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Integrated Pest Management and Controlling Strategies in Pakistan

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ABSTRACT

Insects are considered a potential pest affecting humans, their crops, livestock, or possessions. Various control methods and strategies have been used for a very long time. Various elements, including metals, plant derivatives, pathogens, predatory insects, and insecticides, are being used to control the pest. The emergence of Integrated Pest Management has integrated many management tactics that are less harmful to humans as well as the environment. This article covers the strategies used in Pakistan, including cultural, mechanical, chemical, biological, genetic, and regulatory control strategies. Among all these strategies, the use of biopesticides is considered the most effective. The most traditional method, cultural control, is still in practice for a variety of crops in Pakistan. The mechanical methods are also used widely to protect crops like maize in Pakistan. The most powerful strategy being applied in Pakistan to produce high yield and sustainable crops is the chemical control method. Biological control has played an essential role in conserving the environment by reducing the use of pesticides and controlling major insect pests. Genetic engineering is an emerging controlling strategy that is providing an effective way to protect and enhance the agricultural industry in Pakistan. The legislation could also prove to be an important factor in controlling the pest populations effectively.

INTRODUCTION

An atavistic battle prosecuted by humans for 4000 years or more is called pest control, in anticipation of an extremely tenacious but mostly minute foes. Even though this war is quite old, the dynamics, objectives, and nature of the principal protagonists are still ill-defined. Battles have been won and lost, but lessons have been learned slowly and painfully (Conway, 1976; Dent and Binks *et al*., 2020). An insect evaluated by man as a potential threat to himself, his crops, his livestock or his possessions is called a pest (Bragard *et al.,* 2023) and is sufficient enough to reduce the yield or quality of the 'harvested product' by an amount that is unacceptable to the farmer, either directly (Daelemans *et al*., 2023) to harvestable products, e.g. codling moth larval damage to apples, or in an indirect manner, e.g. by causing a nuisance to livestock or humans or as vectors of plant or livestock.

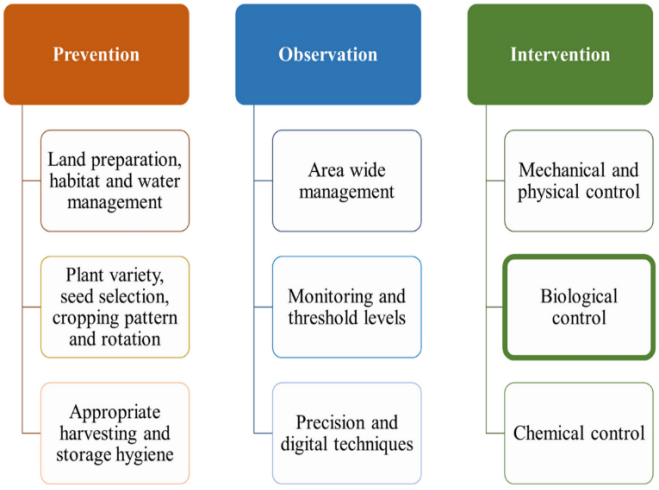
The knowledge of the history of this war can add a dimension by providing insights into foraging driving forces (technical, social, and economical), which gives the idea of future intruding forces. The different control techniques and strategies available to us today were utilized in some shape or form many years BC, aren't new. For instance, the use of Sulphur compounds as mites and insect control by Sumerians from 2500 BC, mercury usage by Chinese, manipulation of planting dates around 1500 BC, burning as a cultural control in 950 BC, manipulation of natural enemies in China and Yemen using ants and even genetic resistance and resistant land races development has been witnessed by history. Thus, by 500 AD all types of control measures were developed and utilized by different civilizations. Parasitism (1685) and the use of predatory insects (1752) for disinfecting crops were introduced later (Abbas *et al*., 2023). Human beings have been using pesticides for a very long time. A variety of elements and metals had been used to produce crops

with a variety of plant derivatives as well. Humans developed the first insecticide in the early 17th century. Pesticides containing arsenic as an important and dominant component were commonly used until 1950. The revolution takes place in the mid-20th century. In the 1960s, herbicides were commonly used. In the late 1970, the latest pesticides, which were artificially synthesized, were being used in common (Shahid *et al*., 2016). IPM emerged after World War-II to cope with the negative impacts of pesticide use, although it has not successfully resolved this problem. IPM has integrated many management tactics, surveillance of pests and other natural enemies, using the threshold for making any decision, and traversing the methods for handling the pesticide product (Pretty and Bharucha, 2015).

The basic strategies used for this can be further categorized as conventional, mechanical, biological, and chemical (Hajjar *et al*., 2015; Ofuya *et al*., 2023 and Azeem *et al*., 2022). Awareness is also quite an influential strategy (Khan *et al*., 2021). Farmers' perspective towards pest control and standards for acceptable levels of insect control has been greatly influenced by the shift from sedentary farming to agribusiness (Morse and Buhler, 1997). The requirement of risk reduction among agriculturalists paved the way for chemical insecticides. But the excess use of pesticides can cause environmental disturbance stirring the equilibrium between pests and their natural enemy (Azeem *et al*., 2022). Thus, a long-lasting systematic strategy is required. The ultimate "universal" control method hunt is entirely delusional (Barzman *et al*., 2015). Changing climate, anthropogenic activities, acceleration of world population, increased food supply requirement by 50-75%, uncertainties and frequency of new pest emergence, resistance to pesticides, low management adoption rate in developing countries including Pakistan and low awareness level has led to lower agricultural yields and possessed serious threats to the agricultural sustainability due to natural source depletion.

In 1946, IPM was introduced and significantly impacted the view, practice, and study of pest control because of its diverse nature, and the range of individuals, disciplines and organizations involved in its study, development, and implementation as it works on 8 basic principles i.e., Prevention and suppression, Monitoring, Decision-making, Non-chemical methods, Pesticide selection, Reduced pesticide uses, Anti-resistance strategies and Evaluation (Barzman *et al*., 2015). The most effective ones are the use of protein based baits, male annihilation technique (Azeem *et al*., 2022) and many more techniques implied individually or in all possible combinations, e.g., Weeding+hand-picking+Steward (Waqas *et al*., 2015). Insect resistance to chemicals started in 1946 and spread worldwide by mid twentieth century which along with vocal scientists, led to funding and development of alternative, more environmentally friendly approaches such as insect pheromones, sterile insect techniques, microbial insecticides, and host plant resistance. IPM was launched worldwide in 1980, and a different model of IPM was born in the primitive world of agriculture of the East. Which emphasized training of farmers, creating sufficient understanding and awareness (Khan *et al*., 2021). Environmental concerns over last 30 years have caused IPM endorsement internationally and will be a key factor in driving pest control in next millennium.

Pakistan, being an agricultural country uses most of its land in the production of crops. It is regarded as a major source of income for most of its population and has a significant impact on the gross production of the country. The use of various substances to control the pest populations and to magnify the production of sustainable crops has been used for a very long time. In Pakistan, pesticides were used for the first time in 1954, and their consumption has been increased greatly in 1980 (Shahid *et al.,* 2016). The integrated pest management strategy was first implemented in Pakistan in 1971 including two major projects on bollworms and whitefly and has been extended in the following years to different IPM projects (Abbas *et al.,* 2023). In Pakistan, the use of biopesticides has evolved and is more effective than the other chemicals being used. A law has been implemented to approve these products before introduction in the country (Arora *et al*., 2016). Comprehensive Infestation and population level studies (research), pheromone traps, bio-efficacy testing and evaluation for commercial use, usage of plant extracts as pesticides, the repellent properties of microbes, larvicidal and insecticidal efficacy testing of microbes, rearing of natural enemies by Sindh government, usage of egg parasite of sugarcane borers and application of pheromone methyl eugenol to control fruit flies are very common IPM techniques in Pakistan (Abbas *et al*., 2023). Varied driving forces influence the prospects of IPM to an unpredictable extent thus it is important to properly consider these prospects (Dent and Binks, 2020).



Cultural Control Method refers to all those conventional practices and methods which are being used to control the pest in a very natural way. This method focuses on controlling the pest and enhancing the production of the crops. The main objective of this method is to make the environmental conditions not suitable for the survival of the insect pests but could be essential for the crops. Several methods like crop rotation, various combinations of crops, tillage, healthy crop production, intercropping, and many more are being used as conventional methods in IPM. To manage the chances of pest outbreak, three main factors need to be considered, i.e., prevention, avoidance, and suppression (Yadav *et al*., 2021 and Bashyal *et al*.,

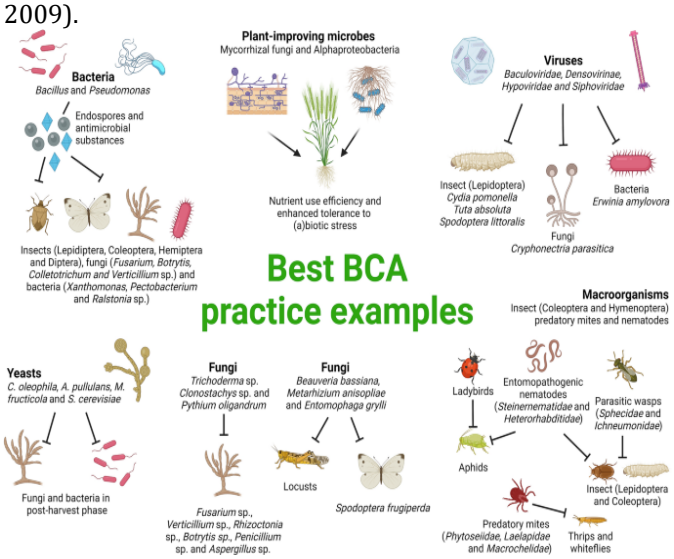
2022). Crop rotation has been used for a very long time. In this method, the crops are grown in a disciplined manner keeping in view the land fertility. This is especially applied to the removal of nematodes (Tanveer *et al.,* 2019). Tillage is another important conventional method that is used to make the soil ideal for the germination of seeds and the growth of a crop. Tillage has been widely used for various crops in Pakistan, like wheat, rice, maize, cotton, soybean, sunflower, pulses, and many more (Wasaya *et al*., 2019).

Physical Control Method refers to those mechanical or hand controls where the pest is attacked or destroyed. A few mechanical methods being used to control pests are Hand picking method, Barriers, Bagging and Screening, the Netting Method, Floding, Airtight technology (The hermetic bag introduced to cease the exchange of gases as well as the moisture content with environment), and Mulching materials such as Organic mulch. Pheromone traps physical control is the best method to control the pest's population. This control can be categorized as *Active-* polishing, mechanical, pneumatic etc., are involved as an active control. *Passive-* use fences, oils, inert dust particles films, trenches, etc. In *Miscellaneous Cold Storage-* Heated air, hot water immersions, flaming etc. (Thakur e*t al*., 2021). The basic principle is the "dry chain" concept in which low seed moisture contents are maintained at ambient temperature. For Example, Pakistan's 3rd largest important crop is Maize, the single largest source of human food and animal feed in Azad Jammu and Kashmir, Pakistan (Khalid *et al*., 2024). The growth of pests can be prevented through climate change. Climate change is also harmful to crops so we should adopt modern pest management technologies and prediction tools to predict the pests (Subedi *et al*., 2023).

Chemical Control Methods (pesticides) are the most powerful strategy used in IPM programs. Chemical controls are planned to suppress pest (insect, pathogen, rodent, etc.) populations to an extent that will not affect the crop (Brunner 1994). Aerial use of insecticides started in the 1920s and become larger after World War II with the extensive adoption of DDT essentially for the repression of spruce budworm, *Choristoneura fumiferana, Clemens* (Lepidoptera: Tortricidae), and other defoliating insects (Holmes and MacQuarrie 2016). The pod borer *Helicoverpa armigera* (specie of Lepidopterain the family Noctuidae) is a major insect pest of chickpea and several other crops in Asia, Africa, and Australia. The present studies were conducted on the integration of practices for the management of *H.armigera* in Punjab, Pakistan, which revealed that indoxacarb (an oxadiazine insecticide) has shown successful in reducing the larval population and pod infestation and follow highest grain yield (Wakil *et al.,* 2009).

Sustainability in food and fiber production is important for all nations. To enhance agriculture crop production, agrochemicals such as fertilizers, weedicides and pesticides have been used. Due to high yield and boosting agriculture crop production the use of pesticides increased year by year throughout the last 20 years (Hashmi, 2016). A review of randomly selected cotton farmers from two districts of Punjab to study the practice of crop protection revealed that use of pesticides is the only method to control pests. All farmers are using pesticide products because spraying chemicals is highly effective and the most useable choice of the time (Khan and Damalas, 2015). The mealybug *phenacoccus gossypiphilous* damaged the cotton crop in Pakistan during 2005. To prevent the cotton crop, insecticides of different groups were analyzed in both laboratories and in field conditions. In laboratory, bifenthrin, profenofos and chlorpyrifos were shown beneficial for mealybug control. In field conditions, the use of methomyl, profenofos, and chlorpyrifos provided the best control. The present review has shown that the insecticides analyzed, bifenthrin, methomyl, profenofos and chlorpyrifos proved best for the control of the cotton mealybug (Saeed *et al*., 2007).

Biological Control Method is the exploitation of living agents including viruses, to combat pestilential organisms, including pathogens pests and weeds, for many reasons to provide human benefits (Baker *et al.,* 2020). In Pakistan, biological control has received a great amount of research attention and is playing a crucial role in controlling major insect pests, limiting the use of pesticides, and conservation of the environment (Qazi and Khachatourians, 2005). There are three different types of biological pest control, i.e., Augmentation Conservation and Importation. Aphids are important pests of cultivated crops in Pakistan. They not only slow down the yield of crops but also act as vectors of disease. There are about 92 species of aphids in Pakistan. In Pakistan, aphids have mostly been controlled by insecticidal use. In IPM, the role of parasitoids and predators is very important. The parasitoids attacking various aphids amount to 30, belonging to 6 families. Honey dew secreted by the aphid inspires black sooty mould development that causes 20-80% damage by covering the leaves and disturbing the process of photosynthesis (Aslam *et al*., 2011). IPM and organic are agreeable approaches to agricultural production that both depend upon biological control. Both reduce pesticide use, risks, and serious impacts (Orr, 2009).



Best practice examples of biocontrol agents (BCAs) currently employed in IPM to control some major pests and diseases. Examples presented here utilize multiple mechanisms, including nutrient competition, antibiosis and mycoparasitism. Plant-improving microbes, including microbial plant biostimulants, often improve plant health by inducing resistance to biotic or tolerance to abiotic

stresses

Genetic Control Method refers to those methodologies in which selected wild species are allowed to mate with the mutated or genetically modified individual in a particular area. The main objective of this method is to limit the pest population and their status in an area by modifying their genetic makeup, by directly killing them, or by reducing their potential to mate. The technique that is being used frequently in this regard is the insect technique in which sterile males are produced by the irradiation process and then allowed to mate with the females to reduce the population of specific pests (Leftwich *et al*., 2021; Alphey and Bonsall, 2018). In Pakistan, the recombinant DNA technology or Biotechnological techniques are an effective way to protect and enhance the agricultural industry. The novel biotechnological techniques are efficacious and commodious by providing a much more convenient method of gaining the products comfortably in bulk quantities. Through genetic engineering, we can introduce such plant varieties that could offer more resistance and efficacy towards plant production. The production of genetically engineered plant varieties or transgenic plants has provided a new insight into the agriculture industry. In this regard, two perspectives have gained much popularity around the globe. First, the use of endotoxin genes of *Bacillus thuringiensis* to provide resistance to the crop or plant. Second, the use of insect resistance genes like protease inhibitors, α-amylase inhibitors, proteolytic enzymes inhibitor, etc., after identifying them in the plants. The Pakistani Government is now focusing on implementing the rules for Biosafety in the production of such transgenic varieties (Karim, 2000). Some other approaches that are being taken into account are the production of genetically engineered strains of specific pest species and the release of toxin-sensitive males produced by genetic engineering in a colossal amount (Alphey and Bonsall, 2018).

Regulatory Control Method- For the better use of pesticides in any area and to reduce the harmful effects of these chemicals on human health, several important acts and rules have been formulated and implemented (Arora *et al*., 2016). Several governing bodies have been established that tend to present these issues in the US, and they are working in collaboration with many international agencies (Nawaz *et al*., 2019). The Federal Government of Pakistan was responsible for the importation of pesticides until 1971 as the rules and regulations on pesticide use were not implemented then. In 1971 and 1973, the ordinance and rules on agricultural pesticides were developed, respectively (Shahid *et al*., 2016; Syed *et al*., 2014). The main purpose of these acts was pointed out on the formation, development, importation, sustainable use, occurrence, sale in the country and the registration strategy for the companies that formulate various pesticides (Nawaz *et al*., 2019; Shahid *et al*., 2016). In 1965, a rule was introduced to check and control the remains of pesticides in the food samples, namely the Food and Agricultural Regulation. The trading, administration, and retailing of pesticides have been privatized since 1989. Pakistan signed the Rotterdam Convention in 1999 and the Stockholm Convention in the following year, 2000 (Shahid *et al*., 2016). A gap still exists in the implementation of these laws (Syed *et al*., 2014).

DISCUSSION

Sustainable pest management is a two-standard approach that needs complete understanding about control strategy, pest biology and ecology, which help to choose the most appropriate method, timing, and place for effective control of pest (Nawaz *et al*., 2019).

The adoption of integrated pest management practices is notably low globally, especially in developing countries. This study focuses on understanding the factors influencing Pakistani farmers' inclination toward adopting integrated pest management in vegetable production. Exploratory factor analysis revealing key factors such as reliance on pesticides (79.4% of farmers), with okra (43.8%), potato (24.5%), and cauliflower (17.9%) receiving the highest pesticide applications. We found hidden factors using a method called confirmatory factor analysis. These factors include knowing about the bad effects of pesticides, thinking that non-chemical ways can control pests, facing obstacles in adopting integrated pest management, having a modern approach to farming, and having the desire to use integrated pest management. The scale we created to measure how much farmers want to use integrated pest management gives useful information for future research. It also helps policymakers plan campaigns to encourage farmers to use integrated pest management in the study area (Khan *et al*., 2021).

The use of pesticides is one of the disputed issues of the public because the extensive use of pesticide produces instant benefits to a small society and agriculture industry while the long-term threats are shared by society. This discussion focused on the disparity between benefits and risks and some long-term ecological problems that have arisen from overuse, misuse, and unwise use of pesticide. Detailed discussion is provided for such ecological catastrophes as insect pest resistance to pesticides, pest revival and the development of secondary pests in conjunction with contamination of food webs and extensive ecotoxicity. It is suggested that the implementation of integrated pest management (IPM) strategies provides the only practical solution to the numerous problems arising from the sole reliance on pesticides for pest control. IPM provides an ecological-oriented tactic for pest control that can maximize the benefits of pesticide use and minimize the risks (Metcalf, 1987).

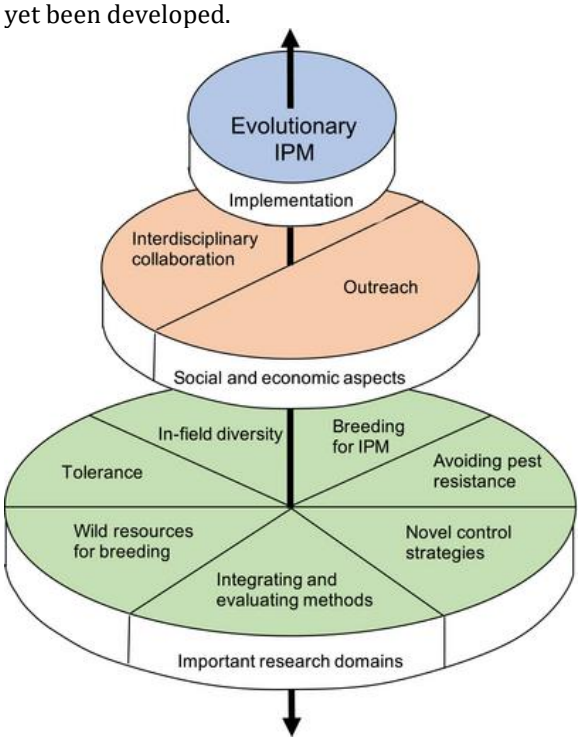
The science of IPM is the systematic study of the compatibility and optimization of simultaneously implemented methods. Such optimization requires an evolutionary perspective which, to date, is lacking.

Commonly used methods that require evolutionary fine-tuning:

- Chemical control—only to be used as a last option
- Biological control—the use of living organisms to control pests
- Semiochemicals—including insect pheromones and kairomones
- Plant diversity—including intercropping and/or cultivar mixing
- Crop vaccination—including priming and induction of crop defenses

- Plant resistance—including antibiosis and antixenosis
- Plant tolerance—a plant's ability to endure enemy attack without yield loss
- Cultural control—including crop rotation, and watering regime

In addition to these pest controlling measures, IPM programs often include monitoring and forecasting of pest populations, as well as use of decision supporting tools to determine when chemical interventions are necessary. However, evolutionary-based support tools that provide robust guidance for combining preventive actions have not yet been developed.



CONCLUSION

It is evident from the study that multiple Integrated Pest Management control strategies have been used and implemented in Pakistan since its emergence. The need for IPM strategies was mainly to control the pest populations' levels and their attack on the crops and yields to protect the country's GDP. Due to the higher illiteracy rate in Pakistan, traditional methods are still used by most of the farmers. This rate has also influenced the adoption rate of these IPM strategies. Some other practices which are being used by many Pakistanis include mechanical control methods, chemical control methods promoting the excessive use of pesticides, biological control method using various natural enemies to control pest, and genetic control method using biotechnology to promote a safer control of the insect pest. A very important factor is the implementation of some rules and regulations regarding the importation of harmful chemicals within the country. Although it is considered that the use of biopesticide provides a promising future to the agricultural industry in Pakistan.

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