REVIEW ARTICLE

IMPLEMENTATION OF BIOLOGICAL CONTROL PRACTICES IN BIODIVERSITY CONSERVATION

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Received-28.03.2018, Revised-22.04.2018

Abstract: Agriculture is the main source of food, fibre, fuel and other useful products. It provides livelihood and subsistence to the large number of people. Agriculture largely relies upon the biodiversity of the ecosystem for pollination, the creation of genetically diverse plants and crop varieties, development of robust, insect resistant strains, crop protection and water shed control. Land overuse, climate change and chemical pesticide usage are the three important factors responsible for biodiversity loss. It is known that intensified agriculture, particularly the use of chemical pesticides, can suppress and displace local natural enemy populations, often resulting in pest resurgence, experience suggests that natural enemies can survive in such events, probably by exploiting natural habitats and other crops in the local area, and recover when conditions improve. Sustainable agriculture is possible through holistic approach towards crop protection through biological control of crop pests and alternative safe agricultural practices. Biological control is achieved by the introduction of biological material and natural pest control agents into the field by inundation and inoculation or through conservation of already existing beneficial organisms in the ecosystem. Such organisms and their products are manipulated by scientists to achieve a check on harmful agricultural and household pests. Many of them have been commercialized and are effectively used worldwide to achieve the target. Isolation, culture, formulation, conservation and application of better biological control agents for potential use in crop protection, is the need of the hour so that the biological diversity of the planet can be conserved.

Keywords: Biodiversity, Ecosystem, Biological control, Conservation, Sustainable agriculture

INTRODUCTION

Meaning of biodiversity

Bio diversity generally refers to the variety and variability of life on Earth. According to the United Nations Environment Programme (UNEP), biodiversity typically measures variation at the genetic, the species, and the ecosystem level. Biodiversity is not distributed evenly on Earth, and is richest in the tropics, which seems to be the result of the warm climate and high primary productivity.[1] These tropical forest ecosystems cover less than 10 percent of **earth's** surface, and contain about 90 percent of the world's species.

Benefits of Biodiversity in the ecosystem

Many recent studies have hinted at the fact that diverse communities perform much better in the ecosystem than one. It is noteworthy to first mention the work of Charles Darwin and Alfred Wallace, who were among the first scientists to recognize the importance of biodiversity for ecosystems and suggested that a diverse mixture of crop plants ought to be more productive than a monoculture (Darwin & Wallace 1858)[2]. Groups of interconnected species in the ecosystem interact in a very positive way and boost its productivity complimenting each other. So in general communities with more diversity will be more stable

"Ecosystem services are the suite of benefits that ecosystems provide to humanity."[3] The natural species, or biota, are the caretakers of all ecosystems. It is as if the natural world is an enormous bank account of capital assets capable of paying life sustaining dividends indefinitely, but only if the capital is maintained. It plays very important role in sustainability of the ecosystem in many ways-

Biodiversity boosts ecosystem productivity where each species, no matter how small, all have an important role to play.

A larger number of plant species means a greater variety of crops.

Greater species diversity ensures natural sustainability for all life forms.

Thus biodiversity is the key to food security and nutrition of the ever increasing human population for which we humans have to utilize natural resources wisely.

Causes of Biodiversity depletion

Earth's biodiversity -- the number of microorganisms, plants, and animals, their genes, and their ecosystems (such as rainforests and grasslands) -- is declining at an alarming rate, even faster than the last mass extinction 65 million years ago. In fact, two thirds of the terrestrial species that exist today are estimated to be extinct by the end of this century. Humans are an integral part of this extensive network of life. We depend on biodiversity for goods and services; we impact biodiversity via rapidly expanding human population growth, consumption of resources, and spread of disease. We need to study biodiversity in order to understand the concept and devise methodologies to conserve, and protect it.

The number of reasons like climate change, habitat destruction, over exploitation of natural resources, introduction of invasive species, genetic pollution and human overpopulation are often considered a threat to biodiversity.[4,5] Three major causes of biodiversity loss are discussed below

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Land overuse: Intensive Agriculture & construction of bridges, buildings roadways etc. has caused the terrestrial habitat loss and resulted in the extinction or reduction in the number of many species of animals and plants.

Climate change: This is a threat because the species have evolved to live within certain temperature ranges and when these limits are crossed they cannot survive as they cannot adapt to these variations. Climate change alone is expected to threaten with extinction of one fourth of the total species populations by 2050, which will be even more than the loss due to habitat loss. The IPCC has predicted that by 2100, assuming if the current trend in burning fossil fuel continues, the surface of the earth will warm on an average by 6 degrees Celsius or more. So we cannot imagine how most of species will respond to this change but the effects will definitely be catastrophic for species biodiversity.

Chemical pesticide usage: Excessive use of pesticides may lead to the destruction of biodiversity. Many birds, aquatic organisms and animals are under the threat from harmful pesticides for their survival.[6,7]

Highlighting the havoc caused by chemical pesticides

Pesticides can be natural compounds or they can be synthetically produced. They may belong to any one of the several pesticide classes. Major classes include organochlorines, carbamates, organophosphates, pyrethroids and neonicitinoids to which most of the current and widely used pesticides belong to. The use of pesticides has increased many folds over the past few decades. According to an estimate, about 5.2 billion pounds of pesticides are used worldwide per year. The use of pesticides for pest mitigation has become a common practice all around the world. Their use is not only restricted to agricultural fields, but they are also employed in homes in the form of sprays, poisons and powders for controlling cockroaches, mosquitoes, rats, fleas, ticks and other harmful bugs. Due to this reason, pesticides are frequently found in the food commodities in addition to their presence in the air. Agricultural pesticides are powerful chemical tools that are developed, produced and used to mitigate crop damage or loss by pest organisms Unfortunately, with the benefits of chemistry have also come harmful effects, some so serious that they now threaten the long-term survival of major ecosystems by disruption of predator-prey relationships and loss of biodiversity.[8] Most of them persist in the environment and accumulate in the tissues of organisms accumulating more and more with each trophic level in the ecosystem. The phenomenon is called Bio-magnification, eg. DDT. Another problem was the development of genetic resistance to these chemicals by pests. So over a period of time heavier doses of chemical pesticides were required polluting the environment so much so that it was totally unsafe for the non-target organisms. [9,10,11] . Frequently used pesticides are the chemicals used to kill insects and other pests of the crops in the fields or storage places while herbicides are the chemicals used to get rid of weeds in the field. These harmful chemicals are a concern for sustainability of environment and global stability Each pesticide or pesticide class comes with a specific set of environmental concerns.[12, 13,14 &15]

i. Some pesticides like DDT can cause egg shell thinning in birds , can work as endocrine disruptors, can be carcinogenic can cause juvenile decline and thus be fatal for many living non target fauna
ii. Chemicals like organophosphates and carbamates can cause immune-toxicity and impair signal transduction pathways and metabolic functions thus leading to acute mortality.
iii. Many other classes of chemical pesticides also cause thyroid disruption, can decrease reproductive capacity or can cause mortality of the species
iv. Sprayed pesticides can contribute to air pollution.
v. Pesticides can cause soil pollution, even affecting the important functions like nitrogen fixation by the microorganisms present there.
vi. Their bioaccumulation causes further problems in the environment.

Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, because they are sprayed or spread across entire agricultural fields. Field runoffs can carry pesticides into aquatic environments while irrigation channels and wind can carry them to other fields, grazing areas, human settlements and undeveloped areas, potentially affecting other species. Other problems emerge from poor production, transport and storage practices. Over a period of time, repeated application increases pest resistance, while its effects on other species can facilitate the pest's resurgence and pest rebound also secondary pest outbreaks.[16]

Since synthetic chemical pesticides pose the grave the threat of poisoning the environment and create health issues, so the switch was made to biological control agents which are the only promise to make agriculture sustainable. Isolation, culture, formulation, conservation and application of biological control agents for potential use in crop protection, is the need of the hour.

Sustainable agriculture and biodiversity

Sustainable agriculture refers to all farming practices capable of maintaining crop productivity and usefulness to society over the long run. It has to be environmentally sound, resource conserving, economically viable and socially supported.

In the field of agriculture sustainability has become the paradigm of our times and in biological research sustainability means plant protection without soil

loss. Crops must have nutrients, and pests must be controlled without compromising the safety of flora and fauna on the planet. Thus sustainable agriculture aims at balancing the need to improve the food and nutrition security and livelihoods of the poor, who mostly reside in rural areas, with that of preventing the degradation, contamination and loss of natural resources and reducing the uncertainties associated with climate change.[17,18] To adapt to these challenges and uncertainties, a large reservoir of biological diversity will be needed and the switch has to be made to safer alternatives to chemical pesticides to maintain this biodiversity reservoir. One third of the land area on the earth comes under farming and if this can be managed sustainably, it can contribute to conservation of biodiversity, saving the ecosystem and reaping the benefits of biodiversity. For this it is very important to maintain water quality, check the erosion of soils, incorporate biological pest control and reduce pollution of all kinds.

Biological pest control applications

Biological control is a method of controlling pests such as insects, mites, weeds and plant diseases using other organisms. It relies on predation, parasitism, herbivory, or other natural mechanisms, but typically also involves an active human management role. It can be an important component of integrated pest management (IPM) programs. There are three basic strategies for biological pest control: classical (importation), where a natural enemy of a pest is introduced in the hope of achieving control; inductive (augmentation), in which a large population of natural enemies are administered for quick pest control; and inoculative (conservation), in which measures are taken to maintain natural enemies through regular re establishment. Natural enemies of insect pests, also known as biological control agents, include predators, parasitoids, pathogens, and competitors.[19,20,35] Biological control agents of plant diseases are most often referred to as antagonists. Biological control agents of weeds include seed predators, herbivores and plant pathogens.

The first reported case of a classical biological control attempt in Canada involves the parasitoidal wasp *Trichogramma minutum*. Individuals were caught in New York State and released in Ontario gardens in 1882 by William Saunders, trained chemist and first Director of the Dominion Experimental Farms, for controlling the invasive currant worm *Nematus ribesii*.[19,21] Since then a number of organisms have been identified, isolated, lab reared, formulated and used in lab and field trials as safer control agents of effective biological control of pests. They include protozoans, bacteria, fungi, nematodes, insects and some vertebrates.

Some biocontrol agents that hold great promise for large scale use are

Bacteria : *Bacillus thuringiensis* & *B. sphaericus*

Fungi (*Coelomomyces spp*., *Culinomuces clavisporus, Lagenidium giganteum, etc.*

Nematodes (*Steinernema* spp.& *Heterorhabditis* spp.

Baculoviruses (Nucleopolyhedrosis virus. & Granulosis virus)

Insects (beetles & wasps)

Larvivorous fishes (*Gambusia affinis, Lebistis reticulatus, Rasbora daniconius, Aplocheilus blockii, Oryzias melastigma, Puntius spp*.etc.).

Bacillus thuringiensis and B. sphericus strains have been commercialized and used worlwide for effective mosquito and other insect pest control programmes.[20] They act as stomach poisons rather than as infectious pathogens (WHO, 1983) Similiarly entomopathogenis fungus strains have been commercialized as biological pest control agents. Beetles and wasps have been used to control harmful agricultural pests in the fields all over the world.

Some biological products can also be used instead of chemical pesticides in reducing domestic as well as field pests like pheromones, Insect Growth Regulators also safe plant products like azadirachtin and pyrethrum.

Agriculturists can resort to other alternative means for pest control. Since olden times a method of crop rotation was practiced for improving soil fertility. This is also important for safe control of insects as it cuts down the life cycle of plant specific pests, reducing the incidences of infection and multiplication. Hand picking of weeds like *Parthenium* also reduces the pressure of chemical usage for herbicidal control. Construction of polyhouses in the recent times and laying down of traps also checks the pest infestation of crops. Exclusion of insect pests has been used since ages. Practices of biofumigation, polyculture and permaculture are the other recent farm practices that further aid in crop protection and improving soil fertility without adding chemicals to it.[23,24,25]

Fig. 1: Need to boost Biological Control

How biological control boosts sustainable agriculture?

Sustainable agriculture must be capable of maintaining the land productivity and its value to human society. Meeting the ever increasing demand for food and other agricultural products all over the world is a great challenge ahead. Synthetic chemical pesticides posed the threat of poisoning the environment and create health issues, so the switch was made to biological control agents.

Closely examining the advantages and disadvantages of different methods of pest control to boost agricultural production we realize that biological control fits our parameters to make agriculture sustainable. Biological control depends on the knowledge of biological interactions at the ecosystem, organism, cellular, and molecular levels and often is more complicated to manage compared with physical and chemical methods. Biological control is also likely to be less spectacular than most physical or chemical controls but is usually more stable and longer lasting. In spite of the fact that biological control methods have been used in agriculture for centuries, as an industry biological control is still in its infancy. Biological control is now being considered for an increasing number of crops and managed ecosystems as the primary method of pest control. One reason why biological control is gaining popularity is that it is much safer than other means and its safety has been tested worldwide safety during the past 100 years. No microorganism or beneficial insect deliberately introduced or manipulated for biological control purposes has, itself, become a pest so far as can be determined, and there is no evidence so far of measurable or even negligible negative effects of bio-control agents on the environment or to the non target fauna and flora It can be used in Integrated Pest Management programmes.[26,27] So biological control can be used as an alternate for the chemical pesticides for sustainable agriculture.

Role of biological control in conservation of biological diversity

Biodiversity is the very essence of life on this planet. It was rather heartbreaking to get the Living Planet Report 2014 (released on September 30) by World Wildlife Fund (WWF) about the biodiversity loss statistics. The report which is the result of a science-based study using 10,380 populations from 3,038 species of amphibians, birds, fish, mammals and reptiles from around the globe—is garnering worldwide attention for its sit-up-and-take-notice findings: between 1970 and 2010, the planet has lost 52 percent of its biodiversity. In the same 40-year period, the human population has nearly doubled. Those figures take a while to sink in, especially since the previous WWF report published in 2012, that analyzed animal populations, showed a decline of only 28 percent over a similar time frame. It is also indicated in the report, that we have lost 76 percent of freshwater wildlife, 39 percent of terrestrial wildlife and 39 percent of marine wildlife of our planet since 1970. While some animal species numbers are increasing and some are stable, the declining populations are decreasing so rapidly that the overall downward trend is indeed shocking. Latin American biodiversity took the biggest plunge, diminishing by 83 percent. It is known that in intensified agriculture, particularly the use of chemical pesticides, can suppress and displace local natural enemy populations, often resulting in pest resurgence, experience suggests that natural enemies can survive in such events, probably by exploiting natural habitats and other crops in the local area, and

recover when conditions improve. Decline in the population of honeybees, sparrows or vultures all over the world is often talked about in the scientific congregations. Often the indicative cause is suggested as the use of harmful chemicals. Sustainable agriculture is possible through holistic approach towards crop protection through biological control of crop pests and alternative safe agricultural practices. Biological control is achieved by introduction of biological material and natural pest control agents into the field by inundation and inoculation or through conservation of already existing biocontrol agents in the ecosystem. Micro-organisms (e.g. pathogens of pests) are often used inundatively and macro-organisms (e.g. insect predators and parasitoids) inoculatively. Animal manure, green manure and compost used in organic farming favour decomposition processes and can replenish nutrients required by crops and supply soil with essential organic matter. Cutting totally the use of harmful pesticides let live the natural microorganisms aiding in the environment carrying on these processes of decomposition and soil restructuring. Such soils due to higher moisture retention capacity need less irrigation also.

Biological control helps in conserving biodiversity as it can be used as an alternative to harmful chemical pesticides and fertilizers. These methods are considerably safe to non target fauna and flora, preserving natural biodiversity of the ecosystem. There are comparatively very few reports of pests developing resistance to biological control agents and no reports of their bioaccumulation. Some of the biological control agents can persist in the environment and recycle themselves in the nature[20], so the cumbersome task repeated task of pesticide application can be avoided.

Long term ecological benefits of biological control have been reported worldwide.[28,29,30]

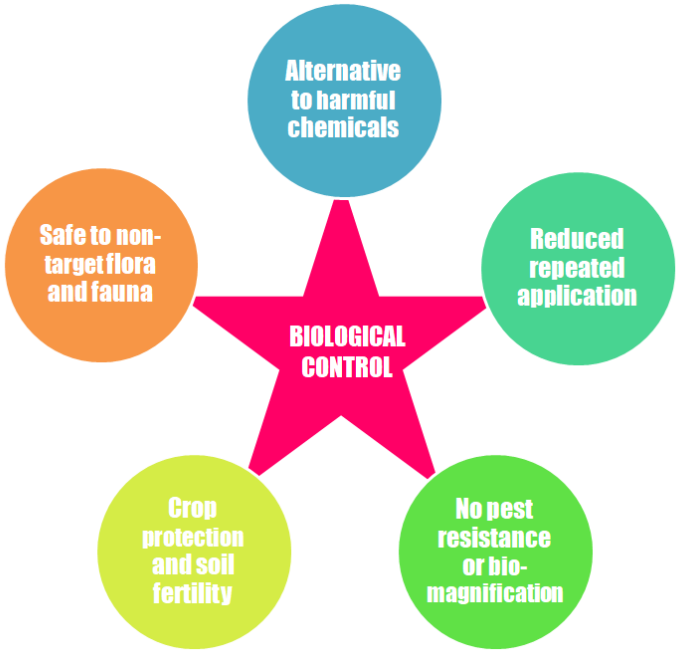

Fig. 2: Five main reasons to opt for biological control rather than chemical methods

Summary

If we play with nature it is going to bounce back and we humans will be the ultimate sufferers. It is only if we recognize the problem and then contribute to its solution we can reverse the loss of biodiversity loss. Conservation of biodiversity is of utmost importance to sustain life on this planet over a period of time. At the same time alarming increase in the world population suggests the need to boost agriculture for feeding the millions. So the only choice left for humans is a switch to safer alternative means and methods for pest control so that the pressure of chemical pesticides on the environment is decreased. The biological control methods can effectively check the crop pests and are at the same time a boon for conserving the earth's treasure house of biodiversity.

Scientists all over the world are on an outlook for new methods of biological control. They are trying to enhance their utility by better formulations of the existing biological control agents, finding newer ways of their enrichment and are now combining them with new tools of recombinant DNA technology, mathematical modelling, and computer technology combined with a continuation of the more classical approaches such as importation and release of natural enemies and thus improving their germ-plasm, breeding, and field testing.[31,32,] Governments and stae agencies are supporting these new ventures and are framing laws for the same. Agriculturists are

now gaining awareness and are getting ready to switch over to these methods of pest control. The consumers too have now started to realize the need to use more organic farm products, thus boosting organic farming.[33,34] India is already exporting range of organic products like tea, cotton, rice etc. All these joint efforts could quickly move bio-control research and technology into a new era and fulfil the desirability of biodiversity conservation.

ACKNOWLEDGEMENT

The author is grateful to DAV College Managing Committee, New Delhi for financial support.

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