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A STUDY ON BIOTECHNOLOGY BASED PEST CONTROL AND PEST MANAGEMENT

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Abstract
Transgenes inserted into crops for pest control have revolutionized pest management in the last 15 years. For pest control, herbicide resistance transgenes and *Bacillus thuringiensis* toxin production are the most common features now accessible. When available, these two features have been quickly embraced by farmers due to their better efficacy and ease of pest management. Insects have been a major source of food production losses, accounting for 20-30 % of global output. Plantations and tropical regions, which are typically the poorest in the world, suffer the most from the high occurrence of insect-pests, with an estimated 67,000 species causing damage. Low selectivity of insecticides used in pest control might impact the population of natural enemies, allowing pests to proliferate and even reinvigorating others. Because of this, researchers have been working harder than ever to find alternatives to conventional insecticides, and the most promising of these are now being tested in the form of insecticide-resistant plants, insecticides that target specific species, parasitoids, and entomopathogenic microbes (*Bacillus thuringiensis*). The employment of gene technology (Cry) in bacteria (*Bacillus thuringiensis*) to manage Lepidoptera's primary pests is a good illustration of this. Ecologically sustainable, pollution-free, residue-free, and lower concentration of inert compounds in food items are all goals of introducing Bt gene technology. Even said, there are still a slew of obstacles to overcome before modern agriculture can fully embrace biotechnology.

Keyword: Biotechnology, Pest control, *Bacillus thuringiensis* toxin, IPM, Pest Management.

Introduction

When it comes to genetics, biotechnology is all about altering the DNA of plants, animals, and microorganisms. Biotechnology has always depended on traditional methods of plant and animal breeding to alter genetic makeup. Newer techniques like genetic engineering are used in modern biotechnology in order to transfer genetic material from one organism to another. Medications, human insulin, and enzymes for laundry detergents and cheesemaking are all examples of biotech products. More recently, the application of biotechnology has resulted in novel pesticides that control a wide range of insects. [1] The inherent pest-fighting powers of many existing plants and bacteria are used to make these biological pesticides, which have features that set them apart from conventional chemical pesticides. [2]

A lack of resources and a changing environment force us to tackle global food security issues that are becoming increasingly complex. Rapid population growth necessitates significant increases in food production. An estimated 26 to 40% of the world's food crops are destroyed each year by pests such as insects, diseases, and weeds. Insect pests may be able to expand their geographic ranges and increase the number of generations they produce each year as a result of climate change and fluctuating water supplies. [3] There has been a rise in the development of pesticide resistance, making it difficult to control these insects. All of these conditions point to the development of new and effective methods for combating insect pests. [4]

Biotechnology in plant protection can also be separated into two major categories: (i) characterization of pests and (ii) management of pests. Rapid and reliable identifications of pests and population genetic characterizations were made possible by the first application. A specific section of biotechnology application is dedicated to this aspect of the field. [5] To develop effective pest management techniques, this first application is proven to be significant since it allows the identification of resistant markers for plants and DNA sections of the pests associated with resistance, which ultimately speeds up the breeding of cultivars with different features. [6]

An endotoxin produced by Bacillus thuringiensis, an organism that lives in the soil. Pest Lepidoptera, Coleoptera, Diptera, and other closely related species can be effectively controlled with *Bacillus thuringiensis* toxins, which are non-toxic to mammals and most other non-target creatures. [7] Transgenic plants with improved resistance to the larvae of lepidopteran insect pests can now be produced using genes expressing endotoxins from Bacillus thuringiensis, a well-established technique (Duke, 2011). It is thought that the insect larvae feed on transgenic plants and take in crystals and spores, which are then processed by the bacterial toxin. The crystals are harmful to insect midguts because the pH is alkaline. This causes septicemia. [8]

Review of Literature

There are a number of fundamental and applied issues that limit the use of insect natural enemies as biological control agents that could be addressed by biotechnology, however. The primary goal of this insect control approach is to produce a large number of insect natural enemies for classical or augmentative release. Due to the possibility of genetic alterations produced by inadvertent selection, inbreeding, genetic drift, and founder effects, it is difficult to maintain quality in laboratory-reared insects (Hopper et al., 1993) [9].

Motheral microinjection is a technique that uses the cuticle of gravid females as a transposable-element vector to microinject exogenous DNA into pregnant females (Presnail and Ho, 1992) [10]. A particular focus has been on genes that encode insecticides known as cry genes. Amino acid sequences of the proteins generated by the genes have been used to categories these organisms into 30 different groups (Yamamoto, 2001) [11].

More than 2,400 plant species have been identified as having pest-controlling characteristics around the world. The neem tree, sweet flag, onion, garlic, custard apple, pyrethrum, derris, common lantana, holy basil, black pepper, and common ginger are among the promising species (Weinzierl, 1998) [12].

Convention on Biological Diversity (1992) defines biotechnology as "any technological application that exploits biological systems, live organisms, or derivatives thereof to generate or modify goods or processes for specialized use." Biotechnology. For the sake of developing valuable products, processes, and services, biotechnology can be thought of as a sequence of enabling technologies that each include the understanding and manipulation of living organisms (plants and pests) or their subcellular components to develop useful products, processes and services (Lebeda and Pokorný, 2012[13]; Cano et al., 2017) [14].

Bioinformatics and bioprocess engineering are among the most exciting, cutting-edge applications of contemporary biological sciences, which include DNA-based characterization of plants and pests, plant tissue and cell cultures, monoclonal antibody production, molecular breeding techniques, recombinant DNA technology and/or genetic engineering, and bioprocess engineering (Fermin-Munoz et al., 2000[15]; Gianessi et al., 2003[16]).

Objectives

- To study trends of biotechnology in pest management
- To study effect of biotechnology in pest control and plant production
- To study properties of GM crop
- To study benefits to GM crop related to pest management.

Research Methodology

The journals were obtained from the online databases, focusing on the area concern with application of biotechnology. On the topic, the identification was focused on the methods employed for the pest control with upcoming techniques in the area interest. Various methods were compared for their application, ease of implementation and cost effectiveness. The techniques were also compared with their future implication along with their drawbacks. A comparative study of their molecular mechanisms is also studied in detail.

Result and Discussion

Genetically modified (GM) crops are those that have undergone artificial DNA modification or genetic engineering in order to boost positive qualities. Other biotechnology applications linked to stress management, agricultural traits and quality enhancement, and other advantageous qualities are also being reviewed in an identical fashion. The results of this review will be published separately. Table 1 below lists the pest management advantages of GM crops [17].

Crop	**Common Use**	**Application of GM traits targeting pest management**		
		Disease management	**Insect-pest management**	**Weed management**
Widely commercialized Genetically Modified Crops				
Alfalfa	Animal feed		Insect resistance	Herbicide tolerance

Apple	Food	Fungus resistance		
Canola	Cooking oil, Margarine, Emulsifiers in packaged foods			Herbicide tolerance
Cotton	Fiber, Cotton seed oil, Animal feed		Cotton bollworm resistance	Herbicide tolerance
Maize	High-fructose corn syrup, corn starch, Animal feed		Corn borer resistance	2, 4-D (herbicide) resistance
Papaya	Food	Papaya Ring Spot Virus		
Potato	Food	Late blight fungus and Virus resistance	Insect resistance	Herbicide tolerance
Soybean	Soybean oil, Animal feed	Soybean dwarf virus and Phytophthora fungus resistance	Insect resistance	Dicamba (herbicide) resistance
Squash	Food	Cucumber Mosaic Virus resistance		
Sugar beet	Food			Herbicide tolerance
Genetically modified crops that have not yet been widely cultivated				
Bean	Food	Virus disease resistance		
Cowpea	Food		Insect resistance (pod) borer *(Maruca Vitrata)*	
Linseed	Food			Herbicide tolerance
Plum	Food	Virus (plum pox virus) resistance		

Rice	Food	Bacterial blight and Fungal disease resistance	Stem borer resistance	Herbicide tolerance
Tomato	Food	Bacterial spot resistance, viral disease resistance	Insect resistance	
Wheat	Food	Powdery mildew resistance		

Table 1. List of GM crops targeting pest management

There have already been at least four reported examples of *Bacillus thuringiensis* -resistant insects in the field because of a worldwide industry's dependence on a single insect resistance trait. New insecticidal proteins and the genes that encode them are now being sought for commercial use in plant protection. [18] Vegetative insecticidal protein, chitinases, protease inhibitors, and alpha amylase inhibitors are a few of the proteins that target the insect gut (Table 2). [19]

TRANSGENE	SOURCE AND MODE OF ACTION	EXAMPLE OF USE
***Bacillus thuringiensis* (Bt) endotoxin**	The Bacillus thuringiensis endotoxin	The *Bacillus thuringiensis* endotoxin
Vegetative insecticidal protein (VIP)	VIPs are produced by *Bacillus cereus* and *Bacillus thuringiensis.* They have similar activity to endotoxins from Bt. Vip1/Vip2 are toxic to coleopteran insects and Vip3 is toxic to lepidopteran insects	Highly toxic to *Agrotis* and *Spodoptera* species. VIP induced gut paralysis, complete lysis of the gut epithelial cells and resulted in larval mortality.
		VIP3Ac1 had insecticidal activity against larvae of *S. frugiperda, Helicoverpazea* and *Trichoplusiani*
Chitinase (enzyme)	Chitinase catalyses the hydrolysis of chitin, which is one of the vital components of the lining of the digestive tract in insects and is not present in plant and higher animals.	Transgenic rapeseed (Brassica napus) expressing *M.sexta* chitinase and scorpion insect toxin increased mortality and reduced growth of *plutella maculipenis*
	Cholesterol oxidase is a bacterial enzyme that catalyzes the oxidation of cholesterol and other 3-	Cholesterol oxidase from Streptomyces caused stunting of

Cholesterol oxidase (enzyme)	hydroxysterols, resulting in production of the corresponding 3hydroxysterols and hydrogen peroxide. Functions by damaging midgut membranes	*H. virescens, H. zea* and *Pectinophora gossypiella* when incorporated into an artificial diet
Lipoxygenases (enzyme)	Dioxygenase enzymes are widely distributed in plants and catalyze the hydroperoxidation of cis-cis-pentadiene moieties in unsaturated fatty acids. Functions by damaging midgut membrane	Lipoxygenase from soybean retards the growth of *Manduca sexta* when incorporated into artificial diet
Alpha-amylase inhibitors	Alpha-amylase inhibitors block starch digestion.	Development of pea weevil larvae (*Bruchuspisorum*, Coleoptera) was blocked at an early stage after ingestion of transgenic peas expressing an alpha amylase Inhibitor from the common bean (*Phaseolus vulgaris*)
Trypsin modulating Oostatic factor (TMOF)	A peptide that blocks trypsin biosynthesis in mosquitoes (*Aedes aegypti*, Diptera [AeaTMOF]) and fleshflies (*Sarcophaga*, Diptera)	Injection or oral ingestion of Aea-TMOF caused inhibition of trypsin biosynthesis and larval growth in *H. virescens.* Mortality of *H. virescens* increased when fed transgenic tobacco plants expressing Aea-TMOF (Stevens J *et al.,* 2012)

Table 2. Use of transgene and their mode of action

Table 3. shows properties of genetically modified crops and its required modification done.[20]

Crop	Properties of the genetically modified variety	Modification
Corn	Insect resistance via producing Bt proteins. Added enzyme, alpha amylase, that converts starch into sugar to facilitate ethanol production	New genes, some from the bacterium Bacillus thuringiensis added/transferred into plant genome
Cotton	Kills susceptible insect pests	Gene for one or more Bt crystal proteins transferred into plant genome

Potato	Bt resistance against Colorado beetle and resistance against 2 viruses	New Leaf: gene for one or more Bt crystal proteins transferred into plant genome
Soybeans	Kills susceptible insect pests	Gene for one or more Bt crystal proteins transferred into plant genome
Tomato	Showed resistance to the tobacco hornworm, tomato fruit worm, the tomato pinworm and the tomato fruit borer	The insecticidal toxin from the bacterium *Bacillus thuringiensis* has been inserted into a tomato plant
Chickpea	Showed resistance to *Helicoverpa armigera* army worm	The insecticidal toxin from the bacterium *Bacillus thuringiensis* have been inserted

Table 3. Properties of Genetically modified Crops

Conclusion

Biotechnology has the potential to improve food safety by protecting it from insect assault and to help contemporary agriculture remain viable in the long term. Continuous study and development of new technologies like agricultural biotechnology could be used to achieve long-term sustainability in the agricultural sector. National institutes and other connected research centers should engage in educational and training programmes for the general public in order to grasp the risks and benefits of biotechnology application. For now, however, the future of GM crops depends on the search for new genes that can provide similar or further resistance to transgenic plants, and this has led to the discovery of a number of genes from diverse origins. Crop protection could benefit greatly from a number of these, according to their evaluations. This means that biotechnological applications for crop protection against insects, such as those using stacking genes, modified Bt-toxins, spider/scorpion venom peptides, vegetative insecticidal proteins, lectins as well as innovative techniques are on the rise in the future. However, the advantages and hazards of using GM insect-resistant crops, particularly in developing countries and among small-scale farmers with limited access to resources, must be considered when implementing such tactics.

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