Available online at www.agrifarming.org

DOI: http://dx.doi.org/10.18782/2582-7146.169

ISSN: 2582 – 7146

Curr. Rese. Agri. Far. (2023) *4*(1), 1-7

Current Research in Agriculture and Farming

Review Article

Peer-Reviewed, Refereed, Open Access Journal

Sustainable Pest Management- A Review in the Indian Context

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Received: 18.12.2022 | Revised: 29.01.2023 | Accepted: 13.02.2023

ABSTRACT

The present study was undertaken to review the current status of sustainable pest management in India. Insect pest management is the key input in sustainable crop production. Sustainable agriculture is a holistic approach to ecofriendly agricultural technologies. Most of the agricultural resources are exploited by modern agricultural technologies without taking care of ecology and possible consequences. It's an urgent need to minimize this exploitation for the safe hand of agricultural resources to the next generations keeping healthy agriculture for wealthy nations. The role of pesticides in crop production to augment output has been well perceived, and these have been considered essential inputs in crop production. The indiscriminate use of pesticides has led to serious consequences like harmful residues in the produce, pesticide resistance and outbreaks of secondary pests. This has brought a complete change in the strategy of insect pest management. This pest management motivated agricultural scientists, administrators and leaders to promote Integrated pest management (IPM). There are varieties of techniques for pest management that have been practised from traditional to modern. The modern approach to pest management has been paradigm-shifting to sustainable pest management. During the past four decades, efforts have been made to reduce the risk of harmful exposure to non-target organisms of insecticides. Many newer insecticides have been developed, which are more selective than conventional ones. Biointensive IPM, Ecological engineering, and Ecofriendly insecticide toxicology have been found to be major current advances in an innovative approach to sustainable pest management. Biointensive IPM attempts to reduce the application of chemical pesticides by using biopesticides, biotic stress-tolerant varieties, and application of eco-friendly insecticides. The Push and pull technique involves a rational approach of insect pests and their bioagents by integration of stimuli.

Keywords: *Sustainable pest management, Integrated pest management, Current status, India.*

INTRODUCTION

Insect pest management is the key input in sustainable crop production. Sustainable agriculture is a holistic approach to eco-friendly agricultural technologies. Most of the agricultural resources are exploited by modern agricultural technologies without taking care of ecology and possible consequences.

Cite this article: Morya, G. P., & Kumar, R. (2023). Sustainable Pest Management- A Review in the Indian Context, *Curr. Rese. Agri. Far. 4*(1), xxx-xxx. doi: http://dx.doi.org/10.18782/2582-7146.169

Modern agricultural technologies like monoculture cause rapid erosion of crops and natural soil fertility and pest outbreaks, while chemical inputs cause environmental pollution and chemical hazards, mechanization causes the high cost of cultivation and capital-intensive agriculture breakdown the social fabric of rural communities. It is urgent to minimize this exploitation for the safe hand of agricultural resources to the next generations keeping healthy agriculture for a wealthy nation. No doubt, Insecticides are the most powerful tool available for use in pest management and will continue to be in the foreseeable future. They are highly effective, rapid in curative action, adaptable to most situations, flexible in changing conditions and relatively more economical. The role of pesticides in crop production to augment output has been well perceived, and these have been considered essential inputs in crop production. But meanwhile, they are obviously biocides having the ability to cause toxicity to all living organisms. Pesticides are highly potent chemicals that enter our food chain and then begin to increase in their concentrations at successive trophic levels. (NAS, 1969; Norris et al., 2003; & Dhaliwal et al., 2013).

The indiscriminate use of pesticides has led to serious consequences like harmful residues in the produce, pesticide resistance and outbreaks of secondary pests. This has brought a complete change in the strategy of insect pest management. This pest management motivated agricultural scientists, administrators and leaders to promote Integrated pest management (IPM). It is an eco-friendly pest management approach that is practical, economical, effective and protective of public health and the environment. So, integrated pest management is generally termed eco-friendly pest management. There are varieties of methods applied for insect pest management. Most are being used isolated in form, unable to successful pest management. Any methods are neither perfect nor ultimate, and each has constraints and drawbacks. The cultural, physical and biological methods cannot be applied at any crop growth stages, and the chemical method is applied as a last resort that may cause toxic hazards. Integrated pest management (IPM) is a sustainable approach to managing insect pests in a compatible manner by combining all available methods of insect pest management. There are varieties of techniques for pest management that have been practised from traditional to modern. Biointensive IPM, Ecological engineering, and Ecofriendly insecticide toxicology have been found to be major current advances in an innovative approach for sustainable pest management. (Norris et al., 2003; Dhaliwal et al., 2013; Rao, 2019; DPPQS, 2021; & FAO, 2021).

Important Approaches in Sustainable Pest Management

Integrated Pest Management (IPM)

Integrated pest management (IPM) is generally termed eco-friendly pest management. It is a multidisciplinary ecofriendly approach to pest management that is practical, economical, effective and protective of both public health and the environment. Integrated pest management is not a new concept. Many of the components of a sound IPM system were known and practised before the advent of modern chemicals. The IPM strategies have been practised for the past 100 years, but the concept was not widely recognized until the late 1970s. The term 'integrated control' was used first time by Michelbacher and Bacon to manipulate insecticide treatment keeping beneficial arthropods for the management of walnut insect and spider mite pests in Northern California. Bartlett cited this term for the integrated use of biological and chemical controls to manage insect pests of agricultural crops. However, the concept of integrated control was first articulated by Stern and his colleagues as an approach applied to integrate biological and chemical control methods of insect pests utilizing ecological principles and laid down the economic theory of insect pest management, i.e., economic threshold level and economic injury level etc. Subsequently, it was broadened to include all control methods and classes of pests. Rachel Carson's Silent Spring had been played a major role in

introducing the dangers of pesticides to the public conscience. (Michelbacher & Bacon, 1952; Bartlett, 1956; Stern et al., 1959; Carson, 1962; Smith et al., 1976; Norris et al., 2003; & Peshin et al., 2009).

Recently, The Food and Agriculture Organization (FAO) has defined, Integrated pest management means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. There are four basic principles of integrated pest management or eco-friendly pest management, *i.e.*, 1. Pest surveillance 2. Understanding of ecosystem 3. Utilization of economic threshold level, and 4. Application of minimum selective chemicals. IPM emphasizes the growth of a healthy crop with the least possible disruption to agroecosystems and encourages natural pest control mechanisms. Now this IPM way forward to Biointensive Integrated Pest Management and Integrated Biodiversity Management. (Norris et al., 2003; Dhawan & Peshin, 2009; Dhaliwal et al., 2013; DPPQS, 2021; & FAO, 2021).

Biointensive IPM

Biointensive IPM is the intensive biological approach for integrated pest management. It is an important strategy to achieve the goal of sustainable pest management. This approach considers the farms as part of an agroecosystem that relies on monitoring and diagnosis for pest management. It is based on proactive measures to redesign the agricultural ecosystem to the disadvantage of the pests and to the advantage of its bioagents. According to Benbrook and his colleagues, "Biointensive IPM is a systems approach for management of crop pests based on an understanding of pest ecology. It begins with steps to accurately diagnose the nature and source of pest problems, and then relies on preventive tactics and biological control to keep pest population within acceptable limits." Minimizing the use of pesticides is the global demand of nature for a safer environment. Biointensive IPM attempts to reduce the application of chemical pesticides by using biopesticides, biotic stress-tolerant varieties, and application of eco-friendly insecticides. Biointensive IPM utilizes all the available techniques which promote pest management more biological and eco-friendly. Ecological engineering and eco-friendly insecticide toxicology are the most effective techniques for bio-intensive IPM. (Benbrook et al., 1996; Dhaliwal et al., 2013; Prakash & Rao, 2016; & Rao, 2019).

There is recently been an effective experience with bio-intensive IPM in cotton by ICAR-NCIPM New Delhi, India. The successfully tested module comprised use of bioagents, biopesticides based on scouting and constant monitoring of pests and their economic threshold levels (ETL) with the introduction of suitable crop management practices. The management practices adopted included planting maize as a border crop interspersed with cowpea for the buildup of ladybird beetle predators and their migration to cotton; Planting a row of foxtail millet between every 9 or 10 rows of cotton to enhance the activity of predatory birds by serving as a food source and acting as a live perch; Sunflower, Mustard, Marigold and Coriander crops border Cole crops. Sunflower crop is the tallest crop to attract the *Helicoverpa armigera*, and it is surrounded by two rows of mustard crops to attract Green lacewings and Ladybird beetles. Marigold is also the preferable crop for egg laying of *Helicoverpa armigera*, and Coriander crop attracts different natural enemies of main crop insect pests; Release of *Trichogramma chilis* @ 1,50,000/ha in cotton fields when 2-8 adult moths of *Helicoverpa armigera* per pheromone trap were captured continuously for 3-4 days in a week; spraying of Neem seed kernel extract (NSKE) 5% a week after the release of *T. chilis*. (Dhaliwal et al., 2013; Sharma et al., 2016; Rao, 2019; DPPQS, 2021; & FAO, 2021).

Ecological engineering

Ecological engineering is the new paradigm to enhance the biological pest management system. It is an important strategy for promoting biointensive IPM to achieve the goal of sustainable pest management. It is based on cultural practices to enhance the bioagent population by habitat manipulation under an agroecosystem of crop fields. According to Gurr and his colleagues, "Ecological engineering emerged as a paradigm for considering pest management approaches that are based on cultural practices and informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops." The primary objective of ecological engineering is to make the environment of the agroecosystem suitable for the better survival of bioagents of insect pests. The ecological engineering provides habitat manipulation of bioagents of pests with nectar, pollen, physical refuge, alternate prey, alternate hosts and living sites. This can be achieved by push and pull technique using trap and repellent crops. The Push and pull technique involves a rational approach of insect pests and their bioagents by integration of stimuli that act to make the protected resources unattractive or unsuitable to the pest (push) while luring them toward an attractive source (pull) from where the pests are subsequently removed. The pests are repelled or deterred from the resource using stimuli that mask host apparency. The pests are simultaneously attracted using highly apparent and attractive stimuli to other areas of trap crops, where there concentrated, facilitating their elimination. The technique involves the combined use of intercrops and trap crops using plants that are appropriate to the farmers, and that also exploit bioagents. (Gurr et al., 2004; Cook et al., 2007; Dhaliwal et al., 2013; & Rao, 2019).

The most successful example currently used in practice was developed in Africa for the management of Lepidopteran stem borers like *Chilo partellus, Eldana saccharina, Busseola fusca* and *Sesamia calamities* in maize and great millet. The technique involves the combined use of intercrops and trap crops using plants that are appropriate to the farmers, and that also exploit bioagents. The stemborers are repelled from the crops by repellent non-host intercrops, particularly Molasses grass (*Melinis minutiflora*), Silverleaf desmodium (*Desmodium uncinatum*) (push). These are concentrated on attractive trap plants, primarily Napier grass (*Pennisetum purpureum*) or Sudan grass (*Sorghum sudanense*) (pull). Garo farmers of West Garo Hills, Meghalaya, India, are planting more fruit-bearing trees in terrace fields to attract birds for hunting and monetary concerns. But, this common practice of planting fruit-bearing trees attracts predatory birds for food and shelter. These birds keep insect pest populations down by preying on them. (Amudavi et al., 2007; Sinha et al., 2007; Dhaliwal et al., 2013; & Morya & Kumar, 2022).

Ecofriendly insecticide toxicology

Ecofriendly insecticide toxicology is the modern biochemical approach to enhance the ecofriendly insecticide application for insect pest management. It is an important strategy for promoting biointensive IPM to achieve the goal of sustainable pest management. The indiscriminate use of insecticides has led to serious consequences like harmful residues, insecticide resistance, outbreaks of secondary insect pests, and a threatened bioagent population. The modification of insecticide application is the most commonly implemented form of conserving bioagents. Selective insecticides are perhaps the most powerful tool that can favour bioagent diversity. Ecological selectivity is the judicious use of insecticide based on critical selection, timing, dosages, placement and formulation with the goal of maximizing the bioagents population. The continuous indiscriminate use of insecticides has also been leading to insecticide resistance, which is one of the serious constraints in effective insect pest management. Therefore, insecticide resistance management is an important component of bio-intensive IPM for sustainable pest management. Insecticide

resistance management has been achievedachieved by three major strategies,: management by moderation, management by saturation and management by multiple attacks res. Though crop losses due to plant ailments in India have been reported to be very high, the intensity of pesticide consumption in the country has been the lowest in the world (0.6 kg/ha), as compared to the USA (7 kg/ha), Japan (12 kg/ha), China (13 kg/ha) and Taiwan (17 kg/ha) and the world average of 03 kg/ha. To achieve the target of the global market of crop production, it's an urgent need to induce the rising use of pesticides. (Dhaliwal et al., 2013; Morya & Kumar, 2016; TSMG, 2016; & Devi et al., 2017).

In India, there have been 290 pesticides registered for agricultural use, and among them 90 insecticide formulations including combinations and biopesticides recommended for insect pest management. During the past four decades, efforts have been made to reduce the risk of harmful exposure to non-target organisms of insecticides. Many newer insecticides have been developed, which are more selective than conventional ones. But their general recommendations have been under broad and long-term evaluation. There have been 16 major classes of novel insecticides registered in India, *i.e*. avermectins, nereistoxins, neonicotinoids, oxadiazines, pyrroles, diamides, triazines, diacylhydrazines, dichloropropenyle ethers, pyridine azomethines, pyridine carboxamide, phenyl pyrazoles, benzoylphenyl urea tetronic acid derivatives, tetramic acid derivative and bacterial fermentation Products, while there have been 04 grand major classes of conventional insecticides registered in India, namely organochlorines, organophosphates, carbamates, and synthetic pyrethroids. Among available biopesticides, there have been 15 types of microbial biopesticides and 03 types of botanical biopesticides registered in India. The *Azadirachta indica* (Neem) based formulations and *Bacillus thuringiensis* (Bt) based formulations have been used widely in rice insect pest management. (Katti, 2013; Chhuneja & Mandal, 2018; Yadav et al., 2018; & DPPQS, 2019).

CONCLUSION

Modern agricultural technologies like monoculture cause rapid erosion of crops and natural soil fertility and pest outbreaks, while chemical inputs cause environmental pollution and chemical hazards, mechanization causes high cost of cultivation, and capital-intensive agriculture breaks down the social fabric of rural communities. It's an urgent need to minimize this exploitation for the safe hand of agricultural resources to the next generations keeping healthy agriculture for wealthy nations. The role of pesticides in crop production to augment output has been well perceived, and these have been considered essential inputs in crop production. But meanwhile, they are obviously biocides having the ability to cause toxicity to all living organisms. The indiscriminate use of pesticides has led to serious consequences like harmful residues in the produce, pesticide resistance and outbreaks of secondary pests. This has brought a complete change in the strategy of insect pest management. This pest management motivated agricultural scientists, administrators and leaders to promote Integrated pest management (IPM). It is an eco-friendly approach to pest management that is practical, economical, effective and protective of both public health and the environment. There are varieties of techniques for pest management that have been practised from traditional to modern. Biointensive IPM, Ecological engineering, and Ecofriendly insecticide toxicology have been found to be major current advances in innovative approaches for sustainable pest management.

Acknowledgement:
I would like to sincerely thank my co-author for their support to complete this manuscript in time.

Funding: NIL.

Conflict of Interest:
There is no such evidence of conflict of interest.

Author Contribution:

Both authors have equal contributions in performing this research.

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