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13

HARNESSING POTENTIAL OF PLANT BIOTECHNOLOGY FOR SUSTAINABLE DEVELOPMENT OF AGRICULTURE IN INDIA

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Abstract

Agriculture productivity is important for economic development of India as still more than seventy percent of our population directly or indirectly depends on it for livelihood. After the green revolution era, during early nineties it was realized by the Indian policymakers that enhancing the productivity as the cost of environment will have adverse effect on Indian agriculture which could pose a challenge for sustaining agriculture production and productivity throughout the country in future. Sustainable Farming with an integrated system of plant and animal production practices focusing on site specific application with an aims to provide food and fuel security to the people in a healthy environment over a long term has been suggested as an option by the visionaries involved in agriculture to address this issue. The term 'sustainable' comes from the word sustain which means to maintain or to endorse so, for practicing sustainable farming there is need of technologies which are socially viable as well as environmentally safe.(FAO,2006). As per the researchers working in the field of agriculture, for sustainable farming various technologies has to be evolved and applied with an integrated approach to enhance productivity along with vigilant environment protection approach. Agriculture biotechnology has established as one of the important tool that could significantly contribute to make agriculture production sustainable without adversely effecting the environment. Agriculture biotechnology refers to application of biotechnological tool and technologies including genetic engineering, molecular markers, molecular diagnostics, plant tissue culture etc., to modify plant, animal and any microorganism directly or indirectly involved in agriculture production system and thus could enhance quality or quantity of agricultural produce. (Hansson and Joelsson, 2013) Keeping in view these facts various technique related to agriculture biotechnology has been discussed here.

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Application of Transgenic for Sustainable Agriculture

Genetic engineering is a technique to incorporated desired traits in an organism through genetic modification of an organism by inserting gene for a particular character in one organism from other organism. Thus use of genetic engineering allows selection of those traits that would not be possible through conventional plant breeding method. It has been used to develop various transgenic varieties having resistant to salinity, drought, disease as well as nutrient efficient which could be utilised to meet the challenge of fulfilling food, fodder and fuel requirement of increasing population.

Reduction in Use of Chemical Pesticides Using Transgenic Plants

Transgenic crops has been developed for insect resistance (GM IR), in the various crops for major pests such as fruit and shoot borer of brinjal, stem and stalk borers, earworms, cutworms and rootworm in maize (eg, *Ostrinia nubilalis, Ostrinia furnacalis, Spodoptera frugiperda, Diatraea spp, Helicoverpa zea and Diabrotica spp*), bollworm/budworm in cotton and pod borer (*Helicoverpa armigeru)* in chickpea. GM crops with desired traits have contributed significantly in reduction of adverse environmental impact associated with indiscriminate use of insecticide and herbicide by the farmers.

Initially developed transgenic varieties which were permitted for cultivation in developed countries like USA and Canada included cotton, soyabean, corn and canola, were resistant to herbicide and insect pests. These transgenic varieties have significantly contributed for the cause of sustainable agriculture as they give higher yields along with efficient pest suppression resulting in reduced application of chemical. Thus it is reducing the cost of cultivation of crops along with protecting our environment from harmful chemicals. In last few decades, development of transgenic crops such as Bt cotton, canola, corn etc has significantly contributed in reduction of use of pesticides which reduces number of sprays per hectare area. As per the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), in 2007 alone use of GMO crops resulted in a reduction of pesticide use of over 77,000 metric tons of active ingredients which is as per the group was equivalent to using 18 percent less pesticide on farmers' fields. (James, Clive. 2007)

In India, cotton is the only crop for which transgenic has been permitted for commercial cultivation. The development of transgenic cotton varieties popularly known as Bt cotton are resistant against bollworm thus increasing the yield as well as reducing the reliance on insecticide. It has also contributing in reducing green house gases which was being emerges out during chemical sprays on the crops thus making the soil healthier. (James, Clive (2009),)

In India several transgenic varieties has been developed but has not been released for cultivation. DMH (Dhara Mustard Hybrid)-11 is one such genetically modified variety of mustard developed by Centre for Genetic Manipulation of Crop Plants at Delhi University. It is developed by using three genes viz., *barnase, barstar* and *bar* from *Bacillus amyloliquefaciens* for hybrid seed production. The *barnase* gene confers male sterility to a plant in which it is inserted and barstar gene/s restore the fertility to produce fertile hybrid plants and seeds. The third gene *bar* synthesize an enzyme call PAT, which is responsible for tolerance to glufosinate in the plant. Glufosinate is a broad spectrum herbicide, which

indiscriminately eliminates weeds and any plant that does not have the bar gene. Glufosinate herbicides contain the active ingredient phosphinothricin, which kills plants by blocking the enzyme responsible for nitrogen metabolism and for detoxifying ammonia, a by-product of plant metabolism**.** Its commercial release has been put on hold by the Environment Ministry (Lakshmikumaran, 2019).

Increase in Carbon Sequestration Using Transgenic Plants

In past few decades, there is increased concern to stabilizing the atmospheric concentration of CO_2 and other GHGs to mitigate the risks of global warming. Atmospheric enriched level of GHGs can be moderated through processes controlling human emissions, or sequestering Carbon in plant biomass or the soil. Carbon sequestration refers to the process by which atmospheric carbon dioxide is fixed in plant issue by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) as well as in soils in such a manner that it is not re-emitted into the atmosphere for a long duration. (Kane, 2015).Thus any form of vegetation whether it is agriculture crop, weed, forest tree or any other plant, it act as a sink of carbon sequestration which ultimately helps to equalize sources of carbon dioxide to the atmosphere, such as deforestation, forest fires, and fossil fuel emissions. Thus by adopting sustainable agriculture practices we can increase the ability of agriculture to sequester atmospheric carbon while enhancing other ecosystem services, such as improved soil health and water quality.

Transgenic plants has been developed to have inherit ability with enhance photosynthesis and thus result in increased biomass yield. They also increased pest resistance thus need less chemical application throughout the growing process. Thus they perform better "no-till" and "reduced-till" farming systems. Infact these production systems have increased significantly with the adoption of GM HT crops as the GM HT technology facilitates farmers to manage competing weeds efficiently, reducing unnecessary tillage practices just to reduce weeds.

GM crops requires less application of weedicide and insecticide compared to traditional crop, thus it contribute in reduction of fuel used for crop cultivation. The fuel savings associated with making fewer spray application relative to conventional crops, and the shifting to conservation, reduced and no-till farming systems, resulted in effective reduction in carbon dioxide emissions.

It has also been reported that in North and South America, crop production using GM HT crops (especially in soybeans) resulted in better management of weeds, thus reducing the need for intensive tillage and seed-bed preparation. Thus GM technology has facilitated shifting from conventional to RT/NT production systems by the farmers in both North and South America Brookes and Barfoot (2018). The largest reductions in carbon dioxide emissions associated with reduced fuel use have come from the adoption of GM HT technology in soybeans (about 85% of total savings) and particularly in South America. There is 5-fold increase in carbon sequestration have been recorded with GM herbicide tolerant (HT) soybeans in Argentina account for 95% of the no -till soybean area. It has concluded that this soil carbon saving is based rapid adoption of RT/NT farming systems, for which the availability of GM HT technology was a promoting factor which result in adoption of this system by many farmers. Thus GM HT technology has been an important

contributor to this increase in soil carbon sequestration, but is not the only factor of influence.

Biofuel Production Using Transgenic Plants

Biofuel has the potential to reduce environmental pollution by decreasing the reliance on petroleum products. This can be achieved by using genetically engineered plants to produce cellulases and hemicellulases, that will reduce the need for pretreatment processes through lignin modification. There are other effective ways also to solve this problem, together with strategies, such as increasing plant polysaccharide content and overall biomass. Therefore biotechnology has proved as a enabling technologies for yield increase and conversion process for fuel crops like corn ethanol, soya biodiesel (Sticklen,2008).

Application of Molecular Markers for Sustainable Agriculture

Molecular markers are powerful tools to estimate genetic diversity and to generate information to better understand the genetics of any crop as they are accurate, abundant and not affected by the environment. Molecular marker tools have been used recently for addressing problem of food security and environmental conservation by utilizing it various research directly. Molecular marker technique is directly applied for molecular diagnosis of diseases and pests, Marker Assisted Selection (MAS), Gene Assisted Selection (GAS) and Genome Assisted Breeding (GAB) related for betterment of Agriculture. In Agriculture and allied field molecular marker based technique has been used for enhancing qualitative and quantitative traits of l crops, animals and forestry species.

Molecular markers associated with important agronomic traits could significantly reduce the time and cost involved in developing new varieties because they help in selecting the best parents and accelerating the rate of genetic gain in the breeding program. Association mapping has become widely used to identify DNA markers associated to important traits in many crops (Lammerts *et al.*,,2010).

Application of Plant Tissue Culture for Sustainable Agriculture

Micropropagation refer to propagation technique where minute section of plant (cell,tissue etc)is used for large scale propagation of plant. It is popularly known as Tissue culture. Scientifically it a type of large-scale clonal propagation. It can be also considered as first major and widely accepted practical application of plant biotechnology.

Technically it is described as the *in vitro* propagation where culturing of plant tissue is done under control and sterilized condition in a lab. As the plant tissue differentiation is completed and a plantlet is produced in tissue culture setup, these plantlets are transferred for *ex vitro* establishment in the soil in fully controlled polyhouses. During last few decades *in vitro* techniques for plant propagation has progressed as technique has been simplified a lot (Aladele,2012).

Plant tissue culture is an important agricultural biotechnological tool that contributes in the production of crops with improved food, fiber, fuel and feed. It is one way towards commercialization to face the food availability challenge in developing countries and allow to cope with their fast growing population in restricted area of land. In addition, plant tissue culture enables rare and nearly extinct species to be rescued and

propagated. In this way plant improvement as well as *in vitro* production of metabolites and plant secondary products can be achieved throughout the year under disease free environment.

Conclusion

From the above context it has been proved that plant biotechnology has played an important role in modern agriculture to boost production and productivity of agricultural commodities and strengthen our economy. In order to increase production and productivity of commodities, there is need of time to focus on development and adoption of technologies such as genetically modified crops, tissue culture for large scale plantation. Government should make policy to consider allowing GM crop for crop cultivation under strict monitoring. Farmer's should be educated about tissue culture plants, transgenic varieties and their advantages. Tissue culture plants should be easily available to the farmers. We all should agree that technically driven and efficiently managed precision farming is the ultimate option to feed our ever increasing population while ensuring sustainability at ecological, environmental and community level.

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