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Review

A review of neem biopesticide utilization and challenges in Central Northern Nigeria

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The status of neem biopesticide research, utilization and challenges in the central part of northern Nigeria was reviewed. In the sampled areas such as the Federal Capital Territory (FCT), Abuja and Niger State, the highest category of neem users (17.19%) were the rural farmers. Majority of the neem users obtained their materials from semi-wild trees on communal land. Our investigations showed that neem leaf and seed powder or extracts controlled weevils in stored maize and cowpea, enhanced germination percentage, and seedling vigour. It also reduced fungal attack and infection on stored seeds and crops on the field. Scale insects were controlled on seed yam dressed with various neem formulations. Application of bionimbecidin HP III (Greengold®) paste at 5 g/Kg of seeds for three weeks in storage significantly enhanced seedling vigour and reduced root-rot index on a susceptible cowpea. Increased bioactivity against *Rhizoctonia* root-rot and *Meloidogyne* root-knot was achieved through synergism from the combined iron weed and neem leaf extract. Forty seven point two percent (47.20%) of the respondent neem users indicated insufficient supply of commercial neem formulation as their main constraints, while 80.15% complained of inadequate processing facilities. Optimal utilization of neem biopesticide could be achieved in Nigeria by addressing the constraints and challenges in the formulation and standardization of the organic pesticide.

Key words: Neem, biopesticide, utilization, challenges, Nigeria.

INTRODUCTION

Botanicals are materials or products of plants origin valued for their pesticidal, medicinal or therapeutic properties. Phytopesticide materials range from whole fresh plants to purely isolate bioactive phytochemicals or their formulations which are effective against pests and pathogens (Prakash and Rao, 1996). These natural pesticides are renewable and could be prepared as fresh dried products, liquid extracts, powders, cakes or in miniporous bags. Farmers all over Nigeria especially the resource-poor ones 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 pesticide in Nigeria (Tsado and Tanko, 2000; Tang'an et al., 2002, Anjorin et al., 2004). Preparation and application of botanicals for crop protection are linked to the folklores and tradition of the farmers (Anjorin, 2008). The use of plant derivatives for pest control was common in the tropics before the advent of synthetic pesticides (Saxena, 1987).

Neem (*Azadirachta indica* A. Juss Fam. Meliaceae) has been a beneficial tree to the inhabitant of central northern zone of Nigeria since several decades ago. It 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 and charcoal production. Its use for protection of crops and homes against pests and pathogens in the area reviewed is linked to their folklores and tradition. Yar'adua (2007) submitted that botanical pesti-

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Table 1. Usage of neem as bio-pesticide in the FCT, Abuja and Niger State, Nigeria.

Zone	Urban farmer		Rural farmer		Agric. personnel/researcher	
	Neem users	Non-users	Users	Non - users	Users	Non-users
Eastern FCT, Abuja	10.00	90.00	16.25	78.75	15.67	84.33
Western FCT, Abuja	15.33	84.67	22.50	82.50	16.67	83.33
Zone A (Bida)	11.77	88.23	15.50	84.50	20.00	80.00
Zone B (Kuta)	7.25	92.75	14.40	85.60	17.00	83.00
Zone C Kontagora	14.49	85.51	17.30	82.70	15.30	81.70
Mean %	11.77	88.22	17.19	82.81	16.93	82.47

Values are in percentage (%) (Source: Anjorin, 2008).

cides are simple to prepare, locally renewable, user-friendly and environmentally safe. 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 documented. Their pesticidal or microbicidal property was attributed to their secondary metabolites which are triterpenoids and non-terpenoids (Finar, 1986; Hellpap and Dryer, 1995). In spite of the aforementioned pesticidal potential of neem, it seems to have been under-utilized for that purpose. This might be due to some constraints militating against its full usage by the farmers. The zone is predominated with sub-urban farmers who have limited access to or might not be able to afford the exotic synthetic agro-chemical inputs (Balogun, 2001). Neem is so important that there have been up to five international conferences on its research and development.

The selected areas, the FCT-Abuja is geographically located in the heartland of the country and lies between Latitude $8^0\ 25^1$ and $9^0\ 21^1$ N of the equator and Longitude $6^0\ 45^1$ and $7^0\ 39^1$ E of the Greenwich Meridian (Mundi and Chup, 2000). While Niger State lies between Latitude $4^o\ 00^1$ and $7^0\ 30^1$ N of the equator and Longitude $11^0\ 30^1$ and $4^0\ 00^1$ E. The two areas have similar vegetation and agro-ecological characteristics (Balogun, 2001). This paper examines the status of neem biopesticide with respect to the level of utilization, development, constraints and challenges in the middle belt zone of Nigeria. Possible interventions were then suggested.

USAGE OF NEEM IN CROP PROTECTION

The extent to which neem is used as a biopesticide in the FCT-Abuja and Niger State in 2006 is shown in Table 1. Among the urban farmers, only an average of 11.77% of them used neem as a biopesticide. This percentage increased by 5.42% among the rural farmers. The highest percentage of neem users among the agro- allied personnel/researchers was from Bida - Zone A of Niger State (20.00%). On the whole, the highest group of users of neem as a biopesticide was the rural dwellers (17.19%) with the highest percentage (22.50%) from Western zone of the FCT.

Salako, (2002) stated that the use of neem has obvious advantages, which include:

i. it is relatively cheap and easily available;
ii. its complex mixture of active ingredients which function differently on various parts of the insects life cycle and physiology makes it difficult for pests to develop resistance to it;
iii. 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;
iv. it parades a wide spectrum of pesticidal activity. Insects controlled by neem include migratory locust, army worms, whitefly and even head lice. The pathogens it controls include *Meloidogyne* root-knot nematode, *Rhizoctonia* root- rot fungus and Rice stunt virus (Anonymous, 1992; Anjorin et al., 2004); and
v. it is found to be safe to beneficial organisms such as earthworms. Khalid and Shad (2002) specifically reported that their toxic effect is normally of an ephemeral nature disappearing within 14 - 21days.

SOURCES OF RAW MATERIALS FOR NEEM PESTICIDES AND PURPOSE OF USAGE

Personal interview indicated that few of the neem users (two out of ten) personally owned their neem tree. Majority of the users (seven out of ten) obtained their neem materials from semi-wild trees on communal land. While one out of ten users paid labourers for raw materials. This was more common among the agro-allied personnel (50.00%). There was no report of government established neem plantation in the FCT inspite of its economic importance. Majority of the farmers (eight out of ten) used neem for medicinal purpose. This is followed by its use for protecting farm produce in the store (66.67%). The purpose of use of neem for the agro-allied personnel was mainly experimental. The least purpose to which neem products is put is for soil drenching (19.05%) on the crop field. The highest percentage of the neem users (66.67%) mostly from the rural areas reported that

Table 2. Usage of Neem products for crop pest control in the FCT- Abuja and Niger State, Nigeria.

S/N	Neem product	Users in urban area	Users in rural area	Users by agro-allied personnel	Mean
1	Raw leaves and leaf powder	71.43	75.86	33.33	60.21
2	Aqueous neem leaf extract	71.43	58.62	50.00	60.02
3	Aqueous neem seed extract	57.14	58.62	33.33	49.70
4	Organic solvent neem extract	14.29	-	50.00	25.65
5	Neem oil	-	-	-	-
6	Neem seed cake	-	-	-	-
7	Commercial formulation	-	-	33.33	16.67

Values are in percentage (%) (Source: Anjorin, 2008).

they use neem because it was in line with their tradition. Next to this reason was that neem materials are cheap and easy to prepare and that it is effective (61.90%). The effectiveness indicated by 50.00% of the agro-allied personnel neem users was only confirmed in the laboratory and not on the field.

Table 2 shows the type of neem products that the urban and rural farmers and agro-allied workers used for protecting their crops. The response of majority of neem users (≥ 60.02%) indicated that they use crude preparation of neem powder or extracts. The percentage of a similar group in India was as low as 26.00% (Childs et al., 2000).

Majority of the urban farmers used raw leaves, leaf powder and aqueous neem leaf extract for crop protection. Among the rural farmers, neem product with the highest percentage of usage was raw leaf and leaf powder used in the store of farm produce. Both the urban and rural farmers are not used to organic solvent neem extract, neem oil, neem seed cake and commercial formulations. Only 33.33% of the agro-allied personnel indicated to have used commercial formulation (such as bionimbecidine HP III and organic solvent extracts) for laboratory or field experimental research work. Though neem seed cake and oil have not been used in the FCT Abuja, it is known to be effective for nematode control and as manure. 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).

Our investigations on neem for pesticidal purposes in the area reported include the following:

a) Neem seed kernel slurry/extract

Green-yellowish matured neem leaves were shade-dried (5 - 7 days), then ground into powder. Raguranman and Jayaraya (1994) found that drying of leaves under direct sunlight could result in their being photothermally degraded. Two hundred and fifty grams (250 g) of the powder was added to 2 L of clean water. It was mixed thoroughly, filtered with a fine sieve and used for cowpea seed dressing before being inoculated with *Rhizoctonia solani* and sown. Ten days after planting (10 DAS), 150 ml of the extract were applied to the stem bases of three seedlings per stand. There was significantly higher ($P < 0.05$) root-rot index (3.5) in the control plots than those applied with neem leaf extract (1.0). Also the germination percentage (85%) and seedling vigour index of the seedlings in the control plots (mean of 2.2) were significantly lower ($P < 0.05$). than the plots that received the treatments (3.9)

b) Control of brown blotch disease of cowpea

Brown blotch cowpea disease was significantly reduced from 3.6 to 2.1 severity index with no scorching observed as a result of application of neem leaf extract and phosphorus fertilization- 200 Kg $P_2$05/Ha (Mohammed, 2005). Also, a significant increase ($P< 00.5$) in grain yield from the treated cowpea plots was obtained (409 kg/ha) while that of the control plots was 301 kg/ha.

c) Seed dressing of yam with neem formulations for the control of yam scale insects

This study investigated the insecticidal potentials and the effect of neem (*Azadirachta indica* A. Juss) formulations (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) on scale insect control and yield of yam. Applications were in two stages: one was before storage of yam setts alone, and the other was both before storage and before planting of the yam setts. The neem formulations improved germination by 14 to 48%, increased yield by 12 to 28 MT/Ha and reduced scale insect score by 0.6 to 2 points. The level of effectiveness however, varied depending on the type of formulation used and the number of applications administered. Furthermore, liquid formulations were more effective than dust formulation.

d) Comparative effect of Bionimbecidine HP III and Apron star fungicides on seed-borne fungi, seedling vigour and root- rot in cowpea (*Vigna unguiculata* [L.] Walp)

Cowpea seeds collected from two different sources in Minna were treated with bionimbecidine HP III - a neem-based fungicide (Green gold) and a synthetic fungicide (Apron star) and stored for 0, 3 and 6 weeks before being assayed for fungal contamination. Agar plating of the seed samples indicated *Aspergillus niger*, *Fusarium moniliforme*, *Penicillium notatum* and *Aspergillus flavus* to be most abundant fungi. Application of the fungicides significantly increased % germination, seedling vigour and reduction of root rottening compared with the control. The coating of seeds with the paste of Green gold resulted in more fungitoxicity than dusting with the powder form, but left some mild discolouring residue on the seed coat. Green gold paste (5 g /Kg) and Apron star enhanced seedling vigour and checked root-rot index most effectively at 3 weeks after storage (3 WAS). Green gold powder and paste at 5 g/Kg had more fungitoxic effect than at 1 g/Kg. The efficacy of green gold should be confirmed on other pathogenic non seed - borne fungi.

e) Interactive effect of different dates of planting, neem extract and benomyl on the yield and disease of three cowpea varieties

The experiment was conducted in the FCT-Abuja to determine the interactive effects of neem leaf extract and benomyl on the yield and disease reaction of three cowpea varieties (Omolohunnu, 1998). Also there was significant effect of the fungicides applied on yields ($P < 0.05$). The yield obtained from the use of benomyl was the highest (801 kg/ha) but was closely followed by the neem leaf extract sprayed on weekly basis (760 kg/ha). IAR 48 was observed to be highly susceptible to fungal diseases as the yield was severely reduced (309 kg/ha) when no fungicide was applied. From this study, it was recommended that neem leaf extract should be applied on weekly basis in order to prevent fungal disease attack and also to enhance yield.

f) Evaluation of some botanicals for the control of *Rhizoctonia* root - rot (RRR) and *Meloidogyne* root - knot (MRK) in Cowpea (*Vigna unguiculata* [L.] Walp.) in the FCT, Abuja

This study analysed the cost and returns of cowpea production using aqueous and ethanolic leaf extracts of neem (*A. indica)* and iron weed (*Blumea perotitiana)* for the control of *Rhizoctonia* root-rot (RRR). In 2005 and 2006, cowpea produced on the synthetic fungicide (Mycotrin®) applied plots had the highest net income than all other treatments in Ido and Kwali fields in the FCT-Abuja (₦31688.48/Ha and ₦35946.67/Ha) respectively. Among the plant extracts used, combined aqueous extracts of *A. indica* and *B. perotitiana* in Kwali field had the highest net income (₦ 23296.83/Ha). This could be attributed to synergistic bioactivity from the combined plant extracts and the cheaper cost of water than ethanol used for leaf extraction.

g) Evaluation of neem extract for the control of groundnut leaf spot

Neem leaf extract (NLE), mahogany bark extract (MBE) and benomyl were evaluated under field conditions at Minna in the southern guinea savanna zone of Nigeria for the control of late leaf spot (*Phaeoisariopsis personata* [Berk & Curt] V. Arx) of ground nut (Salaudeen and Salako, 2007). Benomyl was sprayed thrice at the rate of 0.6 kg a.i./ha in 400 L of water, while each plant extract was applied six times, at a concentration of 25%(w/v). All the treatments were effective against the pathogen. On the average, benomyl, NLE, and MBE reduced leaf spot severity by 66.6, 54.1 and 49.1%, respectively, compared with the untreated control. They also increased pod yield by 37.3, 31.6, and 25.2%, respectively, compared with the untreated control.

CONSTRAINTS IN USING NEEM PESTICIDES

The use of botanical pesticides such as neem materials however has some constraints. Jaryum et al. (2000) observed residual bitter taste on the grains treated with neem seed powder. It was therefore recommended that neem products are most suitable for seed protection than on stored farm produce for consumption. From a survey of the FCT farmers, Salako and Anjorin (2006) reported the constraints of using botanical pesticides to include the seasonality of using the candidate plant leading to inadequate supply of plant raw materials such as neem fruits; 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.

Table 3 shows the constraints to the use of neem pesticides for crop protection among the urban and rural farmers, and the agro-allied workers in the FCT- Abuja and Niger State. 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 to this constraint was the inadequate modern processing facilities (73.81%) especially for the researchers among the agro-allied personnel. This was in line with the submission of Okwete (2006) that modern facilities are necessary for efficient isolation, purification

Table 3. Constraints to the use of neem pesticides in the FCT- Abuja/ and Niger State, Nigeria.

S/N	Constraint	Urban farmer			Rural farmer			Agro–allied personnel			Mean (%) for Yes
		Yes (%)	No (%)	Don't know	Yes (%)	No (%)	Don't know	Yes (%)	No (%)	Don't know	
1	Inadequate raw materials, organic solvent and water	57.14	42.86	-	34.48	65.52	-	50.00	50.00	-	47.20
2	Preparation is laborious and time consuming	71.49	28.57	-	62.07	37.93	-	83.33	16.67	-	72.30
3	Low efficacy and short shelf life	57.14	-	71.49	27.59	10.34	62.07	50.00	-	50.00	44.91
4	Inadequate modern processing facilities	71.49	14. 29	14.29	68.97	24.14	6.90	100	-	-	80.15
5	Insufficient commercial neem formulations	85.71	14. 29	-	86.21	13.79	-	66.67	33.33	-	79.53
6	Inadequate awareness and innovative information	71.49	28.57	-	65.52	34.48	-	3(50.00)	3(50.00)	-	62.34
7	Adverse residual effect on tools/ consumers	14.29	57.13	42.86	27.59	72.14	-	16.67	66.67	16.67	19.51
8	Phytotoxicity and harmful to beneficial organisms	-	42.86	57.14	3.45	24.14	72.41	-	66.67	33.33	3.45
9	Registration and patenting of neem formulations	14.29	14.29	71.49	-	31.03	68.97	50.00	16.67	33.33	21.43

and compounding of natural products into pesticides and drugs. Some of the questions asked but not known by the neem users include the use of organic solvent for extraction, shelf-life of neem formulations, adverse residual effects of neem pesticides and tasks involved in registering a neem product.

In order to produce commercial neem-based pesticides, sophisticated procedures will be required. 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) submitted 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.

Useful innovative information for neem users in crop protection include genetic improvement of neem trees for their enhanced agronomic traits and bioactive ingredients; standardized means of isolating, purifying and characterizing bioactive principles in neem, and assessment of their efficacy. Others are formulation of neem materials into different products, their packaging, storage and marketing strategies; improved neem application procedures and eventual registration of the product.

CHALLENGES AND IMPROVEMENT OF NEEM BIOPESTICIDE UTILIZATION

Establishment of quality standards for neem products involves numerous interwoven practical, scientific and legal issues. There has been lack of coordinated research directed towards the development and validation of neem bioassays through the demonstration of correlation between *in vitro* and field pesticidal efficacy. Infrastructures such as specialized research laboratory and storage facilities for neem raw materials and products are inadequate. Thus it has been very difficult to analyse the quality and quantity of active ingredients in local neem or increase the potency lifespan of neem pesticide. There is need for collaboration with the Government agencies such as National Agency for Food and Drug Administration (NAFDAC), Standard Organization of Nigeria (SON) and the farmers.

Standard formula of extraction technique of crude, semi-purified or purified neem pesticidal products is lacking but should be originated and introduced in order to produce a more consistent botanical pesticide in the area under review. Proper identification of neem products used as biopesticide is imperative. This requires the use of validated methods that will reliably discriminate the presence of substitutes, contaminants, or and adulterants. There is need for a written macroscopic and microscopic descriptions and Thin Layer Chromatography, HPLC (High Performance Liquid Chromatography) and NMR (Nuclear Magnetic Resonance) facilities for characterizing and confirming the identity of neem powder or extracts from different parts of the plant or different geographical locations. Other emerging scientifically superior and high techniques for ensuring identity are capillary electrophoresis (CE) and DNA analysis.

Reference materials or authenticated standards are an essential prerequisite for any type of scientific assessment of botanical pesticide in order to obtain accurate identity and purity testing. However, potential issues in the selection and use

of standards which might be natural active ingredient or synthetic prototype are instability, special handling or storage requirements and their shelf-life. Economics might be an important factor, as the cost of these standards is often prohibitive for routine analysis.

In order to produce and use efficacious neem pesticide, the following points should be noted by the users:

- Neem leaf extracts are less effective than seed extracts due to lower azadirachtin content.
- Contaminated neem seeds with aflatoxin should not be picked from the ground but seeds that are greenish yellow in colour should be picked from the trees or swept regularly under the tree (Gunasena and Marambe, 1998)
- To avoid reduction in bioefficacy, 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 preparations should 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.
- Organic solvent such as methanol and ethanol have been found to extract the active ingredients better than water. Gahukaar (2006) reported that limnoids is generally being highly soluble in alcohol such as methanol or ethanol. The extracted, purified bioassay guided limnoids could be added to inert compounds to produce a neem product with a known stable azadirachtin concentration. World wide, there are over 100 commercial neem formulations (Yaradua, 2007), but only very few are awaiting registration in Nigeria.

FUTURE PROSPECTS

Available in the reviewed area are Sheda Science complex (SHESCO) with natural products and biotechnology facilities in Kwali Abuja, scientific laboratories and herbarium in National Pharmaceutical Research Institute (NIPR) Idu-Abuja, and not less than 10 science and technological-oriented Universities. If these assets are duly explored and exploited, it will boost neem products research and utilization in Nigeria. For instance, standard measure of pesticidal efficacy of neem product could be achieved through gene chip technology in SHESCO, Abuja. Other facilities required include authenticated herbarium voucher specimens such as the one in NIPR Idu-Abuja which is currently richer in medicinal rather than pesticidal plants. Prepared microscopic slides of raw and refined neem sample and electronic inventory of herbal (neem) reference materials could be created.

It is imperative that commercial neem formulations should be produced and made available for use instead of the current crude neem preparation that is in use in the area under review. Crude formulations often degrade rapidly thus it must be applied frequently and precisely. Certified commercial neem pesticide might on the long run involve minimum labour requirements and can be formulated for stability under ultraviolet rays. Care should however be taken to ensure its even distribution, unrestricted availability, its high quality so that it will get to the farmers at the most affordable rate.

To enhance utilization of neem for crop protection in Nigeria especially in North central zone, the following recommendation should be noted: Two or more plant parts or species could 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 could include synergist such as PBO (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 offering training for farmers and experts in these techniques. 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 and around the farms; develop and promote improved processing, formulation and marketing of plant pesticides and carry out training to increase NGOs/extension organizations capacity to promote plant pesticide for crop protection among the farmers. Sasakawa Global 2000 has started something in this direction (Jaryrum et al., 2001); others are encouraged to improve on it.

Fundamental political and financial support is needed to establish the infrastructure and to conduct the necessary research and development of neem biopesticide in Nigeria. 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.

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