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BIOMANAGEMENT OF PESTICIDES FOR SUSTAINABLE ENVIRONMENT: AN INDIAN SCENARIO

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ABSTRACT

There is a worldwide view that the synthetic pesticides have failed to give desired outcome in the management of crop pests. The pesticide has done more damage to human and ecosystem than benefits, even though the consumption of pesticides is very low in India. The indiscriminate use of pesticides has led to the contamination of air, soil, water, elimination of beneficial insects, accumulation of pesticide residues in agricultural products and also development of resistance to pesticides in insects of agriculture, veterinary and public health importance. This review aims to elaborate the usage of synthetic pesticides in India and their adverse effects on eco system. The present review also highlights the potential applications of various biological agents in integrated pest management, the use of biopesticides and Genetically Modified (GM) seeds, non-integrated pest management. This review outlines the current state of knowledge on the synthetic pesticides and their disadvantages in environment and the potential production and usage of biopesticides in control of pests and their eco-friend nature with increasing yield capacity.

Key Words: Biomanagement, pesticides**,** Biopesticide, Integrated Pest Management, Genetically Modified Organisms.

INTRODUCTION

Synthetic Pesticides are toxic agro-chemicals used for control of the pests, weeds or plant diseases. According to FAO, pesticide is defined as any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease. Pesticides show their activity on a wide range of organisms including insects, fungus, herbs, rodents, molluscs and nematodes.

The term "pesticide" includes substances intended for use as plant growth regulators, defoliant, desiccant, fruit thinning agent or an agent for preventing the premature fall of fruit, and substances applied to crops either before or after harvest and to prevent deterioration during storage or transport. Some pesticides are used both in agriculture and as vector control agents in public health programmes. Significant amounts are also being used in forestry and livestock production.

Among all these compounds, organo chlorine (OC) insecticides were banned or restricted after 1960s. The introduction of other synthetic insecticides organophosphate (OP) insecticides in 1960s, carbamate in 1970s and Pyrethroids in 1980s and the introduction of herbicides and fungicides in 1970s-1980s contributed greatly for the pest management. Ideally a pesticide must be fatal to the targeted pests, without causing any adverse effects on non-target species, including man. Regrettably rampant use and abuse of these chemicals has played havoc with biodiversity and ecosystem.

Production and usage of Pesticides in India

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The production of pesticides started in India in 1952 with establishment of plant for the production of BHC in Calcutta, and India is now the second largest manufacturer of pesticides in Asia after China and ranks12th globally (Mathur, 1999).

Although, agriculture is the linchpin of the Indian economy, gradual decline in cultivable land has become an important limiting factor to ensure food security for more than one billion Indian population. This necessitates the use of high yielding variety of seeds, balanced use of fertilizers, pesticides and use of modern farming techniques. On par with steady increase in the use of pesticides, there has been tremendous growth in the pesticide manufacturing industries with a net production of 82,000-85,000 MT of different classes of pesticides in the financial year 2009-2010. In terms of value the magnitude of the Indian pesticides industry was estimated to be Rs.180 bn during financial year 2010, including export of Rs.100 bn. The Indian pesticide industry is dominated by insecticides, whereas globally herbicides and fungicides are the key segments.

Approximately 43,000-85,000 tons of chemical pesticides are being used in India annually to control pests and vectors which directly or indirectly affect the agricultural production and human health. The use of pesticides is predominantly high in case of cotton and paddy, which accounts for about 45% and 25% respectively of the total pesticides used in agriculture. Fruits and vegetables consume around 8% and cereals, pulses, oil seeds and millets use around 6-7% of the total pesticides in agriculture.

Despite the fact that the consumption of pesticides (Figure1) per hectare in India is considerably lower than the consumption in developed countries the level of pesticide residues in cereals, pulses, fruits, vegetables, milk and milk products, is markedly high in India (Figure 1-C).

In addition, 76% of pesticides are used as Insecticides in India (Figure 2) as against 44% globally (Mathur, 1999). The use of herbicides and fungicides is correspondingly less heavy. The main use of pesticides in India is for cotton crops (45%), followed by paddy and vegetables.

Hazards of Pesticides

Although the principal usage pesticide has greater implications on economical potential in terms of increased crop protection and production, their debits results in serious impact on ecosystem and biodiversity. Overwhelming evidence undoubtedly indicate that most of these chemicals do pose potential risk to non-target species including human beings in addition to unwarranted and unwanted side effects to the environment (Forget,1993). The toxic effect of pesticide was first reported in India at Kerala in 1958, where over 100 people were died due to the consumption of wheat flour contaminated with parathion (Karunakaran, 1958). Further, Carlson and Hites (2005) that Organochlorine (OC) compounds could corrupt the tissues of every life form on the earth, lakes and the oceans. Certain pesticides termed as endocrine disruptors are known to elicit their adverse effects by altering natural hormones in the body and it has also been postulated that long-term exposure are increasingly associated to the disorders like immunosuppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer (Brouwer *et al.*, 1999). In India a study revealed that 50% of the vegetable samples taken from farm gate were found to be contaminated with various pesticides (0.01-2.23 ppm) of which 16% were above maximum residual level (MRL) (Kole *et al.*, 2002).

In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects and non-target species. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can also pose risks to non-target organisms. Environmental and human health consideration and the problem of pesticide resistance suggest that there is an urgent need to adopt environmentally safe pest control strategies.

Pesticide Management Strategies

There is a universal opinion that the chemical pesticides have failed to give desired outcome in the management of crop pests. The pesticide has done more damage to human and ecosystem than benefits, even though the consumption of pesticides is very low in India. The indiscriminate use of pesticides has led to the contamination of air, soil, water, elimination of beneficial insects, and accumulation of pesticide residues in agricultural products. In addition, augmented use of pesticides cause development of resistance in insects of agriculture, veterinary and public health importance.

In response to these negative implications of intensive pest usage the following alternative strategies have been developed

1. Integrated Pest Management (IPM)
2. Non-Pesticidal Management (NPM)
3. Biodegradation management plan (BMP)

Integrated Pest Management (IPM)

Origin and Concept of Integrated Pest Management (IPM)

Integrated Pest Management (IPM) was developed by Dr. Ray Smith, in 1940s; Dr. Smith carried out a 10years project to test his basic concept of “supervised control” of pests of alfalfa. Dr. Ray Smith along with Dr. Perry Adkission and panel of experts on integrated pest control expands the concept of IPM on priority basis and worked directly with farmers, experts and policy makers in Latin America, Asia, and Africa and assessed the needs of pest control in these regions. Dr. Ray Smith and Dr. Perry Adkission combinedly received the world food prize in 1997 for the achievement in the development and practice of IPM programme by farmers across the world. The IPM programme was started with a number of objectives like- 1) Reduction of the application of synthetic chemical pesticides; 2) Evolve and apply the environmentally sound practices of pest management; 3) Application of safe chemical pesticides with minimal risk to human health; 4) Re-useable return investment and 5) providing consumable and safe food to consumers (Anonymous 1).

The IPM programme can be defined as "a sustainable approach of management of pest by the combination of biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks". In other words the IPM is an economically justified and sustainable system of protection of crops that leads to the maximum agricultural yield with the least possible negative impacts on the human and ecosystems. Now IPM is a worldwide programme which lays emphasis on the application of biopesticides and bio-agents with rarest and unavoidable application of safe chemical pesticides.

Principle of IPM

The IPM programme is based on following five basic management principles- 1) Identification of key pests and beneficial organisms; 2) Defining the management unit, 3) The agro-ecosystem and development of management strategy; 4) Establishment of economic thresh hold (loss and risks) and 5) Development of assessment techniques and evolving description of predictive pest models.

Integrated Pest Management in India

Status of IPM in India

Agrarian economic countries like India, where 1012.4 million populations is dependent on agricultural commodities cultivated from 124.07 million hectare area by 110.7 million producers (Prasad, 2001). The IPM programme in India was started as a central sector scheme in 1991 by the Ministry of Agriculture, Department of Agriculture and Cooperation, Government of India, and this is the major ecological approach towards pest management. It aims at mixing of all the pest control measures known so as to keep the population of pests below the Economic Threshold Level (ETL). As a system of crop protection, the IPM is an economically justified programme and a sustainable system. The programme will lead to optimize yield without any adverse impact on the environment.

In 1994, Indian government forms regulatory measures of plant quarantine known as 'Destructive Insects and pests Act'. This can prevent the introduction of any insect, fungus, or other pest, which is or may be destructive to crops. The plant protection quarantine (PPQ) is a regulatory system which safe-guards agricultural and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds to ensure as abundant high quality and varied food supply. For rapid dissemination of IPM information, IPM related activities are being implemented through 26 Central Integrated Pest Management Centers (CIPMS) located in 23 states and 3 Union territories.

Major activity under the IPM approach include sample roving surveys for monitoring pest/disease situations on major crops, production and release of bio-control agents and conducting Farmers Fields School (FFSs). Pest/disease situations are monitored regularly in the states covering 644,000 hectares of the targeted area of 469.000 hectares. Pest situation reports received from field stations and states were compiled and comprehensive weekly and monthly reports circulated to the officers and scientists of the state agricultural universities and Indian Council of Agriculture Research (ICAR) to take appropriate remedial measures.

Biological pesticides

Biopesticide, key component of IPM programmes, is receiving much practical attention as a means to reduce the load of synthetic chemical products being used to control plant disease. The term biological pesticides or biopesticides is used for microbial/biological pest control agents who applied in a similar manner to chemical pesticides. Most of these biopesticides are originated from bacteria but some are also derived from fungi, viruses and nematodes, weeds and rodents (Farhan, 2011).

FAO defined the biopesticides as "a compound that kills by virtue of specific biological effects rather than as a broader chemical poison. Differ from chemical agents, the biocontrol agents exhibit high selectivity and specificity to insect".

'Biopesicide' covers a wide spectrum of potential products used as plant protection but based on the purpose of biopesticide, these are divided into different categories.

1. Products based on pheromones and other Semiochemicals (For mass trapping and trap cropping).
2. Products based on microorganisms (Bacterium, fungus, protozoa, virus viriod)
3. Products based on plant extracts
4. Other novel alternative products

Production and Usage of Biopesticides in India

Approximately 16 thousands of bio-control agents have been mass produced in laboratories and released against insects and pests which affect Rice, Cotton, Sugarcane, pulses, vegetables and oil seeds during the year of 2002-03. During the eighth-five year plan from 1994-95 to 2001-02, government of India spent nearly Rs.14, 926 million for biocontrol of pests on different crops, covering a land area of 4.3 million hectares.

Due to the universal importance of biopesticides, its market is growing very rapidly. Biopesticide market, which was merely 0.2% in 2000, has grown to about 4.2% by 2010 (Figure 3) while the market value is estimated to reach more than 1 billion US $. However, the overall growth rate of biopesticides is estimated to be about 10% per annum for the next 5 years. In terms of use, orchards claim the largest share (55%) of the total biopesticides used. Region wise North America consumes the largest share (40%) of the global biopesticide production followed by Europe and Ocean countries accounting for 20% each. In India, 12 types of biopesticides (Table 1) have been so far registered under the Insecticide act, 1968. Neem based pesticides, *Bacillus thuringensis,* and *Trichoderma* are the major biopesticides produced and used in India. Most of these biopesticides find use in public health, except a few are used in agriculture.

The average consumption level of biopesticide is approximately 1kg/ha with the global organic farming area comprising about 24 million hectare and hence global biopesticide consumption is estimated at about 24 million kg.

Some success stories about successful utilization of biopesticides and bio-control agents in Indian agriculture include (Kalra and Khanuja, 2007).

- Control of diamondback moths by *Bacillus thuringiensis*
- Control of mango hoppers and mealy bugs and coffee pod borer by *Beauveria*.
- Control of *Helicoverpa* on cotton, pigeon-pea, and tomato by *B.thuringiensis.*

A) Pheromones and Semiochemicals as biopesticides

The existence of pheromones has been known for centuries, apparently originating in observations of mass bee stinging in response to a chemical released by the sting of a single bee. The first insect pheromones (silkworm moth) was isolated and identified in 1959. Semiochemicals are chemicals that mediate interactions between organisms. Semiochemicals are subdivided into allelochemicals and pheromones depending on whether the interactions are interspecific or intraspecific respectively. Pheromones are released by one member of a species to cause a specific interaction with another member of the same species. Pheromones may be further classified on the basis of the interaction mediated, such as alarm aggregation or sex pheromones. It is the sex pheromones of insect that are of particular interest to agricultural IPM practitioner (Anonymous 2).

The use of Semiochemicals, including pheromones that modify insect behavior is still a developing area of science. The awareness of environmental and safety hazards associated with insecticides, coupled with the technology to measure their presence have lead to increasing restriction on their use.

B) Microbial Products as biopesticides

Widespread failure of chemical insecticides to control *Helicoverpa armigera*, *Spodoptera litura*, and other pests in cotton (Kranthi *et al.*, 2002), prompted efforts to develop systematic IPM of which biopesticides are a component.

The microbial pesticides (Table 2) used in India, including *Bacillus thuringiensis (bt),* which are sourced partly as imported products, but also include many that are locally produced. Indian biopesticide production is currently dominated by antagonistic fungi and bacteria such as *Trichoderma* spp. and *Pseudomonas fluorescence* (Table 2), but the production of nucleopolyhedrosis viruses (NPV), granuloviruses (GV) and entomopathogenic fungi are also established and expanding (Rabindra, 2005). A major goal has been to develop local sourcing of biopesticides as a means of ensuring availability at low cost to benefit poorer farmers and as a base for expanding Indian biotechnology industry. The commercial production of biopesticides began in 1980s, but expansion became rapid in the late 1990s initiated by national and state programmes for IPM promotion (Wahab 2004). *Hyblea puera* NPV was recently developed for controlling teak defoliator (Biji *et al.,* 2006), *Amsacta albistriga* NPV for controlling the pest on groundnuts (Veenakumari *et al.,*2007), *Nomurea rileyi* and *Pochomia chlamydosporia*, on entomopathogenic nematodes. It has been estimated that there are at least 32 commercial companies which actively produce biopesticides, with an additional 32 IPM centers under the Ministry of Agriculture producing selected biocontrol agents (Singhal, 2004). The state departments of agriculture and horticulture in the states of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, and Gujarat have established biocontrol laboratories for producing selected microbial biocontrol agents. A few state agricultural universities and Indian Council of Agricultural Research (ICAR) institutions also produce small quantities of microbial pesticides (Rabindra, 2005). In total, at least 410 biopesticide production units have been established in India, among which 130 in the private sector (Singhal, 2004).

C) Genetically Modified Organisms as Biopesticides

In addition to the wild type biopesticides, recombinant biopesticides provide an attractive option to chemical insecticides for controlling insect pests and can be used as efficient vectors for the expression of foreign genes (Rajendra *et al.,* 2006). Genetically modified bacterial strains especially *Bacillus thuringiensis* used to improve their insecticidal properties and contribute to their development as biopesticides. (Pardo-Lo *et al.,* 2009). The insecticidal properties of this bacterium are mainly due to the production of larvicidal proteins during the sporulation that accumulate (up to 25% of the dry weight) as parasporal crystalline inclusions (also called crystals) within the cell (Salama *et al.,* 1993). The inclusions produced by *Bt* subspecies are composed of several proteins (called as b-endotoxins or Cry proteins) each having a narrow activity spectrum. There is thus a large family of related endotoxins classified as Cry I, II, III, IV and V, etc depending on molecular relatedness and activity against insect larvae (Gill *et al.,* 1992). The recent transformation of *Bt* by electroporation (Peng *et al.,* 2009) has made possible the analysis of the expression of the cloned crystal protein genes in their natural host.

Several approaches and techniques have recently been used to manipulate genetically modified baculovirus strains to improve their insecticidal properties and contribute to their development as biopesticides (Rajendra *et al.,* 1998). It is also evidenced that the increased insecticidal activity of recombinant NPV (ButalT-NP) expressing Lepidopteran-selective toxin derived from South Indian red scorpion, *Mesobuthus tamulas* against *Heliothis virescens* by showing significant reduction in median survival time (ST_{50}) and also a greater damage in reduced feeding as compared to the wild type AcMNPV (Rajendra *et al.,* 2006).

These engineered viruses seem to retain the light stability of wild type viruses and are orally active in several of the most serious pest species in the world. The engineered organisms show a 30% reduction in time to kill compared to the wild type viruses and over a 75% reduction in food consumption. These engineered organisms show no toxic effects on the non targeted organisms tested and greater selectivity for pest insects than the conventional insecticides.

Plant extracts as Biopesticides

Many farmers will prefer to use organic manure over synthetic pesticides, and some consumers will only buy organic produce. However mass production farms rely on synthetic pesticides as they are cheaper than organic ones. Besides, the farmers who use synthetic pesticides have very little understanding of their long lasting deleterious effects and their accumulation in environment. Although specific classes of pesticides are designed to target species with target action, they also damage non-target species including humans.

There are many conceptual advantages of the approach of using plants as biopesticides (Table 3). Of course the greatest benefit is delivery of the pesticidal activity to the pest without direct effects on-non target organisms, risk to field workers or contamination of food or the environment (Hammock *et al.,* 1999). Many plant species produce substances that protect them by killing or repelling the insects that feed on them. For example, the Douglas fir has a special sap that wards off beetles if it is attacked. Neem trees produce oil that alters the hormones of bugs so that they cannot fly, breed or eat (National Academy of Sciences, 1992). It is possible to create effective, natural insecticides from these substances to protect crops that, unlike wild plants, may have lost their capability through cultivation to cope with pests.

This system was not reasonably successful, mainly because the large variation in field situations was not consistent with standard instruction that had been developed at test plots of research stations. Generally, farmers did not understand the logic behind the instructions they received and were not able to implement them to their specific situations. Gradually it became clear that an important bottle-neck for IPM implementation might be due to lack of motivation and involvement of farmers to adopt the IPM strategies.

Non-Pesticidal Management (NPM)

In fact modern IPM system was developed by researchers for sustainable food production and it was too complicated for illiterate farmers to implement. In spite of the regular consumption pattern of pesticides, there are several documented examples of alternative pest management approaches followed by rural agricultural sector in India. However, the NGO involvement had demonstrated that Non- Formal Education methods could assist farmers to understand the ecosystem of their fields and to take crop management decisions based on their own insights and experiences.

Principles of NPM

Non-pesticidal management (NPM) techniques that were developed and proven under IPM, but completely do away with synthetic pesticides. The NPM techniques protect the crops in two ways 1) by promoting the sharing of know-how on crops and pests and 2) by utilizing locally available low-cost inputs.

Non-pesticidal Management (NPM) explains various pest-control techniques which do not rely on pesticides. It is used in organic production of foodstuff, as well as in other situations in which the introduction of toxins is undesirable. Instead of using synthetic toxins, pest control is achieved by biological means.

Some examples of Non-Pesticidal Management techniques include:

- ❖ Use of natural predators.
- ❖ Use of naturally occurring insecticides, like neem tree products.
- ❖ Use of trap crops which attract the insects away from the fields. The trap crops are regularly checked and pests are manually removed.
- ❖ Pest larvae which were killed by viruses can be crushed and sprayed over fields which help in horizontal transfer of viruses in the field thus kill the remaining larvae.

One of the best examples in the success story of the NPM was developed by the case study of Krishi Vigyana Kendra (KVK), Medak district, Andhra Pradesh. The yields of pigeonpea in black soils were more than red soils and this is due to better moisture retention capacity. The intercrop yields were also higher in NPM than Non NPM in all the years. Year wise NPM and Non NPM plots data and cost of plant protection are shown graphically (Figure 4 and 5). The average yields of Pigeonpea are 2.66 and 1.47 quintals per hectare and inter crop yields are 6.59

and 3.34 quintals per hectare respectively. There was yield advantage with NPM practices as well as comparatively low cost of plant protection (Rs. 344 per ha) than non-NPM (Rs.1823 per ha).

Table 1. Annual accessibility of biopesticides in India

S.No	Biopesticides/Bioagents	Quantity/annum (Approax)
1	Neem 300 PPM	1,000,000 L
2	Neem 1500 PPM	250,000 L
3	Bt	50,000 Kg
4	NPV (liquid)	500,000 Kg
5	Beauveria	Meager
6	Pheromone Traps	500,000 nos.
7	Lures	2 Million
8	Trichogramma	1 Million
9	Chrysoperl & other biocontrol insects	Meager
10	Trichoderma	500 T

Table 2. Microbial based pesticides used in India

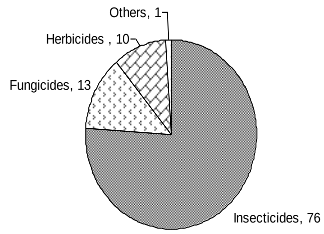
S.No	Microbial based pesticides	Products	Targets
	Fungicide		
1	*Pseudomonas fluorenscens* (Bacterium)	ABTEC Pseudo Biomass Esvin Pseudo Bio-cure-B Phalada 104PF	Plant Soil Borne Diseases
2	*Ampelomyces quisqualis* (Fungus)	Bio-Dewcon	Powdery mildew
3	*Trichoderma harzianum* (Fungus)	Biozim Phalada 105 Sun Agro Derma H	Soil born pathogen
4	*Trichoderma viride* (Fungus)	Monitor,Trichoguard NIPROT, Bioderma Biovidi,Biohit,	Soil born pathogen
	Fungicide/Bactericides		
5	*Bacillus subtilis* (Bacterium)	--	Soil born pathogen
	Insecticide		
6	*Bacillus thuringiensis subsp. israelensis* (Bacterium)	Tacibio Technar	Lepidoptera pests
7	*Bacillus thuringiensis subsp. kurstaki* (Bacterium)	Bio-Dart Biolep Halt Taciobio-Btk	Lepidoptera pests
8	*Beauveria bassiana* (Fungus)	Myco-Jaal Biosoft ATEC Beauveria Larvo Guard Biorin, Biopower Biolarvex,	Coffe berry borer, diamondback moth, thrips, grasshoppers, whiteflies, aphids, colding moth

(**Source:** CIB & RC Website, minutes of the Registration Committee meeting on June 2003-march 2009)

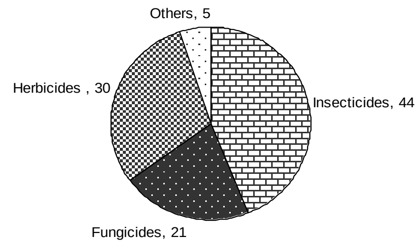
Table 3. Plant parts used as biopesticides

S.No	Name of the plant	Part used
1	Neem *(Azadiricta indica)*	Kernal extract, Cake extract, Neem oil
2	Nirgudi *(Vitex negundo L.,)*	Leaf extract, Leaf extract & Aloe extract, Leaf extract of Pongamia,
3	Tobacco*(Nicotiana tobacum L.,)*	Leaf extract , leaf extract & lime extract, Leaf and Cow urine
4	Pongam *(Pongamia glabra vent)*	Leaf dry,seed oil
5	Tulsi (Basil) *(Ocimum basillicum L.,)*	Leaf extract
6	Aloe *(Aloevera mill)*	Leaf extract
7	Custard apple *(Annona squamosa)*	Leaf extract Custard leaf + neem & red chilies,, Custard leaf + calotropis & tobacco
8	Garlic *(Allium sativum)*	Bulb and mineral oil (kerosine) Garlic oil, Garlic and neem

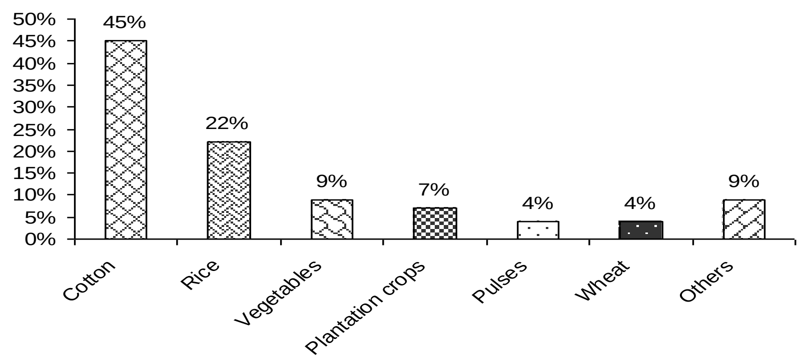
Figure 1



A) Pattern of Pesticide Consumption in India



B) Pattern of Pesticide Consumption in World



C) Pesticide consumption by different crops in India

Figure 2. Consumption Pattern of Pesticide Worldwide

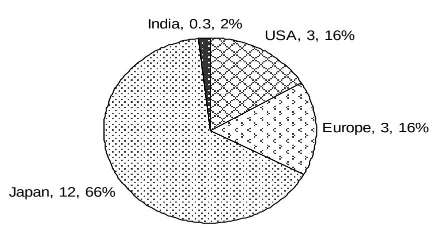


Figure 3. Tendency of global pesticide-biopesticide market

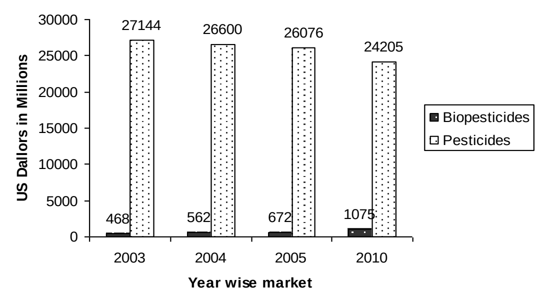
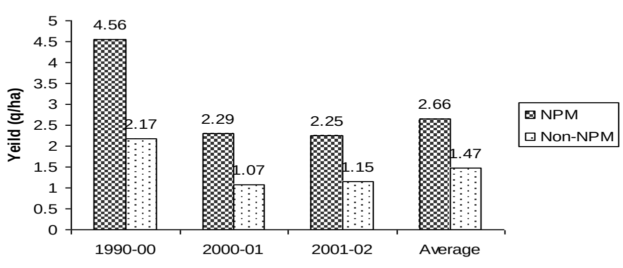
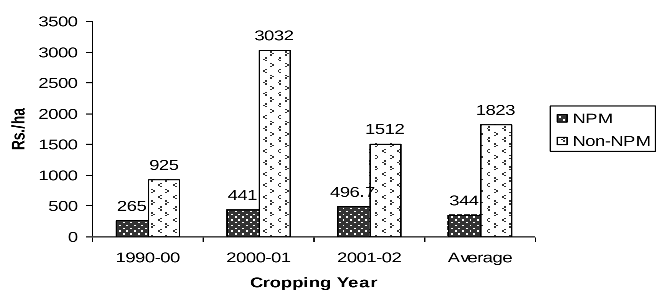


Figure 4. Pigeonpea yields (q/ha) in NPM and Check plots 1999-2002



Source: Non pesticides management of *Helicoverpa armigera* in Pigeonpea – a case study by KVK, Medak

Figure 5. Cost of Plant Protection (Rs/ha) in NPM Vs Non NPM Plots



Source: Non pesticides management of Helicoverpa armiger a in Pigeonpea – a case study by KVK, Medak

CONCLUSION

In conclusion, it is well established that the natural pesticides have many advantages over synthetic ones and may be more cost-effective as a whole, considering the environmental, cost of chemical alternatives. Natural pesticides are biodegradable, barely leave residues in the soil and are less likely to harm humans or animals. In addition, they are cheaper and more accessible in less developed countries. Further research and development of biological pest control methods must be given priority and people in general and agriculturists in particular must be educated about the handling and use of such control measures. However, the need in the present day context is on IPM and Non-IPM by practicing these quality of life and health will be assured.

REFERENCES

Anonymous 1. http://www.careratings.com/content/ResourceCenter/IndustryReport.aspx India's consumption of pesticides, 2011

Anonymous 2. www.eplantscience.com/.../biotech_eb_exsitu_bioremediation.php Ex situ Bioremediation - Environmental Biotechnology.

Biji CP, Suheendrakumar W, Sajeev TV. Quantitative estimation of production of Hyblea puera NPV in three stages of teak defoliator. *J. Virol. Methods*. 2006; 136: 78-82.

Brouwer A, Longnecker MP, Birnbaum LS, Cogliano J, Kostyniak P, Moore J, Schantz S, Winneke G. Characterization of potential endocrine related health effects at low dose levels of exposure to PCBs. *Environ Health Perspect*. 1999; 107: 639.

Carlson DL, Hites RA. Polychlorinated biphenyls in salmon and salmon feed: Global differences and bioaccumulation. *Environ. Sci. Technol*. 2005; 39: 7389-7395.

Farhan. AEBM, Copping LG (ed) (2004). The manual of Biocontrol agents (formerly the biopesticide Manual) 3rd Ed. 2011.

Forget G. Balancing the need for pesticides with the risk to human health. In: Impact of Pesticide Use on Health in Developing Countries. Eds. G.Forget, T. Goodman and A. de Villiers, IDRC, 1993; Ottawa, p. 2.

Gill SS, Cowles EA, Pietrantonio PV The mode of action of *Bacillus thuringiensis* endotoxins. *Annu Rev Entomol.* 1992; 37:615–636.

Hammock BD, Inceoglu AB, Rajendra W, Fuxa JR, Chejanovsky N, Jarvis D, Hanzlik TN. Impact of Biotechnology on pesticide delivery., In : Pesticide Chemistry and Bioscience: The Food-Environment Challenge, Edited by Gerald T. Brooks and Terry R. Roberts, Published by *The Royal Society of Chemistry London*, UK, 1999;73- 99.

Kalra A, & Khanuja SPS. Research and Development priorities for biopesticide and biofertiliser products for sustainable agriculture in India. In. Business Potential for Agricultural Biotechnology (Teng, P. S. ed.), *Asian Productivity Organisation.* 2007; 96-102.

Karunakaran. CO. The Kerala food poisoning. *J Indian Med Assoc.* 1958; 31: 204.

Kole RK, Banerjee H, Bhattacharyya A. Monitoring of pesticide residues in farm gate vegetable samples in west Bengal. *Pest. Res. J*. 2002; 14 (1): 77-82.

Koul O, Wahab S. Neem: today and in the new millennium. 2004; *Kluwer Academic Publishers.*

Kranthi KR, Jadhav DR, Kranthi S, Wanjari RR, Ali S, Russell DA. Insecticide resistance in five major insect pests of cotton in India. *Crop protection*. 2002; 21(6): 449-460.

Liroff. RA, Balancing risks of DDT and malaria in the global POPs treaty. *Pestic Safety News*. 2000; 4: 3.

Mathur SC. Future of Indian pesticides industry in next millennium. Pesticide Information; XXIV 1999; 4:9-23.

Pardo-Lo´ pez, Mun˜ oz-Garay L, Porta C, Rodrı´guez-Almaza´ n H, Sobero´ n C M. and Bravo A, Strategies to improve the insecticidal activity of Cry toxins from Bacillus thuringiensis. *Peptides.*2009; 30:589–595.

Peng D, Luo Y, Guo S, Zeng H, Ju S, Yu Z, Sun M. Elaboration of an electroporation protocol for large plasmids and wild-type strains of *Bacillus thuringiensis*. *Journal of Applied Microbiology.* 2009; 106: 1849–1858.

Prasad SS. *Country Report – India***.** Report prepared for the meeting of the Programme Advisory Committee (PAC), Ayutthaya, Thailand 2001.

Rabindra RJ. Current status of production and use of microbial pesticides in India and the way forward. p1-12, In Rabindra, RJ, SS. Hussaini and B. Ramanujam (ed.), Microbial Biopesticde Formulations and Application. Project Directorate of Biological Control, Technical Document No.55: 2005.

Rajendra W, Kevin J, Hackett Ellen Buckley, Bruce D Hammock. Functional expression of Lepidopteran-selective neurotoxin in baculovirus: Potential for effective pest management, *Biochimica et Biophysica Acta*. 2006; 2 (16): 1-8.

Salama HS, Morris ON, Rached E. The Biopesticide *Bacillus thuringiensis* and its Applications in Developing Countries. Proceedings of an International Workshop organised by NRC-Cairo, *Agriculture Canada and IDRC.* Cario.1993.

Singhal V. Biopesticides for sustainable agriculture: prospects and constraints. p31-40, In E. Kaushik (ed.), Biopsticides in India. All India Biotech Association 'Vipps Centre'. New Delhi. 2004.

Thakore Y. The biopesticide market for global agricultural use. *Industrial Biotechnology Fall.* 2006; 194-208.

Veenakumari K, Rabindra RJ, Srinivasa Naik CD, Shubha MR. In situ field level mass production of Amsacta albistriga (Lepidoptera: Arctiidae) nucleopolyhedrovirus in a groundnut ecosystem in South India. Biol. *Abstr. Int. J. Trop. Insect Sci.* 2007; 7: 48-52.

Wadhwani AM, Lall IJ. Harmful Effects of Pesticides. Report of the Special Committee of ICAR, Indian Council of Agricultural Research, New Delhi, 1972: 44.