Use of Botanicals plant for stored grain pest management: A critical review

Abstract

The current paper has been studied to understand the significance of various plant products (botanicals) against storage insect pests of seeds and grains. Grain storage is critical in agriculture for the next generation and food security. Insect pests are economically relevant among the several biotic and abiotic elements that impact the fate of grains during storage because they cause significant loss. The expanding demands of the world's growing population can be met by lowering or eradicating the insect pest population while storing. The most damaging storage insect pests are Sitotrogacerealella, Sitophilus sp., Rhyzopertha Dominica, Trogoderma granarium, Tribolium sp., Callosobruchus sp., and others. Insect damage includes the ingestion of seed, exuviae debris, webbing, and cadavers, rendering the grain unfit for human consumption and reducing both quality and quantity. They manipulated the storage environment, resulting in the formation of hotspots that are conducive to the spread of storage fungi and other dangerous microflora. Conventionally, we use synthetic pesticides to manage various insect pests that are hazardous to the environment and ecosystem in a variety of ways, including the elimination of natural enemies, insect resistance and resurgence, making soil, water, and air sick, and having residual effects that cause various disorders or diseases in animals and humans. Botanicals such as neem (Azadirachta indica), Bach (Acorus calamus), phoolakri (Lantana camara), draik (Melia azadarach), kali mirch (Piper nigrum), and basuti (Adhatodazeylanica) are biodegradable, non-residual, equally effective, and widely available etc. may show to be a superior solution for controlling insect pests, particularly storage pests, without impacting grain or seed quality or harming our ecology or environment. Thus, botanicals can be used alone or in conjunction with IPM to manage insect pests.

Keywords: pest management, Botanicals, stored grain

Introduction

Storage of grains and seeds is critical in agriculture for starting a new life as well as for food security. The quality of grains and seeds during storage is affected by several factors, including crop or variety, original seed quality, storage conditions, seed moisture content, insect pests, bacteria, and fungi. Among these factors, insects contribute significantly to total loss. Total agricultural crop productivity in India is 3 tonnes/ha, compared to the global average of 4 tonnes/ha, with loss due to insect pests accounting for around 26% and food grain accounting for 20-25% damage by storage insect pests, which is truly mind-boggling. Angoumois grain moth (Sitotrogacerealella), maize/rice weevil (Sitophilus oryzae), lesser grain borer (Rhyzoperthadominica), khapra beetle (Trogoderma granarium), rust-red flour beetle (Triboliumcastaneum), legume weevil (Callosobruchus sp.), and other storage insect pests are the most damaging.

The need for grains and other agricultural products is increasing as the population grows, and we can meet some of that demand by reducing storage bug pest losses. Grain damage owing to inadequate storage facilities and damage caused by stored grain insect pests during storage, shipping, and transportation is a major issue in Southeast Asia and around the world, particularly in developing countries. Insect pests not only harm grain, but they also reduce the weight and quality of stored grains. Insect damage includes direct ingestion of kernels, exuviae detritus, webbing, and cadavers, rendering the grain unfit for human consumption and reducing quality and quantity. Insect infestations have manipulated the storage environment, resulting in the formation of hotspots that are conducive to the expansion of storage fungi and other dangerous microflora. Pest control technique today is mostly reliant on synthetic insecticides. Synthetic insecticides were first used in India following the Green Revolution. In India, insecticides account for 65% of all pesticides applied. Pesticides and related issues have remained a hot topic in the media, debates, and research. for a few decades The various problems associated with currently used synthetic pesticides, such as residual effects, pest resurgence, prevalent environmental and ecological hazards, insect pest resistance, and farmer economy, have led us to botanicals that are environmentally friendly, biodegradable, economical, and equally effective. Furthermore, if grains are to be preserved for food purposes, pesticides might be harmful or fatal. Plant extracts, such as aqueous or organic solvent extracts, are employed as product protectants in several countries. As a result, these plant products can be used alone or as part of an integrated pest management strategy.

Furthermore, since the invention of pesticides, botanicals have been overlooked, with research and development focusing on synthetic pesticides. As a result, further research is needed to explore and exploit botanicals for pest management.

Importance of botanicals in integrated pest management

Pest management, including postharvest infestation, is now a successful and widely accepted strategy through integrated pest management (IPM). The IPM technique, which emphasizes the judicious use of non-chemical means (botanicals, light traps, natural enemies) and selective synthetic applications, is a very efficient way to prevent the development of resistance. Integrated pest management refers to the prudent and effective use of existing resources (natural or synthetic) for pest control without jeopardising the ecological balance. Extensive use of synthetic pesticides should be avoided or combined with botanicals as part of IPM to manage insect pests. Insecticidal plant extracts offer a broad spectrum of action and are simple to manufacture on the farm using locally accessible materials. Sitophilus oryzae, S. Zeamais, Callosobruchus chinensis, C. maculates, Triboliumcastaneum, Rhizoperthadominica, Trogoderma granarium, and other significant botanicals for controlling or suppressing numerous store insect pests. Botanicals are swiftly transformed into innocuous metabolites, do not contribute to the development of hereditary conflict in targeted pests, and are less harmful to other beneficial organisms. As botanical activity differs across geographical locations, different botanicals can be employed effectively to cure grains depending on location, even with variances in storage durations and circumstances. Based on the findings of several researchers, we can conclude that botanicals can be employed effectively in the integrated pest management (IPM) plan.

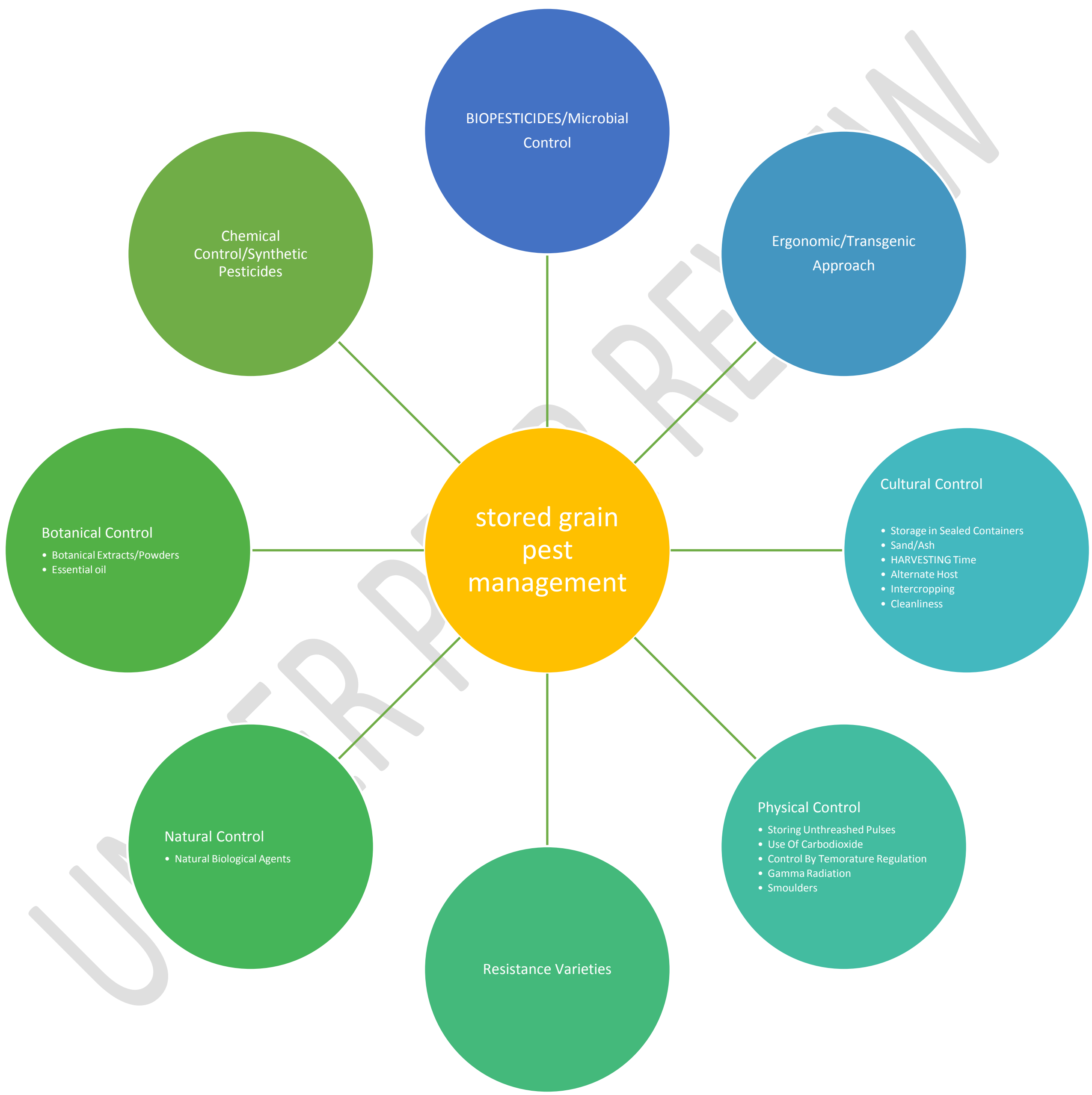

Fig 1. Pest management practices for stored grain pests.

The effect of botanical biopesticides on seed quality

Seed quality is determined by a variety of biotic and abiotic factors such as genotype, seed moisture content, storage conditions, and pests such as fungi, bacteria, insects, and so on. The viability and health of the seeds are most crucial when keeping them for sowing in the following season or year. Maintaining seed quality during storage is critical for optimal crop production and maintaining the integrity of seeds that are vulnerable to the unpredictability of genetic erosion. Infestation of seeds by storage insect pests reduces viability and vigour, negatively influencing germination. Various studies' findings revealed that botanicals had no negative impact on seed quality. Seed quality is determined by biotic and abiotic factors such as genotype, seed moisture content, storage conditions, and pests such as fungi, bacteria, insects, and so on. The viability and health of the seeds are most crucial when keeping them for sowing in the following season or year. Maintaining seed quality during storage is critical for optimal crop production and maintaining the integrity of seeds that are vulnerable to the unpredictability of genetic erosion. Infestation of seeds by storage insect pests reduces viability and vigour, negatively influencing germination. Various studies' findings revealed that botanicals had no negative influence on grain or seed quality. Thus, botanicals can be used alone or in conjunction with IPM to manage insect pests.

Types of Botanicals Used in Food Storage Protection

Botanicals are plants or plant-derived items that contain active compounds that can be used to manage storage pests. These are spices, as well as medicinal and other plants.

Spices: In addition to flavoring foods, spices have been used since ancient times to protect stored goods from pests. Traditionally, pieces of dried spices or ground spices were sprinkled over or mixed with stored meals, but extracts or oils have recently been explored with promising results.

Medicinal and Other Plants: Other than spices, numerous botanicals have been employed to battle stored pests. Among these are medical plants, which are generally used to treat human illnesses but can also be used to safeguard stored food; others are plants that have been shown to have anti-storage pest effects. All of the plants' leaf extracts (Prosophis sp., Nerium sp., Ocimum sp., Acalypha sp., Catharanthus sp., and Vitex sp.) had a strong ovipositional deterrent effect on the pulse beetle.

The leaf extract of Vitex sp. caused the greatest loss in egg viability (61.7%), followed by Catheranthus sp. leaf extract (56.7%).Vitex sp treated seeds at 5% level induced the greatest reduction in adult emergence (85.0%), followed by Catheranthus sp. (83.7%), Acalypha sp. (73.3%), Nerium sp. (70.0%), Ocium sp. (68.7%), and Prosphis sp. (68.0%).Plant powders of A.mexicana, P. juliflora, and T. purpurea were investigated for repellent efficacy against T. castaneum. In general, all of the plantpowders were repellant. Bean seeds treated with pyrethrum outperformed other treatments in terms of the number of holes per seed, the percentage of damaged seeds, and weight loss. Garlic outperformed no pesticide application treatment in terms of number of holes per seed, damaged seeds, percentage of damaged seeds, and weight loss. At the end of the 10th month of storage, the sweet flag rhizome powder @ 10.0 g/kg of seed performed significantly better by recording significantly higher germination percentage (87.00%), vigour index (2694) and dry weight of seedlings (329.50mg) and lower electrical conductivity (0.488 dSm-1) and insect infestation (3.33%) compared to the untreated control (77.31%, 2265, 326.67 mg, 0.540dSm-1. Derbalah (2012) discovered that the tested botanical extracts (Cassia senna, Caesalpiniagilliesii, Thespesia populnea var. acutiloba, Chrysanthemum frutescens, Euonymus japonicus, Bauhinia purpurea, and Cassia fistula) had high efficiency against T. granarium in terms of mortality and adult progeny. The most effective botanical extract against T.granarium was C. senna.Many insects are poisoned by sugar apple seeds.Certain chemicals in its leaves prevent the growth of certain stored grain insects. Indian Privetleaves are insecticidal against storedgrain insects. According to Abdullahi et al. (2011), Vittallariaparadoxa has a high potential for usage as a plant-based biopesticide for suppressing the pulse beetleCallosobruchus maculates. Bitter gourd, karanja, and urmoi seed extracts exhibited grain-protective effects on wheat grains for up to 30 days.Even after three months of treatment, the extracts had no negative influence on wheat seed germination. Among these, Neem seed extract had the highest toxic effect (52.50% mortality), whereas Hijal leaf extract had the lowest poisonous effect (22.24%).Dodder vine extract was found to be beneficial in reducing oviposition, adult progeny development, and seed damage severity. Seeds treated with 5% dodder vine extract were less favored for oviposition, adult emergence, and seed weight loss by Callosobruchus chinensis, and this conc. may be effective in pulseseed protection. The toxicity of plant extracts and plant powders (Kaner leaf extract (Nerium indicum), khejri leaf extract (Prosopiscineraria), neem leaf extract (Azadirachta indica), safeda leaf extract (Eucalyptus globulus), tomato leaf extract (Lycopersicum esculentum), mustard seed extract (Brassica compestris), and mustardseed extract (Brassica). After 24 hours of exposure, the volatile oil of Citrus reticulate resulted in 100% mortality of Sitophilus oryzae, followed by Curcuma longa (90%), Psidium guajava (52.50%), and Pogostemoncablin (20.00%). After 72 hours of exposure, the powder of Zingiber officinale was shown to be efficacious to some extent, resulting in 23.34 percent mortality, followed by P. Guajava and C. reticulata at 6.67 percent and 6.67 percent, respectively. In one investigation, a storage structure was built out of Ipomeacarnea plant stacks and filled with bengalgram. No infestation was discovered for a longer period, and there was no weight loss in this structure throughout the first five months of storage. To deter storage pests, branches of Vitex Negundo with green leaves were placed within the gunny bags. It was reported that mixing grains with the powders of V. negundo and neem in between the layers of grain sacks protected paddy.

Botanical Pesticides: Current Situation

Plants contain several bioactive chemicals that are essential for the connection between plants and their environments. Several publications have been published on ethnobotanical plants that contain known pests and disease chemicals. There are around 2,500 species from 235 plant groups that are beneficial in pest control worldwide. Plant species and their secondary metabolites were used in ancient times, particularly in herbal traditional cultures. Plants from different families may contain chemical structures that are similar for defense, such as isoflavonoids in the Fabaceae and sesquiterpenes in the Solanaceae. Several studies have found that botanical pesticidal constituents are made up of a variety of isolated secondary metabolites that have behavioral and physiological effects on agriculturally important pests and diseases (repellence, oviposition, feeding deterrence, acute toxicity, developmental disruption, and growth suppression). Datura contains bioactive chemicals such as hyoscyamine, atropine, and scopolamine, which have repellent and oviposition deterrent effects against insect pests.Calatropin and calotoxin are bioactive compounds found in calotropis that work against insect pests as an antifeedant, repellant, oviposition deterrent, and insect development regulator. Meanwhile, Vasicine, Vasicinone, and Adhatodin are bioactive compounds found in the Adhatoda that have insect-repellant and insecticidal properties. Karanjin is a bioactive component found in P. pinnata.

It has antifeedant, Juvenile Hormone Analogue (JHA), and insecticidal effects against insect pests. Furthermore, the bioactive compounds found in neem leaf extract include Azadiractin, Melantriol, Nimbinin, Nimbidin, Salanin, Nimbin, Nimbolin A, and Nimbolin B. Against pests, these chemicals have antifeedant, repellant, oviposition deterrent, and insect growth regulator action. The bioactive components in garlic extract that have insecticidal effects are allicin and diallyl sulfide. Capsaicin, the primary element in chili extract, provides repellent and deterring properties against insect pests. Meanwhile, Lantanolic acid and Lantic acid are bioactive chemicals found in Lantana that limit growth and act as insect repellents. Anonaine and squamocin are bioactive compounds found in A. squamosa that have an anti-pest feeding effect. However, these chemicals have numerous advantages and are used as precursors in sustainable agriculture. Because of their diverse modes of action, botanical pesticidal chemicals have noteworthy effects against a variety of agricultural pest species.

Uses of Botanicals

Although several plant-based pesticides have been discovered, considerable amounts have yet to be isolated and analyzed to determine their bioactive components. These substantial botanical sources have been underutilized and neglected as pesticidal agents to treat a wide range of damaging pests and illnesses. Thus, the use of botanicals as pesticides and their usefulness as alternative pest management agents in sustainable agriculture and related industries has been studied. Insect repellents, antifeedants, insecticides, and insect development inhibitors are among the applications for the goods. Furthermore, these botanical bioactive components are used as nematicides, fungicides, bactericides, and virucides, among other things. Several plants appear to have pesticidal capability; much research has been conducted, and various efficacies have been confirmed.

Insecticidal Activities

Botanical pesticides, such as A. indica, A. sativum, C. cinerariaefolium, Datura metel, Hyptissuaveolens, L. camara, Mirabilis jalapa, R. speciose, and Tagetes minuta have been utilized to manage common bean (Phaseolus vulgaris L.) pests, including aphids, armyworms, bean leaf spot, bollworm, cabbage loopers, caterpillars, common grasshoppers, bruchid beetle, pink stalk borer, and thrips. T. minuta and Carica papaya L. extracts were used. The most effective in suppressing the abundance of aphids and causing leaf damage. This could be due to the various insecticidal components found in these plant products. C. papaya leaf extract contains cysteine protease enzymes like papain, alkaloids, terpenoids, flavonoids, and non-protein amino acids that are toxic to plant-sucking insect pests such aphids, spotted bollworms, and whiteflies.

T. minuta leaf extracts include a variety of insecticidal chemicals, including phenylpropanoids, carotenoids, flavonoids, the phototoxinalphaterthieenyl, and thiophenes, which are useful for reducing insect pests.

Fungi Management

Many plant extracts are effective against numerous plant pathogenic bacteria with no negative side effects. Plant-based bioactive chemicals, such as alcohols, alkaloids, phenols, tannins, and terpenes, delay sporulation, DNA, and protein synthesis in addition to suppressing germ tube elongation and mycelial development. Furthermore, they changed the shape of hypha and mycelia, preventing the formation of poisonous compounds from mycotoxin-producing fungi including Aspergillus spp. and Fusarium spp., lowering their pathogenicity. Curcumin also demonstrated 100 and 63% fungicidal efficacy against P. infestans, P. recondita, and R. solani at 500 mg/L, and 85%, 76%, and 45% at 250 mg/L, respectively [182]. Pawpaw leaf extracts at 20%, 40%, 60%, and 80% concentrations were more effective against A. solani. Extracts of Ocimumgratissimum and E. globules reduce wilting in cowpea seedlings caused by Sclerotium rolfsil from 39.6% to 4-12% in untreated plants. Methanol extract of turmeric rhizomes inhibited the growth of Colletotrichum coccodes-induced anthracnose on red pepper. Curcuminoids suppressed the mycelial growth of three red pepper anthracnose infections, C. coccodes, C. gloeosporioides, and C. acutatum, in concentrations ranging from 0.4 to 100 g/mL. According to studies, turmeric essential oil and curcumin are efficient against plant pathogenic bacteria and fungi.

Ricinus communis extracts substantially prevented the proliferation of post-harvest infections. A. niger with Penicillium oxalicum of yams

Bacteria Management

The plant compositions also have antimicrobial capabilities in abundance. According to one study, acetone extracts of Aloe vera impacted the growth of P. aeruginosa, but methanolic extracts inhibited the growth of E. coli and B. subtilis. A. vera's antibacterial activity was assumed to be due to phytochemicals that denature microbe proteins and impede their functioning. Cinnamic acid, for example, decreases glucose absorption and ATP generation.

Some botanical pesticides impeded cellular activities against bacteria, and enhanced plasma membrane permeability could result in cell content leakage and cell death. In the case of T. vulgaris essential oils, the presence of thymol promotes membrane permeability and depolarization, interfering with the cell processes of Bacillus cereus, Klebsiella pneumonia, S. aureus, Salmonella typhimurium, and Escherichia coli.

Nematodes Management

Essential oils obtained from pesticidal herbs caused death in second-stage juveniles of the root-knot nematode (Heteroderacajani).

Again, lipophilic phytochemicals could easily disintegrate nematode cytoplasmatic membranes by interfering with protein structures that promote growth, development, and survival. Some farmers have used the crushed leaves of African 17 marigolds to control worms.

Some plant elements influenced the population of soil microorganisms, resulting in a decrease in the number of eggs and the survivability of nematode larvae.

Some chemicals caused second-stage larval death and toxicity, while others lowered egg quantity and galling, suppressing nematode accumulation.

Under controlled conditions, L. camara and Trichoderma harzianum decreased root-knot nematode multiplication, egg masses, and gall formation in tomato crops. Meanwhile, the presence of bioactive chemicals such as alkaloids, tannins, and glycosides was linked to a decrease in the number of eggs hatched, mobility, and death of juvenile root-knot nematode at the second stage. Active chemicals derived from pesticidal plants have been found to produce paralysis and reduce the infectivity potential of juvenile root-knot worms.

Viruses Management

Some plant chemicals have been discovered to elicit systemic resistance in host plants with antiviral capabilities by limiting virus transmission and killing insect vectors. Furthermore, research has shown that these plant chemicals impede virus penetration and reproduction, as well as hemagglutination and enzymatic activity. The Tobacco Mosaic Virus (TMV) was strongly influenced by cottonseed oil acetone extracts in the laboratory.

Furthermore, under field conditions, the illnesses of Rice Stripe Virus (RSV) and Southern Rice Black Streaked Dwarf Virus (SRBSDV) were reduced. Gossypol and sitosterol chemicals were found as antivirals in cottonseed oil sludge because their derivatives reduced the development of cell fusion-activated cores and apoptosis, respectively. Furthermore, T. orientalis extract inhibited the spread of the Mosaic Virus of Watermelon by reducing virus infection on the hypocotyls due to the inhibition of nucleic acid release.

Perspectives for the Future

Bruchid pest management has been crucial since the dawn of mankind. Grain pulses that had been stored were safe for several years. Several synthetic pesticides were combined with several bruchid pests of stored seeds, although many of these were harmful. Some practices have restrictions that affect non-target creatures, resistance, pollution, and so forth. While the practices discussed above are important in one form or another. However, using plant botanicals alone or in combination may be beneficial. They are modest in cost, widely available, environmentally friendly, and safe for human health when used to manage C. maculatus and other stored grain pests. These are important at the farmer level for protecting pulses from pest infestation. In addition, there should be a combination of several practices, such as low-cost traditional tactics or advanced Botanical, ergonomic, and microbiological practices, as well as a combined integrated pest control approach.

Conclusions and Suggestions

The ability of botanical pesticides to handle agriculturally and economically important pests is critical due to their renewable nature, considerable environmental safety, and human welfare. Plant-based insecticides are commonly employed to manage pests in low-income and emerging countries due to their low cost, availability, accessibility, and ease of use. Nonetheless, the discovery of active compounds from pesticidal plants is still in its early stages. Current efforts to improve the characterization of efficient phytochemicals and their quantities in final products are difficult because accuracy and standardization remain barriers. As a result, to improve and promote the full utilization and use of botanical pesticides as safer and more sustainable pest management solutions in integrated pest management systems, the following recommendations are proposed. Given the large number of raw materials necessary to make plant-based insecticides, vigorous cultivation of plant sources should be undertaken to ensure the availability of raw materials for industrial applications. More research into the limits of botanical pesticides, such as formulations, active components, application rates, storage stability, and volatility under ultraviolet light, may aid in the significant commercialization of botanical pesticides. To facilitate the market penetration of botanical pesticides, researchers, investors, manufacturers, marketers, and farmers must work together with the primary goal of establishing long-term advantages. Addressing the enormous limits of regulatory procedures may promote the viability and affordability of enterprises, encouraging entrepreneurs, public support of agro-programs, investors, and large pesticide corporations to boost botanical pesticide ventures. Low-income farmers and extension workers must get regular training on simple production and application procedures to disseminate botanical pesticide usage. Given global concerns about environmental safety, there is a need for government authorities to raise intense awareness among farmers and manufacturers about the significance of switching to botanical pesticides for a sustainable pest management approach. As a result, numerous issues related to restrictions, opportunities, and regulatory networks for successful utilization, research, and development of botanical pesticides in sustainable agricultural production should be examined regularly.

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