BIOTECHNOLOGY AND SUSTAINABLE AGRICULTURE - FOODS FROM GENETICALLY MODIFIED CROPS

S.Drinić Mladenović, K.Konstantinov, G.Drinić
Maize Reserch Institute "Zemun Polje", Belgrade, Yugoslavia
msnezana@mrizp.co.yu

ABSTRACT

The need to produce an abudance of high quality and safe food, while balancing the need to protect and conserve the enviroment has never been more important than it is today. Development a new crop protection products, seeds, biotechnology provides valuable tools to help farmers to achiave a substainable, safe and economic crop production. Sustainable agriculture means improvments and utilization of enviromentally friendly technologies with the aim of reducing enviromental impact and consumption of resources. Genetically modified crops, crops into which genes isolated from microbes, animals, or other plants have been inserted are the most popular and most widely used of all crop biotechnologies. To date, genetic modification improve crops ba making them more resistant to insects, or more tolerant to herbicide. Genetically modified crops have many possible effect on the enviroment. Potential enviromental benefits include the use of fewer, less toxic, or less persistent pesticides; increase crop yield; reduced soil tillage; improve water quality. Potential risk include uncontroled flows of genes to wild relatives, development of herbicide resistance in wild relatives; and adverse effects on beneficial organisms. Biotechnology provides a set of tools that, if appropriiately integrated with other technologies, could be applied for the sustainable development.

Key words: food, environment, biotechnology, sustainable agriculture, genetically modifications, maiz

INTRODUCTION

Without significant changes in farming on a global basis and shift to more sustainable agricultural practices more people will be hungry in the future. Estimates show that by the year 2050 world population is reach 9 billion people, an increase of 50 percent over the present day. This growth will occur mostly in developing countries. Already, about 1,2 billion people live in a state of absolute poverty and 800 million people are food insecure[1].

At the moment only 0,26 percent more food is being produced than is actually consumed. Over the next decades requirements for world food will more than double and this will make necessary to double agricultural production and supplies. And in the next thirty years we will have to produce more food worldwide than over the whole of the last 10,000 years. During the last doubling of the human population food production was increased by adoption of many new technologies. New irrigation techniques, modern pesticides, improved crop varieties, machinery that harvests more of the crop; synthetic fertilizers and green manures have helped raise food production from 1950. Continuing yield increases are needed, especially if some land is reserved for wildlife. But yields for some crops have levealed off, so current technologies thus will not be able to keep pace with the projected increase in population. Also, the amount of arable land cannot really be increased, the existing land should be made to produce more in eco-friendly manner.

Considering the need to feed rapidly growing world population and recognizing that all agriculture changings the enviroment, everyone agrees that future farming must be «sustainable». Sustainable agriculture as articulated in the «Farm Bill» (Food, Agriculture, Conservation, and Trade Act of 1990, P.L. 101-624, Title XVI, subtitle A, section 1603) means «an integrated system of plant and animal production practices having a site specific application that will, over the long term: satisfy human food and fiber needs; enhance enviromental quality; make the most efficient use of nonrenewable resources and on farm resources and integrated natural biological cycle and control; sustain the economic viability of farm operation; and enhance the quality of life for farmers and society as a whole».
Three basic models could be consider:high intensity agriculture; organic agriculture; and genetically modified crop – based agriculture. High intensity agriculture (fertilizers, herbicides, pesticide, mechanization) has potencial to produce more than sufficient food to feed the world population, but at high enviromental cost. The only device was to get highest possible yield per ha with a large external input of fertiliser, chemicals and machinary to reach the most interesting economical profit on the farm level. One of the most negative effect of this is the generation of resistant insects, fungi, weeds as well as residues of chemicals in crops and soil. On another hand organic farming minimaze the impact on the enviroment and produce food by reducing or eliminating the imput of agrochemicals as pesticides, herbicides, and mineral fertilizers. The use of genetically modified orgasnism or derived products in organic farming is forbidden. The substitution of mineral fertiliser by organic manure may never cover the same nitrogen availability for the crop, resulting in less growth capacity and development, even decreased quality of the crop[2]. Nowdays only 1% of the farm practice in the EU is managed as organic farming and the intention is to reach 5% in 2005.

Biotechnology provides a set of tools that, if appropriiately integrated with other technologies, could be applied for the sustainable development. GM could enhance agricultural productivity by introduction of genes from same or other species; reducing reliance on agrochemicals by producing disease, pest resistant varieties and plants tolerant to herbicides; reduce post harvest losses to pest and improve nutritional value of foods. By increasing yields on land already in production we will be able to prevent the conversion of rainforest and wildlive habitat to crop production. Biotechnology, coupled with traditional seed and plant protection technologies is complementary to Integrated Crop Managment and Integrated Pest Managment. So the best sustainable solution will probably require a combination of different technologies.

BIOTECHNOLOGY IN AGRICULTURE AND FOOD

In the last two decades a series of complamentary advances in the field of molecular biology results in development of a set of new technology collectively term biotechnology. USDA has defined biotechnology as «the use of living organisms, cells, subcellular organelles and/or parts of those structures to effect biological, chemical or physical changes». This technology have several advantages over traditional breeding methods. Unlike traditional breeding, which involves the crossing of hundreds of genes, biotechnology allows the transfer of only one or a few desirable genes.The exchange of genetic material through conventional breeding requires that the two plants being crossed are of the same, or closely related species.

Plant biotechnology allowing transfer of a great variety of genetic information across species in a more precise manner. The gene from microrganism, plants, animal could be transfered to plant genome and genetically modified plants are produced. The development of genetically modified plant involves following steps: i) identification of a gene that would impart a useful trait to the target plant and cloning the gene; ii) modification of gene for expression in plant; iii) incorporation of the modified gene into target plant genome; iv) regeneration of whole plants capable of transmitting incorporated gene to the next generation; v) plant breeding and testing.

Plant researchers look for genes that will benefit the farmer, the food processor or the consumer. For example a gene from the bacterium *Bacillus thurigiensis* have been inserted into corn. The genes make protein lethal to certain caterpillars that destroy corn plants. In the insect gut the protein break down to realise toxin that binds to and create pores resulting in ion imbalance and insect death.

Some of the products currently on the market that have been enhanced through biotechnology are corn, cotton, potato with insect resistance; herbicide resistance (soybean, corn, canola, cotton) and delayed fruit ripening (tomato). Products that should soon be on market including improving or modified oil quality, protein content; food with palette of antioxidants and anticancer compounds, increasing vitamin and nutritional supplements[3]. Products we can expect to see further down the road include: plants that produce human serum albumin, neurotransmitter, produce antibodies, edible vaccines, biodegradable plastic, modified plant texture, produce fuel.

GLOBAL STATUS OF GENETICALLY MODIFIED PLANTS

During the last five years, 1996 to 2000, global area of genetically modified crops increased more than 25 fold, from 1,7 mil ha to 44,2 mil ha in 2000[4]. The increase of area of genetically modified crops between 1999 and 2000 is 11% (4.3 mil ha) as it is about 25 percent of the corresponding increase of 12.1 mil ha between 1998 and 1999. From 1996 to 2000 up to 85% of global transgenic has been grown in industrial countries. The area of transgenic crops in developing countries grew by 51% from 7.1 mil ha in 1999 to 10.7 mil ha in 2000, compared with 2% growth in industrial countries. Prediction for 2001 growing season is that the percentage of crop area planted to genetically modified crops will increase by 17%. During the five year period (1996-2000) the number of countries growing comercially genetically modified crops increasing form 6 to 13 in 2000. There are eight industrial countries and five developing countries. Of the top four countries that grew 99% of the global genetically modified crop area are USA, Canada, Argentina and China. The countries grew commercially genetically modified crop in 2000 include two Eastern European countries Romania and Bulgaria and three European Union countries Spain, Germany and France. Of course the number of country that test genetically modified crops in field trails are much more. As estimated in 23. april 2001 in EU 1668 field trails with genetically modified crop are conducted (*Source: European Commission Joint Research Center)*.

The most popular genetically modified crop currently grown are soybean, corn, cotton, canola, potatoes and tomatoes[5]. Genetically modified commercial crops grown on a smaller scale include sweet corn, peanuts, squash, papaya[6]. The most dominant genetically modified crop is soybean, occupying 58% of the global area of genetically modified crops in 2000; following with corn, cotton and canola. During the five year period 1996 to 2000, herbicide tolerance has consistently been the dominant trait with insect resistance being second. The area of herbicide tolerant crops has increased between 1999 to 2000 as well as crop with stacked genes for herbicide tolerance and Bt, whereas the global area of insect resistent crop has decreased.

ENVIROMENTAL BENEFITS AND RISK

Due to the rapid growth and spread of genetically modified crops assessing their potential benefits and risk is necessary. They can have many possible effects on the enviroment. Potential enviromental benefits include the use of fewer pesticides, increased crop yield, reduce soil tilage. The USDA Economic Research Service determined that the introduction of GM crops reduced use of pesticides[7]. They estimated a reduction of 6.8 to 9 million pesticide acre-tretments (1.9 to 3 percent of the total) between 1987 and 1988, due to genetically alterd crops. The estimated reduction in pounds of active pesticide ingredients ranged from 0.3 to 7.9 milllion pounds (0.4 to 3.4 percent of the total applied).

Weed control is one of the biggest challenges in crop production, becouse poorly controlled weed reduce crop yield and quality. Current agricultural production often necessitates the use of several different herbicides to control the wide range of weed species present in field. Herbicide tolerant plants are developed by introducing a gene into plant that enables the plant to continue growing even when a herbicide is applied that usually would harm it. With herbicide resistant crops, farmers are able to grow weed-free fields by applying a single herbicide instead of spreying several different chemicals. They can spray less often thus saving time, fuel and wear and tear of equipment. Roundup Ready soybeans have grown to over half of the US soybean market since their launch in 1996 and during this period, overall soybean herbicide use has decreased by over 10%. In 1999, the number of herbicide applications decreased by 19 million, or 12%[8]. The benefits of the introduction Roundup Ready soybeans include a cost saving of $216 million in annual weed control costs. Also due to decreased competition from weed the crop is higer quality. Soil and water are natural resources critical to crop production. The development of herbicide resistant crops has expanded farmers ability to practice conservation tillage farming. The stubble protect topsoil against loss to wind and rain. In this regard, transgenic crops could help conserve soil, primarily by alleviating farmers of the burden of tilling the soil to control weeds.

Traditional breeding efforts to select for natural resistence to the corn borer resulted in the development of varieties with intermediate levels of resistance that were used into mid 1970s. However, area planted with these varieties decreased due to the introduction of much higer yielding susceptible hybrids, which have higer yield than resistant hybrids. Genetically modified plants to be resistent to certain group of insects benefit from an additional gene that enables the plant to produce a protein in its tissues which control specific harmful insects. With the Bt crystal protein produced only inside plant, only those insects feeding on the plant, are exposed to, and killed by insect specific toxin. The benefits of built-in insect protection include improvment insect control, improved Integral Pest Managment, reduce insecticide use and exposure, increased yield, reduced fumonisin., saving money, fuel and time.The greatest impact of Bt corn varieties is the increase in production it provides through reduced yield losses due to ECB. Yield losses due to the corn borer vary from year to year with infestation level so the benefits that growers realize from planting BT corn also depends on level of infestation.

But there are also some risks from growing of genetically modified crop as gene flow to other plants, effect on nontarget organisms and biodiversity impacts. While crop genetically modified for resistance to insects may suffer less damage and lead farmers to use less insecicide, there is concern that the toxins these plant produce may harm non-target organisms[9]. In laboratory study Losey et al.[10] found a 44 percent mortality rate in monarch butterfly larve fed on milkweed leaves dusted with Bt corn pollen. No field experiments have shown that Monarch population would be adversely affected by polen exposure in the wild. Corn pollen drops off rapidly at the edge of cornfield and larvae must be present during the few days a year when corn is pollinating and must eat milkweed leaves dusted with Bt pollen rather than undusted leaves. Recently, Wraight et al.[11] studied the effect of different type of Bt corn on different species of butterfly combining field and laboratory studies and reported that a common type of Bt corn had no deleterious effects on buterflies. An additional advantage is that through Bt protection mycotoxins contamination was down by 92 percent[12]. Also widespread use of genetically modified crops for resistance to insects may lead to the development of resistance to Bt in insect population exposed to GM crops. The best way to perserve development of insect resistance is Insect Resistance Managment (IRM). The key component of any IRM plan is a refuge. A refuge is a simply a block of non-Bt plants that is planted on a portion of crop field. It means that up to 80% of crop field are with Bt crop and 20% with non-Bt crop.

Another concern is that crop plants modified for herbicide tolerance and weed will cross-breed, resulting in transfer of the herbicide resistance genes from crops into weeds and make «superweeds». The risk of gene flow is not specific to biotechnology. For any gene to spread, there must be successful hybrid formation between GM crop and recepient species; the two species must flower at the same time; share the same insect pollinator; and be close enough in space to allowe for transfer of viable pollen[13]. Also, genes can be transfered to non-modified crops planted next to GM crops. There are number of factors, that minimize pollen mixing: the pollen load in a field is usually great enough so that it will not allow significant levels of outside pollen to impact crop; pollination timing varies from field to field; pollen traveling depends on enviromental factors; distance minimizes pollen contact[14]. However, for possibility of pollen mixing field with genetically modified crop must be 200m apart form another crop field.
Two ways to ensure that nontarget species will not receive introduced genes from GM plants are to create GM plants that are male sterile or to modify the plant so that pollen does not contain the introduced gene. Another possible solution is to create buffer zones around field of GM crops.

POTENTIONAL HEALTH EFFECT

The health effect of genetically modified food depends of specific content of food itself and could be either potentionally beneficial, for example food with higher content of digestiable iron or elimination of alergent from food or harmfull where alergent or toxin is introduced in food. Genetically modified crops could bring new alergents into food not just from known sources of common allergens, but form plants, bacteria, viruses whose potential allergencity is largely unknown. The testing of GM products for alergencity is part of safety assesment. Proteins introduce in genetically modified food that are now on the market are sensitive to heat, acid and enzymatic digestion, are present in very low level in the food and do not have structural similarities to know allergens so there are no evidence that they will cause allergies.

Genetic engeenering often uses genes for antibiotic resistence as «selectable markers» that help select cells that have taken up foreing gene. The presence of antibiotic resistance genes in foods could have two harmful effects[15]. First, eating these foods could reduce the effectiveness of antibiotics to fight disease when these antibiotic are taken with meals. Second, resistance could be transferred to human pathogens making them resistent to antibiotic. The potential risk of transfer from plants to bacteria is less than the risk of normal transfer between bacteria. Neverthless, avoid using marker genes that encode resistance to antibiotic has been adversed.

The 35S promoter, derived from the common plant virus, cauliflower mosaic virus is a component of transgenic constucts in more than 80% of the genetically modified plants. Some reports have suggested that the 35S promoter might cause accidental activation of plant genes or endogenous viruses or might recombine with mammalian viruses as HIV with unexpected cosequences[16]. Assuming that the integrated 35S promoter have recombinational properties, for it to effect the activation of a dormant virus or create a new virus, the whole promoter have to be either excised and reinserted precisely at the site or its 3′ end linked precisely with another gene. If the gentically modified food was cooked the DNA would be denatured and be very unlikely to renature in a operable form. However, DNA containing the promoter will be exposed to nucleases both from plant cells and in animals gut. Less than 5% administered DNA survives up to 7 hours in a animal gut and DNA is cleaved into very small piecies[17]. Also, there are more than 105 copies of the 35S promoter in each cell of the plant naturally infected by CaMV, in contrast to the one to a few copies of the 35S promoter in each cell of transformed plants. Ho et al.[18] suggested that 35S promoter would recombine with hapadnaviruses such as human hepatitis B virus. This is based on suggestion of a «close relationship between CaMV and hepadnaviruses». However, their replication cycle differs significantly from that of CaMV; they have different genome organisation; there are no similarity between sequences important in replication.

Some of the concerns over the potential threat posed by genetically modified crops to human health have also been raised regarding animal health. No evidence has emerged to show that consumption of GM feeds has affected animal helth.

SAFETY AND REGULATION OF GENETICALLY MODIFIED FOOD

When introducing any new technology into food chain there is need to adopt some safegards to protect human health. Many countries start developing regulatory controls before any GM food reached the market. In most countries regulation include the concept of substantial equivalence. The concept is based on the idea that existing organisms used as food or food sources can serve as a basic for comparision when assessing the safety for humans of modified food or ingradients. Only highly processed foods such as highly refined oil and starch hydrolysates are consider substantially equivalent to their conventional countparts on the grounds that neither DNA not protein would be expected to be present following the processing of food. Biotechnology improved crops and food have gone through more rigorous food and enviromental safety testing than any food before. Years of testing have shown that commercially aviable foods developed through biotechnology are substantially equivalent to foods developed through traditional plant breding.

Of course, consumers all around the world want to know are the food on the market from genetically modified crops and have a right to choose whether to eat genetically modified foods or not. So the labeling of the products is very important. Labeling is often used to deliver information to consumers on characteristics of product hat they are not able to evaulate. There are to type of labeling, positive and negative[19]. In the USA, Canada, Australia labeling is voluntary and is labeled products that are significant different and have alergent.In Jupan until April 2001 helth testing and labeling was volunary and now is mandatory. In European Union labeling is mandatory for products that are signifiicant different, have alergent, contain ethically sensitive genes, derived from GM crop. European Commission has established a 1% treshold for contamination of unmodified foods with GM food products.

Risk and opportunities associated with GM foods may be integrated into general food safety regulation of a country. Regulatory system should be closely associated with exsiting regulatory arrangements for a new pharmaceuticals, foods, and agricultural and veterinary products. National food safety and biosafety regulations should reflect international agreements, a society′s acceptable risk levels,the risk associated with not introducing modern biotechnology, as well as alternative means to achieve the desired goals[20]. Since May 2001 Federal Republic of Yugoslavia have adopt regulation about genetically modified organisms according directives of European Union.

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