Role of Biotechnology in Sustainable Agriculture

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ABSTRACT

Food security and sustainable agriculture have become a burning issues in the national discuss at all levels of government as plans are being made for a changing global climate and increasing global population. One of the most important environmental challenges facing the developing world is how to meet current food needs without undermining the ability of future generations to meet theirs. Agricultural production must be sufficient to feed us now and in the future. Evidently, the current state of agricultural technology will not suffice to meet the production challenges ahead. Innovative technologies have to be exploited in order to enable sufficient food availability in the future. In the current practice of modern agriculture which relies on high inputs such as fuel-powered tractors, chemical fertilizers and chemical pesticides, deploying a smart mix of farming techniques using genetic engineering of biotechnology and integrating same into the traditional smallholders farming system offer a bright prospect of meeting the growing demand for food by improving both yield and nutritional quality of crops and reducing the impact on the environment.

Sustainable Agriculture

The word “sustainable” comes from the word “sustain” which means to maintain, support, or to endure. Sustainable agriculture is the act of farming based on an understanding of ecosystem services, the study of relationships between organisms and their environment. It has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term”. People involved in sustainable agriculture are trying to identify and solve the problems in our current agricultural system in order to provide food and fibre in a healthy environment for people over the long term.(Gold, M. July 2009).

Sustainable Agriculture Techniques

Sustainable agriculture provides high yields without undermining the natural systems and resources that productivity depends on. Farmers who take a sustainable approach work efficiently with natural processes rather than ignoring or struggling against them – and use the best of current knowledge and technology to avoid the unintended consequences of industrial, chemical-based agriculture. One important result is that farmers are able to

minimize their use of pesticides and fertilizers, thereby saving money and protecting future productivity, as well as the environment.

Below are some of the most common sustainable agriculture techniques employed by farmers today to achieve the key goals of weed control, pest control, disease control, erosion control and high soil quality:

Crop Rotation
Cover Crops
Soil Enrichment
Natural Pest Predators
Biointensive Integrated Pest Management
Crop Rotation

Crop rotation—growing different crops in succession in the same field—is one of the most powerful techniques of sustainable agriculture, and avoids the unintended consequences of putting the same plants in the same soil year after year. It is a key element of the permanent and effective solution to pest problems because many pests have preferences for specific crops, and continuous growth of the same crop guarantees them a steady food supply, so that populations increase. For example, right now European corn borers are often a significant pest in the United States because most corn is grown in continuous cultivation or in two-year rotations with soybeans. Four- or five-year rotations would control not only corn borers, but many other corn pests as well. In fact, rotation reduces pest pressure on all the crops in the rotation by breaking the pest reproductive cycles.

In rotations, farmers can also plant crops, like soybeans and other legumes, that replenish plant nutrients, thereby reducing the need for chemical fertilizers. For instance, corn grown in a field previously used to grow soybeans needs less added nitrogen to produce high yields.

Cover Crops

Many farmers also take advantage of the benefits of having plants growing in the soil at all times, rather than leaving the ground bare between cropping periods, which produces unintended problems. The planting of cover crops such as hairy vetch, clover, or oats helps farmers achieve the basic goals of:
preventing soil erosion, suppressing weeds and enhancing soil quality.
Using appropriate cover crops is worth the extra effort because it reduces the need for chemical inputs like herbicides, insecticides, and fertilizers.

Soil Enrichment

Soil is arguably the single most prized element of agricultural ecosystems. Healthy soil teems with life, including many beneficial microbes and insects, but these are often killed off by the overuse of pesticides. Good soils can improve yields and produce robust crops less vulnerable to pests; abused soils often require heavy fertilizer application to produce high yields. Soil quality can be maintained and enhanced in many ways, including leaving crop residues in the field after harvest, plowing under cover crops, or adding composted plant material or animal manure.

Natural Pest Predators

Understanding a farm as an ecosystem rather than a factory offers exciting opportunities for effective pest control. For example, many birds, insects, and spiders are natural predators of agricultural pests. Managing farms so that they harbour populations of pest predators is a sophisticated and effective pest-control technique. One of the unfortunate consequences of intensive use of chemical pesticides is the indiscriminate killing of birds, bats, and other pest predators.

Biointensive Integrated Pest Management

One of the most promising technologies is the control of pests through integrated pest management (IPM). This approach relies to the greatest possible extent on biological rather than chemical measures, and emphasizes the prevention of pest problems with crop rotation; the reintroduction of natural, disease-fighting microbes into plants/soil, and release of beneficial organisms that prey on the pests. Once a particular pest problem is identified, responses include the use of sterile males, biocontrol agents like ladybugs. Chemical pesticides are only used as a last resort.

Feeding the Global Population

Agricultural production must be sufficient to feed us now and in the future and with a rising population, growing more food at affordable prices becomes even more important. Currently, the Food and Agriculture Organization (FAO) believes that more than 800 million people in the world do not have enough to eat, causing 24,000 people to die every day from hunger, three-quarters of whom are children under five.(The State of Food Insecurity in the World 2006, Sustainable Food Security for All by 2020 , 2007) Additionally, the United Nations Sub-Committee on Nutrition estimates that 33% of children under five in developing countries have experienced stunted height-for-age growth.(Report on The World Nutrition Situation Geneva,2000) This suggests chronic

undernourishment throughout their childhood, which can hinder overall health as well as their ability to learn.

"Hidden hunger," or micronutrient deficiencies of iron, iodine, or Vitamin A, is of equal concern. According to the Micronutrient Report, "nearly 20 percent of the population \[in the developing world\] suffers from iodine deficiency, about 25 percent of children have sub-clinical vitamin A deficiency and more than 40 percent of women are anaemic."(Mason JB, 2001) The World Bank calculated that the global loss of productivity secondary to malnutrition, in one year alone is the equivalent of 46 million years of productive, disability-free life.(World Bank. World Development Report 1993)

Meanwhile, the world's population continues to increase. According to the Population Reference Bureau, the world population reached 6.6 billion people in 2006, up from 6 billion in 1999. They project the global population will reach 8 billion by the year 2025 and that 90% of growth will be in developing countries.(Population Reference Bureau. 2006.)

In order to meet these needs, the FAO estimates that global food production must increase by 60 percent in developing countries to accommodate the estimated population growth, close nutrition gaps, and meet dietary needs.

Tools in the Toolbox: Biotech Crops can Help

Biotechnology and Sustainable Agriculture Biotechnology has been contributing to sustainable agriculture through the following ways:

Increased resistance against biotic stresses (insect pests and diseases);

Increased resistance against abiotic stresses (drought, cold, flooding, and problem soils);

Bioremediation of polluted soils and biodetectors for monitoring pollution;

Increased productivity and quality;

Enhanced nitrogen fixation and increased nutrient uptake and use efficiency;

Improved fermentation technology;

Improved technologies for generating biomass-derived energy;

Generation of high nutrient levels in nutrient-deficient staple crops such as rice.

Biotechnology contributes to sustainable agriculture by reducing the dependence on agro-chemicals, particularly pesticides, through the deployment of genes conferring tolerance or resistance to biotic and abiotic stresses. Carefully selected genes from related or unrelated genetic resources are integrated in otherwise desirable genotypes. Systematic pyramiding of genes allows integration of desirable genes in one genotype for different traits, such as tolerance to stresses, productivity, and nutritional quality. Technology, including new varieties and breeds, is an essential element of sustainable agriculture. However, it is not the only element of sustainable agriculture.

Non-technological aspects such as governmental policy and will, institutional and infrastructural support, technology sharing and transfer mechanisms, and peoples attitude

and awareness are equally, if not more important, in providing the needed conditions for absorption and successful exploitation of the technology toward sustainable agriculture.

Biotechnology can be used to meet the growing demand for food by improving yields, improving the nutritional quality of crops and reducing the impact on the environment.It has tremendous potential for impacting global food security, human and animal health, environmental health, and overall livelihood of mankind. Using traditional techniques, such as selective breeding, scientists have been working to improve plants and animals for human benefit for hundreds of years. However its time consuming, often taking 10 to 12 years to breed plants in the traditional manner. With biotechnology, modern crop breeders can select a specific genetic trait from any plant and move it into another plant with greater ease and precision, selecting for the most beneficial traits. These tools also allow plant breeders to select for traits that wouldn't be possible through traditional breeding.

These beneficial traits can have a major impact on the challenges we are facing. Biotechnology can help grow more food by making crops resistant to pests and disease, preventing the loss of billions of pounds of crops, sometimes by replacing the chemistry of pesticides with a protein in the plant itself. According to experts, enhanced crops in the U.S. alone helped prevent the loss of approximately 8 billion pounds of crop in 2005. In addition to fighting the environmental stresses of disease and pests, researchers in both academia and industry are currently working on developing crops that use water more efficiently to help with growth in drought conditions.

Higher yielding crops can also mean higher income for farmers. In developing nations, agriculture employs nearly half the labor force, and many more are indirectly dependent on it economically.

Growing more food means that in addition to having more crops to feed our growing population, incomes for those working in or dependent on agricultural production will rise, which can translate into better diets and health care. In a review of the impact of food biotechnology (Brookes and Barfoot ,2006) found a $5 billion income benefit realized by farmers around the globe, 55 percent of which went to farmers in developing nations, even at this early stage of adoption in these countries.

The potential environmental benefits of biotechnology throughout the world are also significant. For example, biotechnology can be used to grow plants that are resistant to herbicide and pesticides, removing the need to till for weed control and reducing the amount of pesticides that need to be used. This can help reduce carbon emissions and soil erosion, thereby reducing the impact that these cause. From 1996-2005, no-till farms reduced fossil fuel use by an estimated 962 million kg of carbon dioxide equivalent to the CO2 production of 427,556 average-sized family cars.

The ability to leave crop residue from one year to the next also provides a natural "trap" for CO2. Based on the amount of farm land that has been converted from full-till to reduced- and no-till systems, biotech has resulted in an 8,053 million kilogram reduction in CO2 emissions from agriculture, equivalent to 3,579,298 average-sized family cars.

Conclusion

Sustainable food production is important and increasing the world's food supply is seen as the most important aspect of sustainable production. Using a smart mix of farming techniques, such as biotechnology, can help us as we strive to feed tomorrow's population and reduce the impact of farming on the environment.

Thus, Agricultural biotechnology is a collection of scientific techniques, including genetic engineering, that are used to modify and improve plants, animals and micro-organisms for human benefit. It is not a substitute for conventional plant and animal breeding but can be a powerful complement. The present report explores the role of biotechnology in contributing to sustainable agriculture which is the need of the hour.

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