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Pesticides and Their Applications in Agriculture

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ABSTRACT

A pest is any organism that causes an economic loss or damage to the physical well-being of human beings. It may destroy crops, cause diseases in them or in human beings. Chemicals used to eradicate or worn-out the unwanted pest's population from agriculture or experimental field are called as pesticides. Some pesticides are organism-specific and have particular mode of action to remove the pests. Current article is informative about the types of pesticides used in modern agriculture and bio-farming, and its interaction in environmental processes.

Keywords: Fungicides, weedicides/herbicides, nematicides, rodenticides, insecticides, algicides, biopesticides and BCA.

1. INTRODUCTION

Since before 2000 BC, humans have utilized pesticides to protect their crops. The first known pesticide was elemental sulfur dusting used in ancient Sumer about 4,500 years ago in ancient Mesopotamia. The Rig Veda, which is about 4,000 years old, mentions the use of poisonous plants for pest control. Modern agriculture employs a number of chemicals for enhancing crop yield and protecting the same. Synthetic fertilizers are added to replenish the various nutrients and maintain the soil fertility. These chemical fertilizers are added to the soils in order to overcome the deficiency of minerals and to provide extra chemicals required for proper growth of high yielding varieties. Plant development pattern is highly modified by addition of plant growth regulators (PGR) during agricultural practices and plant tissue culture experiments.

PGR are required in low concentrations in plant growth studies. Many growth regulators like malic hydrazide, methyl ester of naphthalene acetic acid (NAA) prolong storage. Still others like 2,4-D and 2, 4, 5-T prevent premature fruit drop and are widely used as weedicides. Ethylene induces early ripening of fruits. Some other physiological effects of growth regulators are rooting of stem cuttings, enhanced vegetative growth, prevention of flowering etc. Agricultural crops are mainly destroyed by insects. Various types of fungi and bacteria cause diseases in plants. According to an estimate, there is an annual loss of up to 30% in agricultural production due to insect pests and plant diseases. If only 50% of this loss could be saved from pests, the food problem of our country can be solved to a great extent.

A pest may be defined as any organism that causes an economic loss or damage to the physical well being of human beings. It may destroy our crops, cause diseases in them or in human beings etc. There are a number of chemicals which can kill or destroy these pests. These chemicals are called as pesticides (*cides* means *to kill*). Pesticides are sprayed over crops, human dwellings etc. Few familiar pesticides are baygon spray, finit (flit), DDT, BHC which are widely used in houses to kill mosquitoes, flies, ants, cockroaches etc. During the Second World War, two synthetic pesticides *i.e.* DDT (dichloro diphenyl trichloroethane) and 2-4 D (2, 4 dichlorophenoxy acetic acid) were

mainly used. Current article, mainly aims to the types of pesticides, their advantages in modern agriculture and side-effects on organisms (pest), and brief idea of integrated pest management.

2. TYPES OF PESTICIDES

The Green Revolution succeeded in tripling the food supply but yet it was not enough to feed the growing human population. Increased yields have partly been due to the use of improved crop varieties, but mainly due to the use of better management practices and use of agrochemicals such as fertilisers and pesticides. Pesticides are of several types depending upon the types of pests killed or controlled. These are fungicides, weedicides/herbicides, nematicides, rodenticides, insecticides, and biopesticides.

2.1 ***Fungicides***

These are substances used to eliminate the fungal infection on crops and destroy fungal pathogens. **Inorganic fungicides** include Bordeaux mixture, Burgandy Mixtue, sulphur, mercuric chloride, etc. **Organic fungicides** are dithane S-21, dithane M-22, dithane Z-78 (all carbamates), oxanthiins (*e.g.*, vitavax), mercury compounds (*e.g.*, agrosan, tillex), benzimidiazole derivatives (*e.g.*, benlate). **Thiram** and **Ziram** is fungicide but toxic to aquatic zooplanktons. Phytochemical extraction such as Neem oil containing **Azadirachtin** and **Nimbin** are antifungal in properties. Fentin is another example of fungicide.

2.2 ***Weedicides/Herbicides***

Herbicides and weedicides are used to kill the unwanted plants or weeds in agricultural land. Depending upon the mode of action, there are selective and nonselective herbicides, contact herbicides, translocated herbicides, foliage applied and soil applied herbicides. Herbicides can be triazines (*e.g.*, atrazine, simazine) carbamates (*e.g.*, thiocarbamates, phenyl carbamates) and auxin derivatives (*e.g.*, 2,4-D, and 2, 4, 5-T). The mixture of 2,4-D, and 2, 4, 5-T is known as **Agent orange** used as defoliant and herbicides developed during world war-II. Modern herbicides may develop Parkinson's disorder in human such as **paraquat**. Atrazine, a herbicide act as a teratogen and influences the gender development in frogs during metamorphosis.

2.3 ***Nematicides***

They kill or repel nematodes, *e.g.*, Aldirab is acetylcholine esterase inhibitor used to kill the nematodes which infects the tobacco production in farming. A nematode *Meloidegyne incognitia* infects the roots of tobacco plants and causes a great reduction in yield. *Purpureocillium lilacinum* is used as biological control agent (**BCA**), it infest the *Meloidegyne incognitia.* One strain of *P. lilacinum* has been shown to produce proteases and a chitinase, enzymes that could weaken a nematode egg shell so as to enable a narrow infection peg to push through.[5] *Paecilomyces*, nematophgus carnivorous fungi, can be useful to control nematode attack. methyl bromide (MB), ethylene dibromide (EDB), chloropicrin are also nematicides. Soil steam sterilization (**SSS**) or soil steaming technique is used to disinfect the soil from nematode/pathogen by enzyme inactivation using heat treatment.

2.4 ***Rodenticides***

It is commonly known as rat poison, *e.g.*, Na^+-fluoroacetate, warfarin, red squill, Zinc phosphide. Rodenticides has inhibitory effects on Vitamin-K cycle in rodents as well mammals thus death of pest. Vitamin D_3, D_2, and D causes hypercalcemia in rodents. **Strychnine**, obtained from *Strychnos nux-vomica* tree or Semen nut tree is rodenticide, causes asphyxia in rats, thus death. **Chloralose** is a chlorinated acetal derivative of glucose, used as rodenticide and avicide too. In combination with copper aceatate the arsenic trioxide forms **Paris Green** rodenticide, which is used also in blue colorant in fireworks.

2.5 ***Insecticides***

Insecticides are stomach/alimentary canal poisons (poisonous on ingestion), contact poisons or fumigants (inhaled) to the insects. Natural insecticides include *Azadirachta indica* (Margosa/Neem), *Boenighausenia albiflora*, *Peganum harmala*, *Derris* (rotenone) and *Chrysanthemum* (pyrethrum). *Azadirachta indica* is also used as larvicide. Aquabac and Vectobac are larvicides. First commerical bioinsecticide is sporeine developed in Germany. **Insect growth regulator** (IGR) are substances used as insecticide which inhibits the exoskeleton development or chitin synthesis, JH and Ecdysone synthesis on insects such as mosquitoes, cockroaches etc. The example of IGR are azadirachtin, hydroprene etc. Synthetic insecticides are organochlorines, organophosphates, carbamates and pyrethroids, Ethylene dibromide (EDB) is a volatile liquid (fumigant) used in controlling insect pests in stored grains and fruits. Chemical pesticides are toxic chemicals used in killing pests. On the basis of chemical structure, major pesticides are grouped into: (i) Organochlorines, (ii) Organophosphates, (iii) Carbamates (iv) Pyrethroids and (v) Triazines.

(i) **Organochlorines:** These are basically organic compounds that have been chlorinated. Organochlorines are lipophilic and show much affinity for fatty tissue of animals. Organochlorines have very low bio-degradation, get accumulated in environment causing serious problems. Important examples of organochlorines are (a) DDT, (b) BHC, (c) Aldrin and (d) Endosulphan.

(a) **DDT** (Dichlorodiphenyl trichloroethane)**:** DDT was first synthesized by a German chemist Othnar Zeidler in 1874 and its insecticidal value was discovered by Paul Muller in 1939. DDT is the most famous pesticide of the world and is a non-biodegradable pollutant. Spraying of DDT on crops produces pollution of air, soil and water. In India, as a result of prolonged use of DDT, 13-31 ppm of DDT can be detected in the body fat of the people, highest in the world. DDT concentrates from water into the body and magnified in higher members of the food web.[9] DDT tolerance level is 10ppm for a freshwater crustacean *Daphnia* and this means *Daphnia* will die beyond that concentration. DDT has become ineffective for killing mosquitoes because of the development of adaptive resistance. DDT does not inhibit cholinesterase activity and is relatively non-toxic to mammals, but in oil solution it is absorbed by skin. Pesticide (DDT) is banned now a days because DDT interacts with the food-chain in our ecosystem and causes serious damages and loss of biodiversity. For example; biomagnification, or bioamplification is the increasing concentration of a substance, such as a toxic chemical like DDT or mercury, in the tissues of organisms at successively higher levels in a food chain. This happens because a toxic substance

accumulated by an organism cannot be metabolised or excreted, and is thus passed on to the next higher trophic level. In this manner, the concentration of DDT is increased at successive trophic levels; say if it starts at 0.003 ppb (parts per billion) in water, it can ultimately reach 25 ppm (parts per million) in fish-eating birds, through biomagnification. High concentrations of DDT disturb Ca^{2+}-metabolism in birds, which causes thinning of eggshell and their premature breaking, eventually causing decline in bird populations. Toxaphene, a cotton pesticide is also banned in USA causes serious health problems of nervous system.

(b) **Lindane:** γ-hexachlorocyclohexane/Gammaxene/Lindane was 1st synthesized by Michael Faraday in 1825 and its insecticidal value was independently discovered by Dupire (1941) in France and Leicester (1942) in England. It is most common pesticide used in India, represents about 50% of total volume of pesticides used in India. Lindane can bioaccumulate in food-chain thus more toxicant than DDT. Lindane is used in shampoos and lotion.

(c) **Aldrin (Octalene):** Aldrin is an insecticide named after German chemist Kurt Alder, applied to foundations of buildings to prevent termites. It has been successfully used in control of locusts and grasshoppers in Asian countries. Aldrin, Dieldrin and Endrin are very poisonous pesticides.

(d) **Endosulphan (Thiodan)** $C_9H_6Cl_6O_2S$ **:** Endosulphan is a pesticide and is useful used in agriculture in the control of insect pests including whiteflies, aphids, leafhoppers, Colorado potato beetles and cabbage worms. It is also endocrine disruptor and carcinogenic to humans.

(e) **Mirex:** it is insecticide used to kill fire ants in agricultural lands. It was banned in USA because of biomagnifications to the turtles, coyotes, and other animals. It is potent endocrine disruptor to animals including human being.

(ii) **Organophosphates:** The insecticidal properties of organophosphates were discovered by Schrader. Organophosphates are the pesticides most toxic to verterbrates. Organophosphates inhibit cholinesterase, an enzyme essential for transmission of nerve impulse across synapse. Malathion, parathion and fenitrothion are main organophosphates used in Asian countries. Malathion is one of the two active ingredients in Flit, the second being Pyrethrin derived from *Chrysanthemum cinerariifolium*. Examples of pyrethroids are Allethrin, Cyclethrin and Barthrin which are quick-acting broad spectrum insecticides. Mosquito-repelling coils contain pyrethrin. Naled is insecticide used to control for the spread of Zika virus in USA during 2015. Fanthion insecticide used to control mosquito in India, but its manufacturing is banned in 2017 due to environmental impact.

(iii) **Carbamates :** Carbamates are derivatives of carbanic acid and have an – OCON = group in the molecule. Some commonly used carbamates are **Carbofuran (Furadan), Propoxur (Baygon) and Aldicarb (Temik)**. Derivatives of carbamates are also used as herbicides (phenylcarbamates, thiocarbamates) and Fungicides dithiocarbamates. Carbamates are useful in the control of nematodes and snails. Mode of action of carbamates is quite similar to that of organophosphates. Methyl isocyanate gas which caused **Bhopal gas tragedy India** on 3rd Dec. 1984, is used as a raw material for synthesizing Carbaryl (Selvin).

(iv) **Triazines :** Triazines (Simazine, Atrazine, etc.) are a group of herbicides derived from urea. Triazines are used for controlling weeds in tea, tobacco and cotton.

Bordeaux Mixture: Bordeaux mixture was discovered by Millardet (1882) in France. It is prepared by dissolving 40*gm* of copper sulphate and 40*gm* of calcium hydroxide in 5*ltr* of water. Bordeaux mixture is used primarily as a fungicide, it was first used to control downy mildew disease of grape-wine caused by a fungus, *Plasmopara viticola*. Bordeaux mixture is used to control potato blight, and apple scab from *Venturia inaequalis*, an ascomycetes fungi.

2.6 Algicide

it is a biocide used to eliminate the algal growth in water. Cupric sulfate or ***Bluestone*** is used as algicide. Diuron/**DCMU** (3-(3,4-dichlorophenyl)-1,1-dimethylurea) is photosynthesis and electron transport chain ETC-inhibitor used as algicide. Dichlorophen with toluene is used as algicide, fungicide, and wormicide/helminthicide/nematocide.

3. PLANTS AND MICROBES AS BIOCONTROL AGENTS

Biocontrol refers to the use of biological methods for controlling plant diseases and pests. Biopesticides are living organisms of their products used for killing pests of interfering with their metabolism. Biopesticides are the biological substances that are used to control weeds, insects and pathogens such as viruses, bacteria, fungi, protozoa and mites. Some of the examples of Biopesticides are control of weeds by use of mycoherbicides and control of insects by use of bioinsecticides like Sporeine, fungal pathogens can be controlled by *Trichoderma* (Ascomycetes)- a free living fungi as it has the ability to secrete chitinase, use of bacterium *Bacillus thirungenesis* in case of Bt cotton which produce toxins. Bioherbicides are used as biological control of weeds involves-utilization of insects which would feed selectively on weeds and use of certain microorganisms which produce diseases in weeds and eliminate them. In India and Australia, the overgrown of cacti was checked by the introduction of cochineal insect (*Cactoblastis cactorum*). The first bioherbicide was mycoherbicide, based on the fungus *Phytophthora palmivora*, and was developed in 1981. Anabasine is derived from *Nicotiana glauca,* Annonin from *Annona squamosa* seeds, Cinnamaldehyde, a from *Cinnamomum*, Rotenone from *Derris spp.*, Ryania from roots of *Ryania speciosa*, Oregano oils etc. are used as bioinsecticide. Baculoviruses are pathogens that attack insects and other arthropods. The majority of **baculoviruses** used as BCA are in the genus *Nucleopolyhedrovirus.* These viruses are excellent candidates for species-specific, narrow spectrum insecticidal applications. They have been shown to have no negative impacts on plants, mammals, birds, fish or even on non-target insects. This is especially desirable when beneficial insects are being conserved to aid in an overall integrated pest management (IPM) programme, or when an ecologically sensitive area is being treated. Cydia pomonella granulosis virus (**CpGV**) is a granulovirus belonging to the family *Baculoviridae* is also used as biopesticide. The presence of **Chitosan, a linear polysaccharide, a** plant in the presence of this product will naturally induce systemic resistance to allow the plant to defend itself against disease, pathogens and pests. Viruside is used to inactivate the virus by preventing its multiplication in any host, thus control viral growth or viral load in recipient one. Cyanovirin-N from

Cyanobacteria *Nostoc*, Virkon, Scytovirin, Griffithsin are virucides used in medicinal researches. Chrysophytes such as **Diatoms** are used as biopesticide and anticacking agent in biofarming, Bonsai development, and hydroponics practices. *Bacillus popilliae* or **Milky spore** is used for the control of Japanese beetle. **Sporeine** was the first bioinsecticide developed on commercial scale in Germany. Sporeine kills insects by inhibiting ion transport in the midgut. Genes for some of these toxins have been isolated and transferred to host through recombinant DNA technology (transgenic plants). Transgenic plants of tomato showing resistance to horn worm larvae have been obtained. Integrated pest management is the selection, integration and implementation of pest control based on predicted economic, ecological and sociological consequences. IPM is based on the assumption that no single safe pest control. Method will be successful. IPM, therefore, seeks to use a variety of biological, physical and chemical methods integrated into a cohesive scheme designed to provide long-term protection. Biological methods include using natural predators of pests, using resistant varieties, crop rotation, intercropping, etc. Mechanical methods include manual destruction of eggs of pests, removing weeds, etc. Use of chemical pesticides is carefully timed.

4. CONCLUSION

Top pesticide consuming countries are China (1,806millions Kg/year), US (386millions Kg/year), Argentina (265millions Kg/year), Thailand (87millions Kg/year), Brazil (76millions Kg/year), Italy (63millions Kg/year), France (62millions Kg/year), Canada (54millions Kg/year), Japan (52millions Kg/year), and India (40millions Kg/year) in the world. No doubt, the pesticides improve the crop productivity in agricultural land as well as promote the faster growth to plants, thus improve the economy, and satisfy the demands but, on dark side, the higher exposure of pesticides may influence abiotic and biotic factors. The soil quality, water purity, air quality all is dealt with it as biomagnification. Some pesticides are mutagenic and carcinogenic for plants (tumor formation) as well human. Thus, **eco-friendly pesticides** shall be modified through researches which may better serve to environment and significant for all human beings. Neem oil, citrus oil, mineral oil, *Eucalyptus* oil, onion and garlic spray, Chrysanthemum flower tea, chile pepper are eco-friendly pesticides. Just as tobacco is hazardous and carcinogenic to humans, tobacco spray was once a commonly used pesticide for killing pests, caterpillars, and aphids. Mix one cup of organic tobacco (preferably a brand that is organic and all-natural) into one gallon of water. Allow the mixture to set overnight. After 24-hours, the mix should have a light brown color. If it is very dark, add more water. This mix can be used on most plants, except those in the solanaceae family (tomatoes, peppers, eggplants, etc.).

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