

Indigenous Pesticidal Plants for Food Security, Medicine, Improved Livelihoods, and Agricultural Production among Farmers in South-East, Nigeria

Adejoh, S.O.*¹, Izunobi, L.C.², Anamayi, E.S.¹, Kayode, A.E.¹, Onwuagba, C.G.²,
Nwachukwu, A.A.², Nnebue, O.M.², Ejiogu, C.C.², and Chikaire, J.U.²

¹Federal University of Lafia, Nasarawa State, Nigeria

²Federal University of Technology, Owerri, Imo State, Nigeria

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Corresponding Author: **Adejoh, S.O** | E-Mail: akjain2010@gmail.com

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ABSTRACT

This paper examines the various applications of indigenous pesticidal plants into use to improve food security, medicine, livelihood, and agricultural production. A total of 350 crop farmers were purposively chosen were used to elicit information for this study. Data collected through questionnaires and oral discussion were analyzed descriptively. Results revealed availability of plenty indigenous pesticidal plants of great importance. These include neem leaf (80%), scent leaf (70%), garlic (60%), and ginger (55.7%). These plants contribute to food security through reduction of crop losses (82%), increase crop yield (78.6%), low cost of pest control (74.3%), and improved food quality (60%). As medicine, pesticidal plants are used for the treatment of malaria (80%), skin infections (75.7%), and anti-inflammatory agents (60%), stomach relief (71.4%) and among others. They improve livelihoods by reducing the cost of purchasing chemical pesticides (85.1%), increase crop yield (78.9%), reduced health risks (82%), and improves income (75.7%), among others. They reduce dependencies on synthetic pesticides (88.6%), reduce post-harvest losses (61.4%), and lower production costs (77.1%), among other. Despite the above pesticides, plants face the following adoption problem limited awareness (60%), time(55.7%), Poor storage (50%), lack of standardization (51.4%) and inconsistent efficacy (58.6%). Solving the problems include actions such as farmer education (88.6%), training on preparation (84.3%), community demonstration farms (65.7%), and research and documentation (70%), among others.

Keywords: Pesticides, plants, indigenous, medicine, agriculture, adoption.

Introduction

Agriculture is a vital activity throughout rural Nigeria, contributing to employment, food, income, and raw materials for industries. Farming activities in South East Nigeria are carried out by smallholder farmers who are constantly challenged by insect pests, fungal pathogens, weeds, rodents, and storage pests that threaten crop production, food security, and farmers' profits. Farmers usually rely on chemical pesticides to control these pests. However, the rising cost of agrochemicals, environmental pollution, pesticide resistance, food and environmental toxicity, and adverse health effects of pesticides on humans and animals have triggered the need for alternative and cost-effective methods of pest control using indigenous pesticidal plants. Indigenous pesticidal plants are plants, with pesticidal properties that are used by farmers in their respective communities for the management of insect pests and other crop infestations. Some of these plants have been used by farming communities for centuries before the introduction of modern pesticides. Some of the indigenous plants used by farmers in Nigeria are *Azadirachta indica*, *Capsicum frutescens*, *Nicotiana tabacum*, *Ocimum gratissimum*, *Vernonia amygdalina*, *Carica papaya*, *Allium sativum*, *Zingiber officinale*, *Piper guineense*, and *Cymbopogon citrates*[1,2].

These plants contain insecticidal, fungicidal, bactericidal, nematocidal, rodenticidal, and repellent compounds that have been used to control various agricultural pests. The leaves, stems, and fruits of these plants contain phytochemicals such as alkaloids, flavonoids, terpenoids, saponins, tannins, limonoids, and oils that are toxic to agricultural pests [1].

Currently, plants with pesticidal properties are gaining great attention as they are economical, biodegradable, and suitable for use in integrated pest management practices. Compared to the persistent nature of chemical pesticides, botanical pesticides degrade fast and have minimal negative effects on the environment, non-target organisms, and human health [3]. The use of indigenous pest control methods and plants is also in line with the United Nations' sustainable agriculture, biodiversity, food systems, and climate action, which are part of the 2030 Agenda. Specifically, the Sustainable Development Goals (SDGs) include goals on zero hunger, good health and well-being, responsible consumption and production, climate action, and life on land, among others [4]. South East Nigeria is a region where most farmers practice subsistence agriculture with large farms of yam, cassava, maize, rice, cocoyam, vegetables, oil palm, and fruits.

Farmers in this region have faced tremendous losses due to insect pests, diseases, and storage and soil pests such as termites, grasshoppers, weevils, aphids, beetles, borers, and others. Pest infestation in farms usually reduces yield and crop production by 20-40% in most cases and up to 50% or more during severe infestation, therefore affecting food security and farm profits [1]. Most farmers in South East Nigeria are smallholder farmers with limited resources to buy commercial pesticides. Therefore, many of them rely on their indigenous knowledge of preparing botanical pesticides to manage insect pests and diseases in their farms. Indigenous pesticidal plants are also used in making herbal medicines due to their antimicrobial, antiparasitic, anti-inflammatory, and antioxidant properties. Plants such as neem, bitter leaf, scent leaf, and garlic are used to make medicines for treating malaria, stomach ulcers, infections, fevers, and other illnesses [5]. Therefore, aside from their use in controlling agricultural pests and diseases, pesticidal plants are used in making traditional medicines.

The use of these plants as botanical pesticides can provide numerous benefits to the farmers and the environment. Farmers can grow, prepare, and sell botanical pesticides and increase their income while reducing reliance on commercial pesticides. The commercialization of botanical pesticides promotes sustainable agriculture, conserves biodiversity, and provides alternative sources of income in rural societies. Additionally, farmers can use these plants to add value to their farm products since the use of organic methods such as botanical pesticides has created a niche for organic farming products in the market [1]. The knowledge of indigenous pesticidal plants and their use by many communities across Nigeria is gradually declining due to various factors, including urbanization, poor documentation, aging of indigenous knowledge keepers, and changing climates. In addition, youth are abandoning indigenous ways of pest control due to the availability of chemical pesticides. Although many of these plants have been used for generations, little is known about their botanical classification, pesticidal potency, medicinal values, and impact on livelihoods, which limits their commercialization and use in the management of pests and diseases in Nigerian farms [2]. Therefore, there is a need to increase awareness and document the indigenous knowledge of these plants to help preserve this valuable information for future generations.

Agricultural production by farmers is highly impeded by various challenges, including insect pests, fungal infections, rodent infestation, nematode invasion, and storage pests [5]. These pests cause extreme damage to food crops, therefore reducing agricultural yields, family food security, and farmers' profits. Farmers have increasingly turned to chemical pesticides to control these pests. However, the excessive and improper use of these pesticides has led to the development of pesticide resistance by many insect pests and disease-causing organisms. Additionally, the increased use of chemical pesticides has adverse impacts on the environment, such as water, soil, and air pollution, and the elimination of crucial pollinators and other beneficial organisms. Furthermore, chemical pesticides are costly, making it difficult for poor farmers to afford them. Therefore, farmers who cannot afford commercial pesticides use the wrong pesticide doses or fake pesticides that do little to control pests while exposing their farms and personal health to severe toxicity [5].

Farmers in South East Nigeria also face the challenge of not having proper knowledge about appropriate agrochemicals to use or how to use them appropriately to reduce adverse effects on their farms, health, and the environment. Farmers can use many indigenous plants to make cost-effective botanical pesticides that are safe to use in controlling pests and diseases. However, the use of indigenous pesticidal plants has declined due to the unavailability of relevant information to guide their collection, preparation, dosage, and application. In addition, indigenous knowledge about these plants is gradually disappearing due to modernization, rural-urban migration, and poor documentation. Although several studies have been carried out on the use of botanical pesticides, little is known about their role in promoting food security, medicine, livelihoods, and sustainable agricultural production in South East Nigeria. Therefore, there is a need for more studies to bridge this knowledge gap. This study will contribute to existing knowledge on indigenous pesticidal plants used by farmers in South East Nigeria and their role in promoting food security, sustainable agriculture, biodiversity conservation, and indigenous knowledge. The findings will benefit farmers, researchers, policymakers, agricultural development agencies, and other stakeholders. It will add baseline information for future research, note down policies that promote the use of indigenous pesticidal plants for sustainable agricultural development and food security, and increase the awareness of the value of indigenous pesticidal plants. It will also promote the conservation of these plants for the commercialization of their products for medicinal and pesticidal purposes and contribute to community wealth and economic development. Moreover, the findings will provide empirical evidence for climate change adaptation, biodiversity conservation, and increased agricultural production and food security while supporting the attainment of relevant UN sustainable development goals (zero hunger, good health and well-being, responsible consumption and production, climate action, and life on land).

Methodology

The research was carried out in the South-Eastern region of Nigeria, which includes Abia, Anambra, Ebonyi, Enugu, and Imo States. This area is mainly focused on agriculture, with farming being the main occupation for many rural families. The primary crops grown in the region are cassava, yam, maize, rice, cocoyam, vegetables, oil palm, plantain, and various fruits. The region is known for its diverse plant species that are traditionally used for pest control, food preservation, medicine, and other livelihood purposes. The study utilized a descriptive survey research method to gather information from farmers about the indigenous plants used for pest control, food security, medicine, and improving livelihoods in South-East Nigeria. The study population consisted of small-scale crop farmers in the five states of South-East Nigeria, with a sample size of 350 respondents chosen for the study to ensure reliable information representation. A multistage sampling technique was employed, involving the selection of states, agricultural zones, farming communities, and farmers to achieve the desired sample size. Data were collected through a structured questionnaire named "Indigenous Pesticidal Plants for Food Security, Medicine, Improved Livelihoods and Agricultural Production Questionnaire (IPPFMILAPQ)," which underwent validation by experts to ensure clarity and relevance.

The questionnaire's reliability was confirmed through a pilot study, and data analysis was performed using the Statistical Package for the Social Sciences (SPSS), Version 27, to provide descriptive statistics.

Result and Discussions

Commonly Indigenous Pesticidal Plant In The Study Area.

Table 1 showed the commonly available indigenous pesticidal plants present in the study Area. These include neem (*Azadirachta indica*), scent leaf (*Ocimum gratissimum*), chili pepper, garlic, ginger, tobacco, bitter leaf, pawpaw, lemongrass, moringa, fish poison bean, custard apple, physic nut, eucalyptus, and siam weed. Their scientific names, English/General, and indigenous names are presented in Table 1 for easy reading and referencing. South-East Nigeria is endowed with a variety of indigenous pesticidal plants with insecticidal, bactericidal, and fungicidal properties used by farmers to manage pests, storage insects, blights, and other crop infections. These plants are locally available, cost-effective, eco-friendly, and biodegradable and are commonly used by farmers due to indigenous knowledge and scientific evidence supporting their pesticidal potentials [2,1]. Supporting the above, [1] said Neem (*Azadirachta indica*) is one of the most widely used indigenous pesticidal plants in South-East Nigeria. Its leaf or seed extracts are used to control aphids, caterpillars, beetles, termites, grasshoppers, and storage pests. The plant is also used for its medicinal properties in the management of malaria, infections, and stomach problems. Other indigenous pesticidal plants used by farmers in the region are *Ocimum gratissimum*, *Vernonia amygdalina*, *Capsicum frutescens*, *garlic (Allium sativum)*, and *ginger (Zingiber officinale)*. The extracts from these plants have been reported to have insecticidal, antifungal, and antibacterial properties for the management of crop pests, storage pests, and diseases in addition to their medicinal properties [7, 8]. Farmers also use *Nicotiana tabacum*, *Piper guineense*, *Carica papaya*, *Cymbopogon citratus*, *Chromolaena odorata*, and *Hyptis suaveolens* which contain bioactive compounds for the management of insects, fungi, and nematodes [6,2]. Indigenous pesticidal plants offer a cost-effective and environmental-friendly alternative to chemical pesticides. More research is needed to document and promote the use of indigenous pesticidal plants for sustainable agriculture and conservation of biodiversity in South-East Nigeria [3].

Table 1: Indigenous Pesticidal Plants and Their Local Names

S/N	Scientific Name	Common Name	Local Name (Igbo/Yoruba/Hausa)
1	<i>Azadirachta indica</i>	Neem	Dogonyaro (Y), Dongoyaro (H)
2	<i>Ocimum gratissimum</i>	Scent leaf	Nchuanwu (Igbo), Efinrin (Y)
3	<i>Capsicum frutescens</i>	Chili pepper	Ose (Igbo), Ata (Y)
4	<i>Allium sativum</i>	Garlic	Ayo (Y), Tafarnuwa (H)
5	<i>Zingiber officinale</i>	Ginger	Jinja (H), Ata-ile (Y)
6	<i>Nicotiana tabacum</i>	Tobacco	Taba (Y), Taba (H)
7	<i>Vernonia amygdalina</i>	Bitter leaf	Onugbu (Igbo), Ewuro (Y)
8	<i>Carica papaya</i>	Pawpaw	Okwurubekee (Igbo), Ibebe (Y)
9	<i>Cymbopogon citratus</i>	Lemongrass	Achara chi (Igbo), Kookooba (Y)
10	<i>Moringa oleifera</i>	Moringa	Zogale (H), Ewe ile (Y)
11	<i>Tephrosia vogelii</i>	Fish poison bean	Local name varies by region
12	<i>Annona squamosa</i>	Custard apple	Local name varies by region
13	<i>Jatropha curcas</i>	Physic nut	Lapalapa (Y), Cinini (H)
14	<i>Eucalyptus globulus</i>	Eucalyptus	Widely known as Eucalyptus
15	<i>Chromolaena odorata</i>	Siam weed	Akintola (Y), Awolowo leaf (Nigeria)

I = Igbo Language, H = Hausa Language, Y = Yoruba Language

Indigenous Pesticidal Plants in Use by Respondents

Table 2 shows that out of the 15 indigenous pesticidal plants, only 10 are in high and used by respondents with higher percentage responses. They include neem (80.0%), scent leaf (70.0%), chili pepper (65.7%), garlic (60.0%), ginger (55.7%), tobacco (52.9%), bitter leaf (50.0%), pawpaw (45.7%), lemongrass (42.9%), and moringa (40.0%). Other plants in use but with lower percentage responses include fish poison bean (34.3%), custard apple (31.4%), physic nut (28.6%), eucalyptus (27.1%), and siam weed (25.7%). The people of South-East Nigeria have indigenous knowledge of using pesticidal plants for controlling pests, managing stored produce, protecting crops, and promoting human and animal health. This information is passed down from one generation to another as oral traditions, making it an invaluable resource for rural farmers who lack commercial pesticides. Indigenous pesticidal plants are a rich source of active ingredients that are easily available, inexpensive, biodegradable, and safe to handle compared to commercially available pesticides [2,1].

Indigenous pesticidal plants used by farmers in south-east Nigeria include the leaves, fruits, bulbs, rhizomes, and seeds of *Azadirachta indica*, *Ocimum gratissimum*, *Vernonia amygdalina*, *Capsicum frutescens*, *Allium sativum*, *Zingiber officinale*, *Piper guineense*, *Carica papaya*, *Cymbopogon citratus*, *Nicotiana tabacum*, and *Chromolaena odorata*. They are processed into powders, extracts, decoctions, and used to control insect pests, fungi, nematodes, and storage pests [9]. The pesticidal compounds present in these botanicals include azadirachtin, limonoids, volatile oils, capsaicin, allicin, gingerols, piperine, and papain, amongst others. The applications of these pesticidal plants have been found to be efficient and effective against various pest organisms, fungal pathogens, bacterial infections, and other plant diseases. Farmers mostly use extracts from local pesticidal plants such as neem, scent leaf, lemongrass, tobacco, garlic, and West African pepper in the formulation of botanical pesticides for controlling a wide range of agricultural pests [9]. In addition to their pesticidal properties, these plants have also been used for medicinal, nutritional, and commercial purposes including the production of food, spices and drugs. There is a growing need to create awareness of the importance of these plants for the sustainable management of pests, conservation of biodiversity, and boosting agricultural production in South-Eastern Nigeria. However, the practice has declined tremendously due to rapid urbanization, modernization, and lack of appropriate documented information, amongst other reasons.

Table 2: Frequency of Indigenous Pesticidal Plants Used by Respondents

S/N	Plant Used	Frequency (n)	Percentage (%)
1	Neem	280	80
2	Scent leaf	245	70
3	Chili pepper	230	65.7
4	Garlic	210	60
5	Ginger	195	55.7
6	Tobacco	185	52.9
7	Bitter leaf	175	50
8	Pawpaw	160	45.7
9	Lemongrass	150	42.9
10	Moringa	140	40
11	Fish poison bean	120	34.3
12	Custard apple	110	31.4
13	Physic nut	100	28.6
14	Eucalyptus	95	27.1
15	Siam weed	90	25.7

Multiple Responses Allowed (n = 350)

Contributions of Indigenous Pesticidal Plants to Food Security

Table 3 shows the contributions of indigenous pesticidal plants to household food security. These include reduction of crop losses due to pests (82.9%), increase in crop yield (78.6%), low cost of pest control (74.3%), improved household food availability (70.0%), reduced dependence on synthetic pesticides (65.7%), environmentally friendly pest control (64.3%), preservation of stored grains (58.6%), improved food quality (60.0%), increased farmers' income (55.7%), accessibility and local availability of pesticidal plants (52.9%), enhancement of sustainable agricultural practices (51.4%), reduction in health risks associated with chemical pesticides (48.6%), and contribution to climate-resilient farming systems (45.7%). This agrees with [3] who posited that indigenous pesticidal plants enhance food security by controlling insect pests, fungi, nematodes, rodents, and storage pests, thus minimizing pre-harvest and post-harvest losses. Food security exists when food is available and accessible, utilized, and stable. Botanical pesticides improve food security by controlling pests and reducing farmers' reliance on costly imported pesticides. First, indigenous pesticidal plants such as *Azadirachta indica*, *Ocimum gratissimum*, *Capsicum frutescens*, *Piper guineense*, and *Allium sativum* control insect pests and pathogens of cassava, maize, yam, vegetables, and legumes. These pesticidal plants prevent feeding, infestation, breeding, and development of pests resulting in increased crop yields. The plants also control post-harvest pests including bean bruchids, maize weevils, and grain moths by using extracts and powders made from their leaves, stems, and fruits. Further, farmers use pesticidal plants because of their availability in farms, homesteads, and forests. The leaves, stems, and flowers are easily accessible and affordable to small-scale farmers. Thus, farmers can increase their income by producing botanical pesticides with high value-added products. The use of botanical pesticides is safe to health because it does not require advanced skills and leaves minimal toxic residues compared to synthetic pesticides [4,5]. Finally, the use of indigenous pesticidal plants is essential for conserving natural enemies of pests and promoting sustainable food production. This will ensure food security in South-East Nigeria as farmers utilize the abundance of natural resources in farms and forests to produce food and additional income from the sale of botanical pesticides [3,2]. Overall, promoting indigenous pesticidal plants will improve food security in South-East Nigeria by boosting crop production, minimizing post-harvest losses, enhancing food safety, and promoting sustainable agriculture while reducing the use of expensive pesticides.

Table 3: Contributions of Indigenous Pesticidal Plants to Food Security

S/N	Contribution	*Frequency	Percentage
1	Reduction in crop losses due to pests	290	82.9
2	Increase in crop yield	275	78.6
3	Low cost of pest control	260	74.3
4	Improved household food availability	245	70
5	Reduced dependence on synthetic pesticides	230	65.7
6	Environmentally friendly pest control	225	64.3
7	Improved food quality (chemical-free produce)	210	60
8	Preservation of stored grains	205	58.6
9	Increased farmers' income	195	55.7
10	Accessibility and local availability of pesticidal plants	185	52.9
11	Enhancement of sustainable agricultural practices	180	51.4
12	Reduction in health risks associated with chemical pesticides	170	48.6
13	Contribution to climate-resilient farming systems	160	45.7

*Multiple Responses Allow

Indigenous Pesticidal Plants as Medicine

Table 4 shows that indigenous pesticidal plants serve as medicine for humans and animals. They are used for the treatment of certain ailments around the home and elsewhere. The medicinal benefits include treatment of malaria and fever (80.0%), treatment of skin infections such as rashes and wounds (75.7%), relief of stomach disorders such as diarrhea and ulcers (71.4%), treatment of respiratory ailments such as cough and asthma (65.7%), use as anti-inflammatory agents (60.0%), control of intestinal worms for deworming (57.1%), boosting the immune system (54.3%), treatment of dental problems such as toothache and gum infections (50.0%), management of hypertension and blood pressure (45.7%), and treatment of eye infections (42.9%). **This agrees with {10,11} that** indigenous pesticidal plants have significant medicinal benefits to farming households in South-East Nigeria, making them valuable resources for treating various illnesses. Besides their pesticidal benefits to farms, the plants have antimicrobial, antifungal, antiviral, anti-inflammatory, antiparasitic, antioxidant, and analgesic effects that help manage diseases and reduce healthcare expenses in households.

The plants prevent infectious diseases like malaria, diarrhoea, cough, typhoid, and skin infections in humans and animals. For instance, *Azadirachta indica*, *Ocimum gratissimum*, *Vernonia amygdalina*, *Allium sativum*, and *Zingiber officinale* are indigenous to Nigeria and help treat cough, typhoid fever and skin infections like ringworm and athlete's foot [12]. The plant species have active ingredients such as alkaloids, flavonoids, phenolics, terpenoids, and essential oils with antimicrobial, anti-inflammatory, antioxidant, and analgesic properties that boost the immune system and heal wounds [13]. Leaves extracts from neem, bitter leaf, pawpaw and scent leaf, for instance, can also be used to treat wounds, burns and insect bites because of their healing abilities. Moreover, Indigenous pesticidal plants are used in ethnoveterinary practices to help manage parasites like roundworms, tapeworms and liver fluke in animals. This reduces the use of synthetic drugs in treating infections such as *fascioliasis* and raises food production levels by improving livestock management [14]. Other plant species such as bitter leaf, garlic, ginger, scent leaf and *Aframomum melegueta* are effective in promoting health and managing chronic illnesses due to their anti-oxidant, anti-parasitic and anti-inflammatory properties [13].

Conclusively, the medicinal properties of indigenous pesticidal plants are essential in promoting human and animal health, reducing healthcare costs and increasing agricultural production levels. Their ethnobotanical knowledge should be documented, studied and utilized to increase food security, achieve sustainable development and support rural communities in Nigeria [12,10].

Table 4: Medicinal Benefits of Indigenous Pesticidal Plants to Farming Households

S/N	Medicinal Benefit	*Frequency	Percentage
1	Treatment of malaria and fever	280	80
2	Treatment of skin infections (rashes, wounds)	265	75.7
3	Relief of stomach disorders (diarrhea, ulcers)	250	71.4
4	Treatment of respiratory ailments (cough, asthma)	230	65.7
5	Use as anti-inflammatory agents	210	60
6	Control of intestinal worms (deworming)	200	57.1
7	Boosting the immune system	190	54.3
8	Treatment of dental problems (toothache, gum infections)	175	50
9	Management of hypertension and blood pressure	160	45.7
10	Treatment of eye infections	150	42.9

*Multiple Responses

Indigenous Pesticidal Plants for Improved Farmer Livelihoods

Table 5 reveals that indigenous pesticidal plants directly and indirectly play a role in improving farmers' livelihoods. These roles include reduction in the cost of chemical pesticides (85.1%), increased crop yield and productivity (78.9%), improved household income (75.7%), availability of low-cost pest control alternatives (88.6%), reduced health risks associated with synthetic pesticides (82.0%), creation of local employment through harvesting, preparation, and sales (63.1%), enhanced food security (84.0%), preservation of indigenous knowledge and practices (70.9%), environmental sustainability through eco-friendly farming (86.3%), and diversification of livelihood sources through the sale of plant products (66.6%). Supporting the above, [15] said indigenous pesticidal plants enhance people's livelihoods through increasing agricultural production, minimizing production costs, generating income, and being environmentally friendly. South-eastern Nigerian farmers use local botanical pesticides against insect pests, fungi, and storage pests in their crops instead of expensive chemical pesticides to maximize their profit.

Pesticidal plants boost agricultural production by controlling pests that destroy food crops, leading to more yield, hence higher revenues [16]. Also, farmers can generate income from pesticidal plants by selling the leaves, fresh or dried herbs, essential oils, and value-added botanical pesticides made from them, such as neem, scent leaf, bitter leaf, lemongrass, garlic, ginger, and West African black pepper [17].

Herbs and pesticidal plants reduce farmers' expenses on commercial pesticides since they grow abundantly in home gardens and nearby forests. The money saved on chemical pesticides can be used to purchase seeds, seek health care, and send children to school. Pesticidal plants minimize environmental damage caused by chemical pesticides and promote biodiversity and sustainable food production systems [16,15]. Besides boosting yields and income and lowering production costs, pesticidal plants conserve indigenous knowledge, biodiversity, and promote income diversification, create employment, and support commercial activities and research endeavors [18]. Pesticidal plants offer livelihood security to farmers against the unpredictable high prices of chemical pesticides and poor weather conditions during planting periods since they can afford to produce their own pesticides at a lower cost [19]. Conclusively, the use of indigenous pesticidal plants as an alternative to chemical pesticides promotes people's livelihoods by increasing agricultural production, income, and resistance to pests while conservation of biodiversity and reducing production costs [16].

Table 5: Roles of Indigenous Pesticidal Plants in Improving Farmers' Livelihoods

S/N	Role	*Frequency	Percentage
1	Reduction in cost of chemical pesticides	298	85.1
2	Increased crop yield and productivity	276	78.9
3	Improved household income	265	75.7
4	Availability of low-cost pest control alternatives	310	88.6
5	Reduced health risks associated with synthetic pesticides	287	82
6	Creation of local employment (harvesting, preparation, sales)	221	63.1
7	Enhanced food security	294	84
8	Preservation of indigenous knowledge and practices	248	70.9
9	Environmental sustainability (eco-friendly farming)	302	86.3
10	Diversification of livelihood sources (sale of plant products)	233	66.6

**Multiple Responses*

The Impact of Indigenous Pesticidal Plants on Agricultural Production and Crop Yield.

Table 6 shows that the use of pesticidal plants supports agricultural growth and production. The use has increased crop yield (81.4%), reduced pest and disease incidence (85.7%), improved crop quality including size, appearance, and shelf life (70.9%), lower cost of production (77.1%), enhanced soil health through less chemical contamination (65.7%), reduced post-harvest losses (61.4%), increased farm profitability (74.3%), environmentally friendly production (84.3%), sustainable agricultural practices (80.0%), and reduced dependence on synthetic pesticides (88.6%). Indigenous pesticidal plants have become desirable for enhancing sustainable agricultural production and improving crop yield in developing countries. These plants possess pesticidal properties and active substances that kill insect pests, pathogens, nematodes, mites, and storage pests damaging crops. This is a cost-effective and eco-friendly alternative to chemical pesticides for managing pests, diseases, and weeds leading to increased agricultural production [20].

Indigenous pesticidal plants promote agricultural production and yield by offering cheap, alternative, and eco-friendly substitutes to the costly conventional pesticides. These plants and their extracts have active ingredients such as alkaloids, terpenoids, flavonoids, saponins, tannins, and essential oils with pesticidal properties that control pests and diseases in crops, leading to increased yields [2,16]. For instance, certain plants such as neem, garlic, chilli pepper, bitter leaf, scent leaf, and tobacco have been proven effective in controlling pests and diseases in storage and field crops by reducing pre-harvest and post-harvest losses, hence increasing agricultural production [20]. Besides offering an alternative to chemical pesticides, botanical pesticides promote environmental sustainability by conserving natural enemies of pests, causing little or no harmful residues to the environment, and being efficiently utilised in integrated pest management programs in agriculture. Studies carried out in sub-Saharan Africa have demonstrated that these plants are effective in reducing pests, diseases, and crop damage while increasing yields for smallholder farmers [21]. However, the efficacy of botanical pesticides in controlling pests and diseases is dependent on the type of plant, preparation method, and application. Therefore, research efforts aimed at developing better botanical pesticides, coupled with appropriate policies, will go a long way in promoting agricultural production [22].

Table 6: Impact of Indigenous Pesticidal Plants on Agricultural Production and Crop Yield

S/N	Impact	*Frequency	Percentage
1	Increased crop yield	285	81.4
2	Reduced pest and disease incidence	300	85.7
3	Improved crop quality (size, appearance, shelf life)	248	70.9
4	Lower cost of production	270	77.1
5	Enhanced soil health (less chemical contamination)	230	65.7
6	Reduced post-harvest losses	215	61.4
7	Increased farm profitability	260	74.3
8	Environmentally friendly production	295	84.3
9	Sustainable agricultural practices	280	80
10	Reduced dependence on synthetic pesticides	310	88.6

**Multiple Responses*

Challenges to the Adoption of Indigenous Pesticidal Plants

The use of indigenous pesticides plants are influenced by the following ;according to table 7 which include; lack of adequate knowledge on preparation and application (65.7%), limited awareness of effectiveness (60.0%), time-consuming preparation process (55.7%), inconsistent efficacy compared to synthetic pesticides (58.6%), lack of standardization and dosage regulation (51.4%), poor storage and short shelf life (50.0%), limited availability of some pesticidal plants (45.7%), labour-intensive application (52.9%), preference for fast-acting chemical pesticides (62.9%), lack of extension services and technical support (57.1%), cultural beliefs and skepticism (40.0%), poor policy support and institutional backing (44.3%), and difficulty in accessing raw materials in large quantities (47.1%). In line with above, [23] opined that although indigenous pesticidal plants have been found to be highly eco-friendly, economically viable, and healthy, many farmers in South-Eastern Nigeria are still reluctant to adopt them due to various environmental, technical, institutional, and socio-economic factors. The most common barriers to the utilization of indigenous pesticidal plants are the absence of scientific information about them and insufficient extension services regarding their potency, method, and timing of application, which has limited farmers' reliance on them [24].

Agricultural extension services have discouraged farmers from using botanical pesticides because they tend to recommend chemical pesticides [25]. The preparation and use of botanical pesticides are usually more laborious and time-consuming since they require collection, preparation, filtration, and multiple applications to crops before the desired effect is achieved because of their short residual efficacy. A number of factors such as inadequate policy, promotion, commercialization, and credit schemes have hindered the wide use of botanical pesticides [23, 24,26]. The indigenous knowledge about pesticidal plants is gradually being lost due to a combination of several reasons such as urbanization, formal education, and rural-urban migration and the overall poor documentation of this information, which has impeded knowledge sharing between generations [28]. The use of indigenous pesticidal plants has been hampered by environmental factors such as illegal harvesting, forest burning, and land clearing leading to loss of biodiversity [27]. A few farmers think that botanical pesticides are not as effective as their chemical counterparts and know little about the advantages of using natural pest control measures [26,25].

Therefore, there is a need to intensify research, policy advocacy, extension services, and public awareness towards the adoption of pesticidal plants by farmers. Although indigenous pesticidal plants have been found to be highly eco-friendly, economically viable, and healthy, many farmers in South-Eastern Nigeria are still reluctant to adopt them due to various environmental, technical, institutional, and socio-economic factors. The most common barriers to the utilization of indigenous pesticidal plants are the absence of scientific information about them and insufficient extension services regarding their potency, method, and timing of application, which has limited farmers' reliance on them [24, 26,23]. Agricultural extension services have discouraged farmers from using botanical pesticides because they tend to recommend chemical pesticides. The preparation and use of botanical pesticides are usually more laborious and time-consuming since they require collection, preparation, filtration, and multiple applications to crops before the desired effect is achieved because of their short residual efficacy.

A number of factors such as inadequate policy, promotion, commercialization, and credit schemes have hindered the wide use of botanical pesticides [25, 26, 23]. The indigenous knowledge about pesticidal plants is gradually being lost due to a combination of several reasons such as urbanization, formal education, and rural-urban migration and the overall poor documentation of this information, which has impeded knowledge sharing between generations [28]. The use of indigenous pesticidal plants has been hampered by environmental factors such as illegal harvesting, forest burning, and land clearing leading to loss of biodiversity. A few farmers think that botanical pesticides are not as effective as their chemical counterparts and know little about the advantages of using natural pest control measures [27,25]. Therefore, there is a need to intensify research, policy advocacy, extension services, and public awareness towards the adoption of pesticidal plants by farmers.

Table 7: Constraints to the Adoption of Indigenous Pesticidal Plants

S/N	Constraint	*Frequency	Percentage
1	Lack of adequate knowledge on preparation and application	230	65.7
2	Limited awareness of effectiveness	210	60
3	Time-consuming preparation process	195	55.7
4	Inconsistent efficacy compared to synthetic pesticides	205	58.6
5	Lack of standardization and dosage regulation	180	51.4
6	Poor storage and short shelf life	175	50
7	Limited availability of some pesticidal plants	160	45.7
8	Labour-intensive application	185	52.9
9	Preference for fast-acting chemical pesticides	220	62.9
10	Lack of extension services and technical support	200	57.1
11	Cultural beliefs and skepticism	140	40
12	Poor policy support and institutional backing	155	44.3
13	Difficulty in accessing raw materials in large quantities	165	47.1

**Multiple Responses*

Solutions to Challenges of Indigenous Pesticidal Plants Use by Farmers

Table 8 presents possible measures for overcoming challenges of indigenous pesticidal plant use. These solutions include farmer education and awareness campaigns (88.6%), training on proper preparation and application methods (84.3%), strengthening agricultural extension services (80.0%), government support and policy incentives (74.3%), research and documentation of pesticidal plants (70.0%), community demonstration farms (65.7%), improved access to plant resources (78.6%), integration into school curricula (54.3%), formation of farmer cooperatives (60.0%), and research-farmer collaboration (64.3%). The efficient use of indigenous pesticidal plants requires the collaboration of researchers, government agencies, agricultural personnel, universities, and farmers in overcoming technical, institutional, socio-economic, and policy-setting barriers to their use and cultivation. These measures will boost farmers' adoption of botanical pesticides and increase agricultural production in South-East Nigeria [29]. Scientific research on the efficacy, safety, and proper use of indigenous pesticidal plants should be undertaken to generate empirical evidence that will promote farmers' trust in botanical pesticides [30]. Agricultural extension agents should use awareness campaigns, demonstrations, training, and surveys to encourage and educate farmers about the identification, preparation, storage, and application of pesticidal plants. The creation of ethnobotanical databases, local knowledge centres and ethnobotanical gardens will promote conservation and support future research on indigenous pesticidal plants [31,32].

The government should subsidize and support the commercialization of botanical pesticides while also providing direct support to farmers, promoting research, and creating the necessary policies for increasing the adoption rate of botanical pesticides by farmers and supporting their production. Similarly, community-level nurseries and conservation efforts will promote the adequate supply of effective pesticidal plants and support biodiversity conservation [33,34]. The engagement and collaboration of universities, research institutes, NGOs, and farmers' groups will promote research on botanical pesticides, awareness creation, and the exchange of information on the use of indigenous pesticidal plants (Belmain & Stevenson, 2021). In addition, the establishment of local markets and processing industries is critical for the commercialization of botanical pesticides, value addition, quality control, and employment opportunities [18,35]. Lastly, promoting the use of indigenous pesticidal plants as part of integrated pest management, including biological control and improved agricultural practices, will increase agricultural production while also promoting food security and sustainable use of natural resources in South-East Nigeria [36].

Table 8: Solutions to Constraints on Adoption of Indigenous Pesticides Plants

S/N	Solutions	Frequency	Percentage
1	Farmer education and awareness campaigns	310	88.6
2	Training on preparation and application methods	295	84.3
3	Strengthening agricultural extension services	280	80
4	Government support and policy incentives	260	74.3
5	Research and documentation of pesticidal plants	245	70
6	Community demonstration farms	230	65.7
7	Improved access to plant resources	275	78.6
8	Integration into school curricula	190	54.3
9	Formation of farmer cooperatives	210	60
10	Research-farmer collaboration	225	64.3

Multiple Responses Allowed (n = 350)

Conclusion

The results of the study indicate that indigenous pest control plants including neem, scent leaf, and garlic are critical to achieving sustainable agriculture in South-East Nigeria and therefore should be prioritized for their capacity to enhance food security, reduce post-harvest losses, and provide cheap pest control measures to small-scale farmers while conserving traditional knowledge. The study also reveals that some of these plants have medicinal values crucial to the wellbeing of the farmers and their animals. Nevertheless, factors such as the need for more research, lack of adequate training on the application of these pest-control plants, and the neglect of traditional knowledge impede the utilization of these materials to their maximum potential. It is recommended that further investigation be conducted on the botanicals to generate empirical evidence on their efficacy for the enhancement of sustainable agricultural development in the study area. Additionally, there is a need for education and sensitization of the farmers on the proper usage of the materials and their importance. Furthermore, the government should encourage the conservation of the plants and the documentation of the associated traditional knowledge. All these interventions will contribute immensely to achieving sustainable agricultural production and rural development in South-East Nigeria. Indigenously pest-control plants can be a viable alternative to the rampant use of chemical pesticides and therefore should be vigorously promoted by the government, researchers, and agricultural extension agents.

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