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Review Paper

Bio-pesticides and women empowerment: A review and case study

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Abstract

Synthetic chemical pesticides/insecticides have adverse effects and significantly persistent in nature and are a serious cause to the human and animal life as well as to the environment. So, the need of the present day situation is to use natural pesticides as a safety measure. In this analysis, we are assessing some information based on natural pesticides like, pyrethrum, rotenone, nicotine, and other out-of-date natural pesticides, as well as the newer botanicals, like essential oils and the empowerment of women through the production of the natural pesticide like, Trichodermaviride etc. Their effectiveness, uses, safety, commercialization, and future developments of pesticides are discussed. Natural pesticides are necessary substitutes to the synthetic toxic chemicals for pest management. They are best suited for use in organic food production in industrialized countries but can also play a much greater role in developing countries as a new class of eco friendly products for controlling pests. The concept of empowerment has been much talked about in the context of organization. Various authors have defined 'empowerment', in different ways. To some, it means' giving people, the power to make decisions', to others, it means 'getting people involved in a participative way. So it can be defined as the motivational concept of self-efficacy. The major workforce in the society is women in the participation point of way in life of society in the modern time. They are highly skilled for the formation of groups and organization for the participation worldwide and becoming increasingly active in their communities, governments and the international arena.

Keywords: Bio-pesticides, formulations, Neem, Azadirachtin, women empowerment, socioeconomic profile, production.

Introduction

Synthetic chemical pesticides are toxic to human as well as to the environment, so they pose a problem to the personnel who are engaged in farming sector. This eventually leads for the development of the safer chemical pesticides or use of natural pesticides. Also, they are cost effective and have minimum side effects on the non-target living beings including human, with the food that is free from the pesticides residue and clean environment[1]. By using natural pesticides as for example, in rotation or in combination, we can reduce the use of chemical pesticides along with reducing the synthetic chemical pesticides among pest/insects. There are some natural pesticides like, rotenone and nicotine which are not as safe as pyrethrum and Neem including their commercial formulations. Essential oils are also very popular nowadays and have commercial availability. Botanical pesticides have the ability to repel pest/insects and in turn reduce the spreading of the disease among human and plants[2].

Since long back, we were entirely dependent on the synthetic chemical pesticides for the crops protection. But, chemical pesticides have revolutionized agriculture sector in crop protection. This has been started long back in 1800 by the use of the arsenic pesticides including Bordeaux as fungicide to the modern chemical pesticides which are very potent in toxicities. Nowadays, some peoples are producing more crop produce and that is also on lower cost as compared to recent back[3].

However, the adverse effects of synthetic chemical pesticides pose a growing concern about the environment as they are persistent for a long time and cost is also an important factor for generating new chemicals. So keeping these things in mind, there is a need of developing new and safer chemicals or use of botanical/natural pesticides for pest management. Hence, it becomes important to be dependent on the natural/biological agents that has almost the same efficacy as the synthetic chemical pesticides and can be produced at large scale with long shelf-life with safer handling[4].

Bio-pesticides: Bio-pesticides are generally obtained from natural resources like, plants, animals and microbes etc. Also, it categorized as biochemical, which includes pheromones, plant extracts including essential oils and plant growth regulators. On the other hand, microbial pesticides are based on bacteria fungi and some other microbes.

Botanical Pesticides

Pyrethrum: Among the natural pesticides/insecticides pyrethrum use is widely accepted for indoor applications and in particular it is used as an aerosol for pest knockdown. It is obtained from the flowers of *Tanacetum cinerariaefolium*

(Asteraceae) by grinding to powder form and extracted with non-polar organic solvents like, hexane followed by rotary drying to result an orange liquid containing the active component, pyrethrum[5]. Most of the pyrethrum was produced initially in Kenya, Tanzania and Australia in 1996 and supplying to rest of the world. The percentage of pyrethrum in technical grade is about 20-25% pyrethrin and it is used in the formulation preparation. Some of the chemical like, piperonylbutoxide and n-octylbicycloheptanedi carboximide, enhance insect mortality including shelf-life of the product.

Rotenone: It belongs to isoflavonoid chemically and obtained from the roots/rhizomes of a tropical legume, *Derris, Lonchocarpus,* and *Tephrosia*. Though its use is reduced in the standard agriculture crops but, is being used in organic farming. Rotenone is generally used in California for the lettuce and tomato crops[6]. It was being used in south-east Asia since a long time to paralyze fishes to easily catch them from the water surface, but relatively higher doses can kill the fish without harming the other living organisms. Its degradation process is also fast comparatively. Commercially, it is available as a dust powder with 1-5% active ingredient for domestic use and liquid formulation for organic farming with about 8% active rotenone[7].

Nicotine: Nicotine, nornicotine and anabasine belong to alkaloids and are obtained from the tobacco plant (*Nicotiana*spp.: Solanaceae) and Anabasis aphylla (*Chenopodiaceae*). They have insecticidal properties and mimic acetylcholine neurotransmitter. They are similar in symptoms produced by the organophosphate and carbamate pesticide. The use of nicotine has been reduced, as it is quite potent poison if used in high concentration to human. This can be transferred to body by ingestion, inhalation and skin exposure and 60 mg is the lethal dose for human being. Hence, due to its harmful effects it is being used in very few countries like, China and Africa as their crude tobacco extract[3]. On the other hand, it is now discontinued in North America and European countries. So, it is used as a fumigant for small pests and as nicotine fatty acid soap with reduced toxicity to human.

On the other hand, alkaloid compounds in the pure state are toxic to mammals as well but rotenone concentration in powdered seeds is low and this is the advantage for safety[8].

Neem: Neem (*Azadirachtaindica* A. Juss: Meliaceae) is distributed to Southeast Asia and in particular India, Pakistan, Nepal, Bangladesh, Africa and Arica and can grow in harsh conditions as well like, poor, degraded including saline soil[9]. It has numerous medicinal priorities and is considered to be a nature's gift to human kind. But in countries, where it is found abundantly uses more for shade, firewood and windbreak as compared to a medicinal and insecticidal applications.

It was first time observed by Heinrich Schmutterer that swarming desert locusts from Sudan is not able to defoliate Neem tree. So, it was though that neem has some active chemical components that are responsible for the above said properties. Later studies showed that it has properties like, antifeedant and as insect growth regulator (IGR) and that is due to the presence of Azadirachtin and related compounds. Apart from these, it has fungicidal, bactericidal, diuretic, antiarthritic and nematicidal properties as well. Some more properties like, immunomodulatory, anti-inflammatory, antihyperglycaemic, antiulcer, antimalarial, antiviral, antioxidant, antimutagenic, and anticarcinogenic are also reported. Azadirachtin has some systematic effects for some particular crop with enhanced efficacy and persistence[10]. Other plant components, which have anti-feedant as well as IGR effects includes, limonoids like limonin, nomilin from Meliaceae and Rutaceae families were also uses in India long back for insects controlling agents.

Plants with Anti-feedant and Insect Regulation effects: Insect growth regulator (IGR) chemicals hinder the maturation processes like; juvocimenes from *Ocimumbasilicum* is resembles juvenile hormone of the insects. Precocenes from *Matricariarecutita* inhibits the juvenile hormones secretory gland, this eventually results in the retarding growth of the insects. Juvabione also reduces insect's growth[4].

Essential oils: Essential oils from the plants are the mixture of volatile organic compounds and in context of plants functions are known as the secondary metabolites. These can be obtained by the steam distillation of the respective plants materials and were primarily used for their good fragrance as in perfumes and cosmetics including food industries and aromatherapy agents. They have very strong odor with low density compared to water. Out of 3000 types of essential oils known today and 300 of which are also commercially available and have applications in perfumes, cosmetics, pharmaceuticals and pesticidal sectors[11].

There are many families of plants, which have been found to have insecticidal properties like, Myrtaceae, Lauraceae, Rutaceae, Lamiaceae, Asteraceae, Apiaceae, Cupressaceae, Poaceae, Zingiberaceae, and Piperaceae. To protect their self from pathogens and herbivores plant secretes some volatile chemicals like, terpenes, alcohols and certain aromatic compounds. These volatile chemicals repel insects from plant or stop from being eaten by herbivores with their toxic and other related effects. In addition, they also help plant in pollination, plant communication and plant disease protection. Also, they are being used by individuals since long back as fungicides, virucidal, bactericidal, parasitidal and medicinal etc. these chemicals also bring out some of the behavioral, moulting and mating/ovi position changes in the insects.

Plant Growth Regulators (PGRs): Physiological functions of the plants are affected by specific chemicals and these are known as plant growth regulators. These are naturally occurring and synthetic also which are produced by mimic the natural chemical compounds in the laboratory. These chemicals can modify/inhibit the physiological functions of a variety of plant

species. Now they are being used in the mainstream agriculture sector significantly and their benefits are well known among the crops growers[12]. PGRs increase the overall productivity, quality and genetic limitations. These can be categorized in five different classes and each class has many PGRs and each of which have a particular function for plant.

Insect Growth Regulators: Insect growth regulators function differently from chemical pesticides and in most of the cases they prevent the insects reaching to reproductive stage. Eventually insect's population decreases significantly. These are categorized in two different class one that bring changes in the insect hormonal regulation and other the one which hinder the chitin formation for exoskeleton of the insects. Modern agriculture uses the hormones changer and is known as hormones mimic. One such important regulator is Azadirachtin and used as IGR for molting.

Microbial Insecticides

Bacteria: Bacillus thuringiensis: In this category, pathogenic microorganisms are used as the insect control strategy. The microorganisms are isolated from the infected insects during the insect's epidemic period. There are around 400 different species of bacteria and 90 types of bacteria species are known to date which are prone to infect various insects. *Bacillus thuringiensi,* is used for controlling of caterpillar, mosquitoes and black flies with commercial availability. Fungal pesticides were introduced in the year 1979 and in 1981. Till date, approximately 40,000 *Bacillus thuringiensis* different species have been known and isolated. Studies have shown that these belong to 39 different serotypes. These microorganisms work against *Lepidoptera*, or *Diptera/Coleoptera*. So, there is a need to develop bio-control product with careful microbial screening procedure with bulk production protocols, which include optimizing the quality as well as quantity of the product and eventually end up with a product with some known self-life and help in the delivery of the product with improved bioactivity.

Bacillus species based formulations for use against plant pathogens is a hot topic but is of limited type in terms of commercial availability. So, various types of formulations can be prepared like, wet table powder (WP), dusts, granules and some liquid state formulations and cell suspension in water, many emulsions and oils with cell encapsulated product. Also, great care is required to maintain the bioactivity during optimization, preparation steps including delivery of the product to the target coverage.

Viruses: Baculoviruses (Baculoviridae): One such natural defense against insects is viruses like e.g., Baculoviruses. These are rod-shaped DNA viruses and multiply inside the host cell and exist as polyhedron-shaped occlusion bodies which are composed of protein. As an example, caterpillar infected with Baculovirus eventually die with the contamination of the leaf surface of the plant leaving behind the occlusion bodies, which later on release new viruses and incoming insects become infected and this cycle goes on. Hence, with the Baculovirus epidemic most of the caterpillar pests like, cotton bollworm, earworm, tobacco budworm and cabbage nemesis[13]. Commercial production is underway and several companies are engaged in developing virus cultures of insect cells compared to insects as a whole. This concept based technology is economic in terms of labor cost as well as keep the culture contamination free.

Fungi: Entomopathogenic fungi are known to regulate the insect/pest population through epizootic. Pest inoculation with fungi are well known for gypsy moth though, the common method is inundatory. Due to their short life, they are difficult to produce at commercial scale and this makes the inundator difficult[2]. Resting spore and mycelia technologies is quite effective method for the production and enhances the utility of the entomophthoralean fungi.

Entomopathogenic Nematodes: Nematodes are also known for pest/insect control and there are 30 plus species which are related to insects and invertibrates. More importantly, only seven families have been selected for the R & D from nematodes which includes Mermithidae, Tetra-donematidae, Allantonematidae, Phaenopsitylenchidae, Sphaerulariidae, Steinernematidae and Heterorhabditidae. These are more effective species in pest control. Two species steinernematid and heterohabditid are well reported to be effective against a range of insects/pests. These are more effective particularly against soil and cryptic habitats insects[14]. High-value crops are being protected by using them inundatively.

Role of Women in Bio-pesticide Production: Any country's development depends on its peoples and everyone has some different types of uniqueness or the expertise. So, men and women should contribute to the nation's development. Women constitute about 50% population of India and have a key role in the society[15]. Hence, empowering women in our country is basic key to achieve the desired development and can be emerges as the groups, organizations worldwide and becoming active in communities, government and international/national platform[16].

Career Options for women in agriculture: Indian economy is solely depends on the agriculture and 60-70% population of India are engaged in agriculture. In the context of women, so every woman has the quality of entrepreneurship and this can be used for the generation of employment in the field of agriculture. Education in the field of agriculture was stated by M.S. Swaminathan's Committee 1997. According to it, agriculture must help farm graduates to own the responsibilities to intensify and diversification of the agriculture field with the addition of the values in combined way. There are many opportunities for career in modern farm science for female graduates[17]. Women can start practical farming and agriculture business with improving the benchmark of living as well as the progress of the country.

Career concept would be regenerate more land to get more crop produce along with more Neem. In the field of forestry, women can be engaged themselves like, good quality of seeds, nursery related work, plantation, harvesting of crops and finally in marketing. Also, contribution of women in the production of bio-pesticide formulations is very demanded for agriculture as well as for the economic point of view. So, women are better and can do the things more effectively and successfully with their patience[18].

Mass Multiplication of Bio-pesticides: One of the important sectors of bio-pesticide is their large scale production. So, in this move TNAU has initiated and produced bio-control agents for fungal and bacterial related infections. Hence, agriculture graduates can participate in the large scale production of the bio-pesticides. Central Insecticide Board (CIB) has instructed to register the bio-pesticides and in this TNAU has done a good job. Also, bio-pesticides are now selling at a cheaper price like, for example, pseudomonas fluoresces which is effective against fungus, nematodes including pest/insects.

A Case Study

M.S. Swaminathan Research Foundation has started eco-entrepreneurship in rural areas by promoting Sustainable Self Help Group (SSHG) concept. Man power mobilization, group formation including SSHGs federation, enterprises identification with to and from linkages, building of capacity for managing the enterprises for successful venture are some of the crucial points which are involved in the multiple livelihoods for villagers. In Tamil Nadu, Elayathendral Women Self Help Group has started production and marketing of *Trichoderma viride*[18].

Kannivadi Bio-Village: Seed village project was managed by MSSRF and working since 1996 on this project and emphasizing on the value added to the time and labor including the connection between the farmers and seed industries for continuous development. So, bio-villages was focused by MSSRF from 1999-2000 and they targeted Kannivadi region but, as this is a semi-arid region so increased productivity and economic livelihood opportunities are some key concerns for the region. Bio-village concept acts as a value addition to the system to generate eco-jobs for poor, women and ecofriendly for nature. Hence, production of *Trichodermaviride* was started by a team of women to facilitate the livelihood of the poor in Kannivadi region. This contains processes for enterprises identification its training and marketing[18].

Socio-Economic Profile of Kannivadi Region: Kannivadi area in Reddiarchatram block is situated in the middle part of Tamil Nadu and its population is of mixed culture type and many communities with multiple occupations living in the area. It's around 26% population is below poverty line. The main economic activity of this region is agriculture and augmented by cattle rearing. This region has cultivation land around 24,624 hectares with the dry and irrigated lands. There are 29,568 families which are engaged in the farming. Also, 50% families are under marginal category and for farming the main sources for irrigation are wells, rivers and rainfall/harvested water[18]. The average rainfall in this region is around 845 mm and the crops are mainly paddy, pulses, grains and oil seeds, fibre and horticulture crops. During the last decade the coconut and banana are cultivated in the region.

Establishing the Production Unit: This region's peoples met Canara Bank in Kannivadi in 2002 and discussed the business proposal which subsequently was approved by the Canara Bank in 2003. The cost of the business was estimated to be Rs.2, 40,000/- with the inclusion of registration fee. The unit was established in 2003 with the Rs. 1, 75,000 from Canara Bank loan and Rs. 65,000 for registration. The registration fee was supported by Community Bank from MSSRF[18]. Later the group members own a house on rent for Rs.500 per month and the production was started with 1000 kg per month and that also with the very low cost techniques used for the large scale production. Initial support was done by the faculty members of the TNAU in the establishing the sterile room. Further support was also made for the mother culture maintenance to ensure the contamination free inoculation bottles. The production of bio-pesticides mainly includes the following steps: i. Medium preparation, ii. Mixing of mother culture and medium, iii. Incubation, iv. Mixed with talc, v. Air drying, vi. Packaging.

Figure-1: Participatory appraisals in different villages.

Figure-2: Production and packaging of microbial pesticide.

Market Linkage

Technical skill was provided by the backward linkages to team/group members which lead to the forward linkage to the market and this is very important for eco-enterprises. Research foundation led by M S Swaminathan has facilitated the group members to identify a permanent market for the sale of the product. Meanwhile an agent from the market was selected during the meeting of NABARD agro-clinic and agribusiness. The aim of this project was discussed with the agent like SHGs principles, microenterprises and multiple livelihoods were explained which eventually leads to a joint meeting in June 2003 at JRD Tata Eco-technology Centre at Chennai of all the SHG members.

Conclusion

Synthetic chemical pesticides are not only toxic to targets but also to non-target as well and lead to the resistance in the pest/insects. Current integrated pest management suggests that synthetic chemical pesticides used at present are not necessary. Therefore, use of synthetic chemical pesticides has extra burden on the farmers with the health issues and impact on the income and environment. Also, these chemical pesticides are costly so not possible for the farmers to afford them and using natural protection for their stored products is well established.

On the other hand, botanical pesticides which are safe and effective to a significant amount in every respect but also preventing the dumping of the tons of synthetic chemical pesticides on the earth. Also they are quick in bio-degradation to the harmless components with the help of water and sunlight.

High cost spent on the importing of synthetic chemical pesticides can be reduced or completely removed by the production of botanical pesticides. But to be used effectively the botanical pesticides should have longer shelf life, good ability to kill the pests, better efficacy in the field along with reduced cost for the user so that botanicals become more versatile for the pest management. Formation of groups, organization and federation like, SSHGs, enterprises identification with linkages and building of capacity to manage the enterprises will be successful venture for poor people.

The production of *Trichodermaviride* was started as an eco-enterprise by the rural people of kannivadi region in TN. So in this production unit 90 labor days every month was generated 500 kg of natural pesticides (*Trichodermaviride*). But the team is planning in future the production of 1000 kg every month and also according to the market demand. Also, they are planning to increase the 200 days labor per month with this each member is getting an extra income Rs.750-800 per month in addition to the wage. But initially it was planned that initial profit will be used to repay the loan from the bank. Hence this type of jobs creation along with increased skills of rural people (women and man) would create more employment and empowerment.

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