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Promotion of Bio-Agrochemicals for the Sustainable Pest Management: A Safe Approach

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Abstract

Synthetic pesticides are being participated a key role in crop protection since last 50 years. In recent years, pesticide negative impact seen in environment and human beings. Therefore, a safe alternate to synthetic pesticides is required. Biopesticides can be the safer alternate to synthetic pesticide. There are many botanicals have been studied which has insecticidal property. Their limited usage is mainly due to certain factors like instability, unavailability, inefficient delivery systems etc. new generation formulation technologies can overcome all these factors and convert them into efficient mode of crop protection agent in near future. There are many biopesticide formulations are available but lot of research is required to uplift these bio-pesticide in society.

Keywords: Biopesticide; Formulation; Synthetic pesticide; Insecticidal property

Introduction

Over the past 50 years, crop protection has relied heavily on synthetic chemical pesticides. The market for pest management products for crop protection has shown a regular growth of 7-10% per year [1]. Pesticide use has surely contributed towards improving agricultural production, in terms of both yield and quality, hence pesticides plays an important role in enhancing agricultural income. Despite of all positive points, recently some negative impact seen in humans, other living organisms, and the environment by careless and non-judicious use of conventional insecticides in crop protection programs around the world and resulted following problems [2]:

- Disturbance of environment.
- Pest resurgences.
- Pest resistance to conventional pesticides.
- Lethal effect to non-target organisms.
- Fatal effects on humans and animals

Therefore, there has been a growing demand for food safety and Public awareness about the adverse effects of pesticides has increased in recent years. Now, it is necessary to search for the alternative new green products of pest control, which can minimize the risks of synthetic pesticides. Therefore, promotion and development of natural product based insecticide is required to reduce the adverse effects generated by conventional pesticides [3]. Natural chemicals based insecticides will definitely participate a significant role in the future in pest control around the world. Natural insecticides have become increasingly accepted in recent years and considered safer than synthetic insecticides. Previous many research studies have proved that natural insecticides are target specific, effective in small amount and decompose quickly without leaving harmful metabolites in environment [4]. Hence, natural insecticides can reduce the usage of synthetic pesticides and becomes a main component of Integrated Pest Management (IPM) programs.

It seems that, yet now natural insecticides cannot completely replaces the synthetic insecticides completely so, synthetic pesticides in combination with available green insecticides can reduce the adverse effects generated by the synthetic insecticides. It is expected that natural insecticides will equalize with synthetic insecticides, in terms of market size, between the late 2040s and the early 2050s. The promotion of green insecticides in the future is strongly related to research and development work on natural products like identification, formulation development, efficacy enhancement of natural products.

Plant Families Having Insecticidal Property

Several botanicals sources of phyto-chemicals offer great promise for the pest control. according to Google, Google Scholar and Scopus search data 15 plant families out of 44 has insecticidal properties which includes Apiaceae, Apocynaceae, Asteraceae, Boraginaceae, Brassicaceae, Campanulaceae, Fabaceae, Lamiaceae, Myrtaceae, Papaveraceae, Polygonaceae, Primulaceae, Proteaceae, Rosaceae, Rubiaceae and Scrophulariaceae appear to have the greatest potential for providing future mosquito control agents.

Many bioactive compounds (phyto-chemicals) have been discovered by the researchers, which have good activity against different insect pests [5]. Botanical plant with insecticidal properties mainly constitute secoundry metabolites such as terpenoids, phenolic compounds and alkanoids (Table 1) [6].

Botanical insecticides are classified into toxicants, repellents, antifeedent, ovipositional deterrent and growth inhibitors according to the pest behavior after application [6]. Botanical plant extract and essential oils are the main sources of these plant have been used for crop protection for last so many years [7,8]. These botanical bioactive agents (phyto-chemicals) can effectively replace the presently available synthetic pesticides against mosquito. At present, natural insecticides shares only 5% of global usage but it is increasing 10% every year. It is expected that the global market of these natural insecticides

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will further increase if these insecticides successfully substitutes the synthetic insecticides in a safe manner.

These phyto-chemicals have high degree of biodegradation so; these are environmentally sound control agents. These phyto-chemicals will be popular in near future, due to ever increasing public interest and awareness toward the environment, in both developed and developing countries.

Factors Affecting Usage of Botanical Pesticides

1. Raw material for pilot scale up of the botanical is not available.

2. Botanical extracts contain complex mixture of chemical-constituents so, characterization and optimization is not simple.

3. Different chemical compounds of various plant species and their plant part are soluble in different Solvent types. Therefore, extraction procedure is very complex and time consuming.

4. Botanical constituents are easily degraded at slight variation in temperature, moisture or light.

5. Botanical pesticide registration is not easy task because plenty of data is required for registration.

6. The public perception has a negative effect in the utilization of botanicals, due to their slower and nontoxic pest control compared with conventional insecticides so, market demand is very less.

7. Weather conditions affect the synthetic pathways of various phyto-chemicals therefore same plant shows different chemical composition in different weather conditions. Therefore, consistency in chemical composition is not possible.

Currently, a very few natural insecticides registered by India due to scarcity of complete and systemic reports. In this context, more research work is required for discovery of new green products and their formulation and delivery mechanism. This will boost up the commercialization of green insecticides in future. Moreover, for promotion of these green insecticides co-operation of public and private sector is necessary. Additional research and development is necessary for common pilot production of green insecticides and accessibility for farmers at low cost, complete data for registration of low risk insecticide products. These all development will facilitate the promotion of safe insecticide products and enhances the availability at the market level and slow down the demand of synthetic chemical insecticides in near future.

Role of Formulation in Promotion of Botanical Pesticides

1. Increase the shelf life of botanicals by adding some stabilizers

2. Enhanced the bio-efficacy by adding synegists

3. Concentration of botanical can be fixed

4. Easy to apply

5. Provide diverse mode of application

6. Limit the wastage of botanical and give a targeted delivery mechanism.

Botanical Pesticide Formulations

Conventional formulations

A. **Granules:** A granular formulation is a product with a size range (250-1,000 microns). The active ingredient concentration is usually from 1-40% and the granules are free flowing and disintegrate in the soil to release the active ingredient (Agrow Report, 1995).

B. **Wettable Powders (WP):** Wettable powders are finely divided solid pesticide formulations, which are applied after dilution and as a suspension in water. The powders are prepared by wetting and dispersing agents and inert carriers or fillers along with botanical extract up to 50%. Wettable powders contain many particles of less than 5 microns and all the particles should pass through a 45-micron screen [9].

C. **Dustable Powder:** It consists of active ingredients (botanical powders) along with inserts and carriers like china clay. Active ingredient either solid or liquid is gradually added in china clay. After complete addition of the active ingredient, it is ground in a mixer to get a uniform composition. It is easy to formulate and use.

D. **Emulsifiable Concentrate (EC):** They are formulated by dissolving the botanical extract or extracted botanical chemical constituents solubilize in organic solvent and then emulsifying agent added. EC formulations give a stable "milky" emulsion after dilution with water. Stable emulsion has very little creaming and no oil separation and droplets up to about 10 microns are formed when the product is diluted in water in the spray tank [10]. IPFT has developed various botanical EC formulations.

New Generation Formulations

A. **Microemulsion:** Microemulsions are thermodynamically stable formulation and droplet size have very fine size less than 0.05 microns (50 nanometers). There are three main component of micro emulsion active ingredient, water and surfactant/co-surfactant. These components form a single phase containing relatively large "swollen micelles" [11]. Neem oil based microemulsions were successfully developed at IPFT, Gurgaon [12].

B. **Nanoemulsions:** These are very fine oil-in-water nanoemulsions with droplet size ranging from 5-100 nm [13]. They are thermodynamically and kinetically stable stabilize systems of botanical along with surfactants [14]. Eucalyptus oil nanoemulsion with karanja and jatropha aqueous filtrates as a pesticide by making a nanoemulsion for the control of Tribolium castaneum, a secondary pest of stored grains [15].

C. **Controlled Release Formulations (CRF), Microencapsulation:** This technology regularize the release of active constituents and reduce the toxicity [16]. Polymeric coating by interfacial polymerization mechanism is the popular microemcapsulation technique. Release kinetics of active ingredient depends upon the thickness of the polymeric coating. Botanical pesticides with high volatile chemical constituents needs to be polymerize with thick polymeric coating with high degree of cross-linking and reverse for less volatile bio-constituents.so, these formulations are effective for extended period of time.

Table 1: Most common plant families, which has pesticidal property.

Plant family	Plant species (%)	Chemical compounds
Lamiaceae	28	Eugenol, thymol, menthone, anethole, pulegone, caryophyllene oxide
Fabaceae	10	Caryophyllene oxide,Eugenol, thymol, anethole, xanthotoxin, cinnamaldehyde, anisaldehyde
Asteraceae	8	Menthone, anethole, anisaldehyde ,Eugenol,
Apiaceae	7.7	Eugenol, elemicin, caryophyllene oxide, myristicin, isopimpinellin, psoralen, xanthotoxin
Solanacea	6	Solamargine ,Eugenol, cinnamaldehyde, tomatine
Myrtaceae	4	Eugenol, cinnamaldehyde, caryophyllene oxide

D. Suspension concentrates Suspension Concentrate (SC) of water insoluble botanical extracts is well known [17]. SC is a finely ground, botanical active ingredient dispersed in water along with various surfactants. Particle size distribution in the range of 2-20 µm. These small particles improves the bio-efficacy as smaller the particle size translocation will be easier. SC formulations are eco-friendly, user friendly and economical as well. Hence, botanical suspension concentrates are most suitable formulation for botanicals to detain their greener characteristics.

E. **Oil Dispersions (OD):** These formulations are the same as SC, main difference is in dispersion medium, and here dispersion medium is oil instead of water as in SC. Therefore, OD formulations have good spreading and permeation. The Oil dispersion can be most suitable for hydrolytically unstable botanicals. In addition to this oil, dispersions give synergist effects with the botanicals and broaden the pest control. Most common oil dispersion medium being used is soyabean oil [18].

F. **Capsule suspension (CS):** these formulations are in the suspension forms in which stable suspended microcapsules with active ingredient. Biopesticides are encapsuled in various polymers like cellulose, starch, gelatin ect. Fungal biopesticide has been formulated by CS formulations [19,20]. Various stabilizers and thickners used to stabilize the encapsulated microspheres in the suapension. These formulations are very less in demands inspite of great efficacy due to their high production cost [21].

Institute of pesticide formulation technology, Gurugram in India is the only Institute of its kind devoted to the development of safe and environment friendly new generation insecticide formulation technology. There are some new formulated products of natural insecticides like controlled release formulations, Nano-formulations or water based formulations which enhances the efficacy of natural pesticides against insect pest. The work carried out at IPFT, greatly emphasizes on the development and promotion of environment and user-friendly pesticide formulations, also biodegradable, with the incorporation of latest technologies, and on their commercialization.

Future Considerations for the Promotion of Safe and Green Biopesticides

Biopesticides have long been attracting global attention as a safer strategy than chemical pest control, with potentially less risk to humans and the environment. To this end, co-operation between the public and private sectors is required to facilitate the development, manufacturing, and sale of this environmentally friendly alternative. In this context, discovery of new substances and research on formulation and delivery would boost commercialization and use of biopesticides. Additional research on integrating biological agents into common production systems is necessary. Maintaining low cost to farmers for a given product quality and availability, particularly in developing countries, is also important. Moreover, regulations that promote registration of low-risk compounds with provision of Agriculture incentives could also facilitate commercialization and availability of biopesticides in the market. While new substances could serve as a promising option for use in pest control, more field research is required to assess the efficacy on specific pest problems in various cropping systems. Microencapsulation based on nanotechnology could improve the residual action of biopesticides, and this could increase their field use.

Therefore, it is very necessary for strengthening the research in these safe and green insecticides.

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