B.N.S; Adebitan, S.A; Adbul, S.D. and Ogidi, J.A. 2002. Fungicidal activity of some plant extracts on *Cercospora sojina* Hara: the causal agent of frogeye leaf spot of soyabean. *Annual Conference of the Nigerian Society for Plant Protection*, University of Agric. Abeokuta.**pp**. 1-4.

[35] Tsado, E.K and Tanko, M.A. 2000. Evaluation of three local plants for the control of Storage insect pests of maize and cowpea. *30th Annual Conference of the Nigerian Society for Plant Protection*, University of Agriculture, Abeokuta.**pp**. 2-5.

[36] Yaradua, A.A. 2007. Potentials of biopesticides from neem tree (*Azadiracta indica* A. Juss) in sustainable pest and disease management in Nigeria. In: Medicinal plants in Agriculture. Proc. *Akure-Humbolt Kellog 3rd SAAT Annual Conference*. **pp**. 237- 254.