SJIF IMPACT FACTOR: 5.416 CRDEEP Journals
International Journal of Environmental Sciences Maya Yadav Vol. 7 No. 2 ISSN: 2277-1948
International Journal of Environmental Sciences. Vol. 7. No. 2. 2018. Pp. 68-71

Review Paper

Biotechnology for Sustainable Agriculture and Livelihood Security: A Preliminary Review

Maya Yadav
Assistant Professor, Department of Botany, Dr. S.P.M. Govt Degree College, Bhadohi, India.

Article history
Received: 15-01-2018
Revised: 22-01-2018
Accepted: 28-01-2018

Corresponding Author:
Maya Yadav
Assistant Professor, Department of Botany, Dr. S.P.M. Govt Degree College, Bhadohi, India.

Abstract
Climate change is one of the most important global environmental challenges with implication of food production, water supply, energy requirements, health issues, conservation of forest ecosystem and livelihood security etc. for exploding population. Sustainable development is the need of the challenging situations. However, Sustainable agriculture is that path of agricultural development which is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable. Biotechnology, third wave in the biological sciences introduce improved methods of production and proved beneficial for present and future generation requirements in terms of agricultural productivity, reduce greenhouse gases, create innovative diseases therapy, diminish the use of pesticides, promotion of biofuels and renewable source of energy. Therefore, the promising future of biotechnology helps in attainment of set goals of sustainable development. It also helps in increasing global crop productivity to improve food, feed and fiber security in sustainable crop production systems that also conserve biodiversity. This review provides a preliminary insight of application of biotechnology in agriculture, importance of bio fertilizers and use of vermicomposting. The prospects of genetically modified crops are also discussed.

Keywords: *Sustainable development, Climate change, Global warming, Biotechnology.*

Introduction

The important requirement of human life is food and for the food production the sustainable agriculture is utmost important. The Green Revolution brought spectacular yield gains to many crops in many parts of the developing world. Now the focus is on the potential of agricultural biotechnology to produce traits that reduce risk, rather than unconditionally increase yields. Decrease or static land availability need to efficiently grow crops and mitigate risk of abiotic and biotic stress, decrease losses, increase output. For the developing countries like India, where a majority of families, in both the farm and non-farm sectors, derive their livelihoods from agriculture, sustainability of agriculture cannot be discussed or even defined in isolation of the issue of livelihoods. Livelihood is defined as adequate stock and flow of food and cash with an individual or a family to meet its basic needs. Livelihood security then means secured ownership of, or access to, resources and income-earning activities, including reserves and assets to offset risks, ease shocks and meet contingencies (Acharya , 2006). The genesis of sustainability in development can be traced to the first UN conference on human development held in 1972 at Stockholm, when global consciousness on ecology, environment and poverty was brought to the centre stage of development. However, a conceptual breakthrough on sustainable development came after 15 years in 1987 through the Report of Brundtland Commission. Consequently, a blue print for sustainable development came in June 1992, when it was adopted as Agenda 21 during the UN Conference on Environment and Development, held at Rio de Janeiro. Since then, the expression 'sustainable development' has been receiving increasing attention and has become inevitable in all the development discourses. The World Commission on Environment and Development (WECD) defined sustainable development as the development that meets the needs of present generation without compromising the ability of future generations to meet their needs. The environmental concerns, economics of resource-use, and social goals have been described as sustainability tripods of development (Acharya, 2006). For understanding or defining the sustainability, lot of research work and dialogues have gone into the fields of greenhouse gas emissions, deforestation, genetic manipulations, air and water pollution, land degradation, extraction of water, human poverty and levels of living.

It must be recognized that agriculture by definition is the most aggressively managed ecosystem, which is closely linked to the world's food system. However, in predominantly rural economies like India, growth of agriculture is critical to the achievements of goals of poverty reduction and household food-security. This requires resolution of the issue of trade-off between sustainable agriculture and a growing agriculture. What is needed is a sustained growth of agriculture by adopting some new approaches like organic farming.

Sustainable Agriculture is *"an integrated system of plant and animal production practices having a site-specific application that will over the longer term; that satisfy human food and fiber needs. Enhance environmental quality and the natural resource base upon which the agriculture economy depends. It makes the most efficient use of non-renewable resources and on farm resources and integrates where appropriate, natural biological cycles and controls. It sustains the economic viability of farm operations and enhances the quality of life for farmers and society as a whole."* It is reducing environmental footprint of agriculture. Food and Agriculture Organization (FAO) has defined sustainable agriculture as the management and conservation of resource base and the orientation of technological and institutional changes in such a manner that ensures attainment and continued satisfaction of human needs of present and future generations. It follows that sustainable agriculture is that path of agricultural development, which is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable' (FAO, 1991). Nevertheless, the rising trend in resource intensity of consumption cannot be brushed aside for sustainability of natural resources. To address the problem, there is a need for adopting and inculcating a model based on 3 'Rs', i.e. Reduce, Reuse and Recycle.

In 1919, a Hungarian engineer named Karl Ereky coined the word Biotechnology. During that time, all techniques were referred to as production with the help of living organisms. UN convention on Biological diversity has come up with one of many definitions of Biotechnology: as *"The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non - living materials for the production of knowledge, goods and services"* for society. It is not just the science; it is really the application and the business. Emergence and development of molecular biology and genetic engineering provided new paradigms to life sciences and new principals of engineering and technology for applications. The newly emerged fields of genome sequencing, editing, imprinting, epigenetics, reverse genetics, genomics, proteomics and bioinformatics etc have changed the pitch of biotechnology. In addition to this the sustainable biotechnology satisfies human food and fiber and fuel needs, increased yield through biotech crops, consumer benefits, societal well being. It also contributes to climate change mitigation and bio economy solutions to 21st century problems.

However, biotechnology helps in increasing global crop productivity to improve food, feed and fiber security in sustainable crop production systems for livelihood security and only few studies are there to highlight the issues therefore in this review the biotechnology and the related issues have been highlighted.

Biotechnology and Agriculture

Researchers have put forward agricultural biotechnology, that is *"any technique that uses living organisms or substances from these organisms to make or modify a product"* (FAO, 2004), as a tool for increasing food production, while, at the same time, making agriculture more sustainable from an environmental point of view (Hansson et al., 2013). Research suggests that genetic engineering can be used to develop crop varieties that cope better with drought and salinity (Wang, et al.,2003; Thomson, et al., 2010); are more disease resistant (Qaim, 2009; Fuchs., 2010) and use nutrients more efficiently. These features are particularly desirable in a changing climate where the population grows and competition over arable land increases. However, agricultural biotechnology is a controversial topic, and not everyone is convinced that the net benefits of genetically-modified (GM) varieties will be positive overall. India is one of the leading developing countries making economic progress through industrial and agricultural development programmes. Agricultural biotechnology is a collection of scientific techniques used to improve plants, animals and microorganisms. Based on an understanding of DNA, scientists have developed solutions to increase agricultural productivity. Starting from the ability to identify genes that may confer advantages on certain crops, and the ability to work with such characteristics very precisely, biotechnology enhances breeders' ability to make improvements in crops and livestock. Biotechnology enables improvements that are not possible with traditional crossing of related species alone. Developing an efficient sustainable agriculture in the current context of major global threats (climate change, soil degradation and erosion, water scarcity, biodiversity diminution) coupled with a continual population growth represents an imperative for conceiving a coherent strategy aimed to ensure the food, feed, and fiber and fuel security. Agriculture is the major source of livelihood, particularly in rural areas, where about 65-70% of the people have been living. However, the present level of agricultural production has not reached the optimal stage because of series of hurdles. Major bottlenecks among them, are lack of resources such as water nutrient and good quality planting material, improper management of pests and diseases and poor harvest management of the produce. As against the world average of 172 kg/ha chemical fertilizers, Indian agriculture consumes only about 70 kg/ha. The average fertilizer consumption would be even lower, if the fertilizer applied for three important crops like paddy, wheat and sugarcane were kept out of the average. Thus, a majority of the crops suffer due to nutritional deficiency. In the areas of intensive agriculture such as Punjab, Haryana, Tarai region of Uttar Pradesh and the sugarcane belts in the rest of the country, excessive doses of imbalanced fertilizer application has been a problem of serious concern. These areas also suffer from excessive use of water for irrigation, when soils turn alkaline or saline and the fertilizers applied to the soils are not available for the crops. Biotechnology can help to solve these problems in two ways. Firstly, for crops where fertilizer application is very low, bio-fertilizers can fix atmospheric nitrogen and provide micro-nutrients useful to plant growth. Use of blue-green algae has also been beneficial to rice crop. Microbes such as mycorrhizae have been helpful to overcome the stress from drought and diseases. Increase in the cost of fertilizers even in Western countries has forced their farmers to use bio-fertilizers for many crops.

Bio fertilizers

Use of bio fertilizers carrying *Rhizobium* and *Azotobacter* have been in practice since a long time. However, the technology did not catch up till recently probably because of inadequate awareness, lack of marketing and insignificant results in the field. These bio-fertilizers were generally distributed free of cost by the agricultural department mostly to poor farmers and neither the promoters nor the users were serious about the use or benefits. This product came to the field at the last moment without any planning and hence farmers would not have taken this as a serious input for their crops. Bio fertilizers produced mainly by the government sponsored laboratories, had no marketing expertise to launch the product in the field. Hence, biofertilizers could not establish their superiority before a well planned marketing to launch the product in the field. The third and the most prominent cause of poor uptake was poor quality product. Most of the bio fertilizer laboratories did not have adequate production and quality control facilities and hence there have been wide variation. The carrier used was not of a standard quality. After the acidity nature, the carrier killed the bacteria before reaching the field. These problems have now been solved to a great extent through the application of biotechnology combined with a marketing strategy to organize the sale through the fertilizer marketing network without any cut throat competition. The technologies have been further simplified to use the culture in liquid form, which can have a long shelf life and are less expensive (Arun., 2007).

Further, the focus for promoting bio fertilizer has shifted from more intensive crops like groundnut, wheat, paddy, sugarcane to other crops where farmers have not been applying adequate doses of fertilizers. This has helped to improve the crop yields while reducing the cost of production. Those who have realized the benefits are now coming forward to purchase bio fertilizers on their own without any subsidy from the government. This is a good trend which ensures the growth of this sector. Soils having high Phosphorus have the problem of availability of phosphorus to plants and phosphate solubilizing micro-organisms (PSM) can be useful to reverse this process (Mishra et al., 2013)

Vermicompost

Vermicomposting is also an extension of biotechnology, which is being reinvented with the growing awareness on organic farming. Earthworms constitute more than 80% of the soil invertebrate biomass. They play a significant role for maintaining the soil productivity. Earthworms enhance the decomposition of organic matter and they also contribute 20-100 kg nitrogen per ha per year, besides other mineralised nutrients and plant growth factors. There is a need for promoting grass-root level vermiculture promotion units to supply superior quality culture to farmers for production of vermicompost.

Genetically modified crops

Genetic engineering allows the transfer of useful characteristics (such as resistance to a disease) into a plant, animal or microorganism by inserting genes (DNA) from another organism. Virtually all crops improved with transferred DNA (often called GM crops or GMOs) to date have been developed to aid farmers to increase productivity by reducing crop damage from weeds, diseases or insects. Application of biotechnology for plant protection has been gaining popularity during recent years (Ives et al 2001). GMOs use enables farmers to reduce the variety and number of treatments with pesticides in comparison with conventional plant protection systems or even to eliminate such practices, thus reducing the fuel consumption, human labor and greenhouse gas emission into the atmosphere and diminishing pollution of air, soil and ground waters. GMOs release in agricultural practice are equally important, taking into account their powerful contribution to the hunger and poverty alleviation, farmers enhanced social standing and, last, social peace in the world communities (James., 2003). The rapid extension of GMOs in different countries represents the fastest adoption of an innovative scientific and technical progress in the agriculture history and it is said by various workers the imminence of a new great revolution 'the gene revolution' come after the 'green revolution' in the second part of the last century.

Conclusion

A safe and sufficient food supply, grown in an environmentally responsible fashion, is essential for humanity. Like any technology, agricultural biotechnology will have economic and social impacts. Since their introduction, crops improved using biotechnology has been used safely, with benefits such as the reduction of pesticide use etc. Agricultural biotechnology is only one factor among many influencing the health and welfare of farmers and other citizens in the developing world. As biotechnology continues to evolve, factual and open public discourse is vital to define the role it should play in society. In this way present study open up fascinating prospects i.e. plants that consume less water, make better use of nitrogen, resist parasites, use less energy and produce plants whose nutritional and sanitary properties are improved, producing new molecules for the development of the medicine. However, the genes of biotech crops are moved to soil microorganisms through horizontal gene transfer mechanisms. Therefore, there is an urgent need to monitor how the biotech crops affect the microbial diversity present in soil and their enzymatic pathway.

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