Chapter

Modern Technologies for Pest Control: A Review

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Abstract

The major concern for farmers is important loss due to pests and diseases, which is regardless of any production system adopted. Plant pathogens, insects, and weed pests devastate over 40% of all possible sustenance creation every year. This loss happens despite utilizing approximately 3 million tons of pesticide per year in addition to the use of a variety of nonchemical controls such as biological controls and crop rotations. If some of this food could be saved from pest attack, it could be utilized to bolster an excess of 3 billion people who are malnourished in the world today. Expansive range of conventional insecticides such as carbamates, organophosphates, pyrethroids, and organochlorines were developed. They have been used to control insect pests in the course of recent decades, resulting in the reduction of the loss of agricultural yield. However, problems of resistance reaching crisis proportions, the extreme unfavorable impacts of pesticides on the environment, and public complaints led to stricter protocols and regulations directed to reduce their utilization. The pest control industry is continuously examining novel technologies and products that will improve the way to manage and prevent pests. The general objective is to likewise diminish the effects of various available pesticides on the environment and on nontarget creatures, besides the economic influence on bottom lines.

Keywords: pesticides, insects, agriculture, biological control

1. Introduction

Pests are organisms which can damage the crops and compete with them. They cause decrease in the plant density, stunted growth of plant, a lower production capacity, and lessen the yield or nature of horticultural products. A standout among the most well-known approaches to regulate or dispense pests is to kill pests using pesticides. The pesticides may cause biological or physical damage to pest organisms. Some pesticides are applied indirectly or by spraying on a plant which can be consumed by an insect.

Several techniques for crop protection were developed to prevent and minimize the loss of crops due to pests in the field (preharvest losses) and during storage (postharvest losses). Crop protection involves products, tools, and practices which can be used by farmers to protect their harvest against insects, disease, and weeds. Weeds steal sunlight, nutrients, and water from crops. The food production can be influenced by insects and disease. Farmers around the globe settle on various choices every day with respect to how best to secure their crops by using different practices like biological control, microbial pesticides, pest behavior, genetic manipulation,

Methods	Actions
Biological control	Suppression of pest populations by natural enemies (predators, parasites, competitors, diseases)
Microbial pesticides	Relatively stable formulations of microorganisms that suppress pests by producing poisons, causing diseases, preventing establishment of other microorganisms, or other mechanisms
Pest behaviour-modifying chemicals	Exploitation of the chemical signals used by living organisms to evoke specific behaviours from other organisms
Genetic manipulation of pest populations	Release into the pest population of individuals genetically altered to carry genes that interfere with the pest's reproduction or impact
Plant immunization	Enhancement of plant resistance to pests by means other than breeding or genetic engineering

Table 1.
Different methods to control pests and diseases.

and plant immunization of pest population. Fortunately, a variety of solutions are available with advances in modern agriculture. **Table 1** shows different methods to control pests and diseases.

2. Literature review

It was studied that the farmer takes into account to control the steady-state mice populations in order to use no or a moderate amount of pesticide. It depends on the prices as well as the shape of the grain production function which is determined by the microparameters of grain reproduction [1].

It was found that the barn owls (*Tyto alba*) can be used for the purpose of vertebrate pest control, and farmers in some agricultural regions breed barn owls and hunt on their farms by installing artificial nest boxes. The barn owl diet and nest box occupancy in an intensive agricultural landscape in the Central Valley of California were used to measure whether agricultural land use affected the barn owl diet [2].

It has been studied that heat treatment (HT) methods can be used to control insect pests in flour mills by thermal analyses and temperature trend models. The results show that to achieve an air temperature above 45°C, the time period of HT should be increased by 9 h. In thermal bridges, the surface temperatures should be lethal to insects and be capable of dropping sensible heat flux loss with the help of insulating materials [3].

It was observed that lablab bean (*Lablab purpureus*) faces major losses due to insect pests in spite of heavy dependence on conventional insecticides. It was managed by testing biorational insecticides as substitutes for conventional insecticides to control pod borers (*Maruca vitrata*) and aphids (*Aphis craccivora*) [4].

It has been stated that the important life-sustaining actions of phytopathogenic fungi, parasitic nematode, and phytophagous insects are the preeminent constraining variables of agricultural production organizations [5].

It has been stated that integrated pest management (IPM) is broadly stimulated among the European Union (EU) member states. The effectiveness of natural enemies for pest control is low as compared with insecticides, especially under high pest damage levels. Farmers with greater income have more financial flexibility to adopt either pest control method. The environment surrounding a farm may also influence its owner's willingness to promote natural pest control [6].

It has been investigated that crop damage can be minimized by using vertebrates which could consume numerous crop pests [7].

It has been studied that to obtain healthy crop as well as high yield, the control of pest attack is a significant feature in agriculture. The growth of awareness level is supposed to be relational to density of the healthy pests in the crop field. Global sources like televisions, radio, etc. can enhance the awareness level. The basic reproduction number represents the existence and the stability criteria of the equilibria. The Hopf-bifurcation analysis was done at the endemic equilibrium by considering time delay as the bifurcation parameter. The analytical results were justified by numerical simulations [8].

This overview provides a valuable insight to various stakeholders in the food chain on how food handlers and companies perceive pest control [9].

It was found that there are several methods to control pests, which involve the use of molting hormone (20-hydroxyecdysone) analogs (e.g., tebufenozide), chitin synthesis inhibitors (e.g., diflubenzuron), and juvenile hormone analogs (e.g., methoprene). They have been collectively called as "insect growth regulators" or IGRs, as they harmfully affect the normal growth and development in one way or another like they affect insect reproduction [10].

3. New methods of pest control

Following are the new advanced methods for pest control.

3.1 Biorational products

Biologically based pesticide products or biorational products contain pheromones (a chemical substance released by an animal into the environment, particularly an insect or a mammal, affecting the physiology or behavior of its other species) or living microorganisms, which have little negative impact on the environment and are nontoxic. *Bacillus thuringiensis*-based (*Bt*-based) microbial pesticides are most effective biorational pesticides. These types of biorational pesticides can be used in the place of competitive chemical products, which are banned in export markets where the concerns about food residue are high, and in environmentally sensitive areas.

"Pheromone-assisted technique" increases the efficiency of insecticides against ants. When a combination of insecticide and pheromones is used, it can actually trap away ants from their trails and nests to the insecticide. Thus, it reduces the contact of insecticide with the environment, while increasing the exposure of ants to the insecticide for eradication.

3.2 Insect growth regulators (IGRs)

Insect growth regulators (IGRs) are synthetic insect hormones, which can be used as insecticides to regulate the populations of harmful insect pests. IGRs prevent an insect from reaching maturity by interfering with the molting process. Many IGR products are mixed with other insecticides that kill adult insects. IGRs are generally less toxic to humans.

3.3 Nontoxic heat treatments

New methods of pest control are based on low-toxic solutions that can be more sustainable and effective than harsh chemicals; one such method is to use heat to eliminate insects. Rentokil's Entotherm is a new solution that eradicates bedbugs and

cockroaches. Rather than using sprays, which often do not penetrate the hard outer shell, the heat delivered by the Entotherm system kills insects from the inside through dehydration and damage to essential physiological processes. Another benefit is that the heat effectively kills all the life stages of insects—egg, larva, pupa, and adult, without needing to go over 56–60°C, which is high enough to kill the pests rapidly.

3.4 CRISPR technology to control pests

CRISPR gene editing tool is a method to alter key genes that regulate the fertility and sex determination of insects. CRISPR technology has allowed researchers to invent a new effective control technology which can be safe, self-limiting, and scalable genetic population for a specific species. It has the potential to be developed and utilized for a plethora of insect pests and disease vectors. This technology can be safely used in the field to suppress and even destroy target species.

3.5 Second-generation green products

Since last few years, the major focus surrounding green products has been from a public health perspective. The demand of green products is increasing and shifting to eco-protection. Nowadays, second-generation green products are emerging. These second-generation green products will have better ingredients, greater efficacy, and less disadvantages. For example, a first-generation insecticide containing plant essential oils may have an unpleasant smell. In contrast to this, the second-generation insecticide contains different amounts of the original ingredients or other materials, which reduces the smell, while it is still being effective.

3.6 Communication tools

The mobile data-capture devices can be introduced for pest control, which are able to capture real-time data about the location and nature of the pest problems and then store it in a central database online, which both facility managers and pest control professionals could access. This also made it simple to track multiple facilities and allowed for more timely corrective actions and more targeted pest-control treatments.

3.7 Rodent birth control

For the past few years, pest management used birth control for pest birds like pigeons as a means of managing populations. The rodent birth control may soon provide an effective way to control prolific breeders like mice and rats without negatively impacting many nontarget creatures. Be on the lookout for rodent birth control in the near future.

3.8 Fly baits

The fly bait stickers can be used near the food storage area or where the flies congregate. The small sticker is coated with insect food and an insecticide that has the ability to knockdown flies in just 1 min upon contact.

4. Conclusions

Conventional pesticides are toxic residues, pest resistance, secondary pests, and pest resurgence. Thus, they are not only dangerous to the environment but also

hazardous to human health. In order to encourage organic farming, plant protection, and reduce pesticides' usage in food products, pheromone traps and other modern technologies can play a crucial role. So, it necessary to apply novel technologies that result in producing high quality of food and better income generation.

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