5. BIOTECHNOLOGY AND ITS ROLE FOR A SUSTAINABLE AGRICULTURE

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Abstract

Developing an efficient sustainable agriculture in the current context of the global major threats (climate change, soil degradation and erosion, water scarcity, biodiversity reducing), coupled with a continual population increasing, represents an imperative for conceiving a strategy that should integrate conventional and biotechnological approaches, aiming to optimize productivity and contribute to food, feed, fiber and fuel security.

The successful developing and implementation of this strategy depend largely on establishing regional cooperation and a network that addresses to similar agricultural needs, priorities and practices, science based on regulations that should be able to protect public health and environment and to stimulate economic development, regional and global trade, modern agricultural practices, advanced food and feed production industry.

The germs of such a regional cooperation and networking are developed by the Black Sea Biotechnology Association (BSBA), established in June 2004, as a public non-profit organization that has proved to be a very promising example of cooperative achievements. This example deserves to be followed and extended on a large scale inside all Europe and even outside the continental limits. Very valuable information has been accumulated during fourteen years of genetic modified organisms (GMOs) cultivation (since 1996), continuously spreading in a number of 25 countries on different continents, under the dedicated management of International Service for the Acquisition of Agri-Biotech Application (ISAAA), led by remarkable specialist dr. Clive James. The global impact of GMOs cultivation consists in higher level of productivity and economic benefits, as well as a considerable reduction of pesticide use, a decreasing of CO_2 emission and soil, water and biodiversity preservation.

The up-to-date evaluation of GMOs cultivation and use has not registered any negative effect on the human and animal health, the biodiversity, the consequences of the gene-flood to the conventional crops, the environmental resources.

There are some strong reasons to join our efforts for promoting GMOs adoption in agricultural systems, without any further delay and to improve public perception of biotechnology achievements.

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Introduction

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, fiber and fuel security.

Two main conditions have to be taken into consideration for the successful development of such a challenging and far-reaching strategy: the use of all valuable knowledge and practical results accumulated so far, especially by the integration of conventional and biotechnological achievements and the common use of the highest competence gained not only at the national levels, but at the regional, continental and global ones.

The germs of such regional cooperation and networking are developed by the Black Sea Biotechnology Association (BSBA), settled in June 2004, as a multinational public non-profit organization.

BSBA is aiming to bring together countries with historically similar agricultural needs, priorities and practices, science based on regulation that not only protect the public health and environment, but also stimulate economic development, international trade and agriculture modernization.

Another mission assumed by BSBA is to increase the region's contribution to and participation in the global debate regarding agricultural biotechnology in order to overpass the unjustified barriers that encumber the scientific progress.

BSBA intends, also, to build a system of mutual recognition of regulatory and safety data for agricultural products improved or produced through biotechnology and to found a regional human and organizational capacity to develop and responsibly employ agricultural biotechnology.

Up to now, BSBA has proved to be a very promising example of cooperative achievements, example that deserves to be supported and extended on a larger scale inside all Europe and the best catalytic forum could be the Union of European Academies of Agriculture.

Realizing that no any single approach will provide solution to food, feed, fiber and fuel security and that the conventional crop improvement alone will not succeed to double food production by the middle of this century (Clive James, 2007), a wise solution is to take into account the experience acquired by GMOs cultivation and to decide to use it.

Results with GMOs utilization and discussions

Nobody could deny that GMOs are one of the most significant achievements of the last century due to their promises to reinforce further the conventional agriculture to face its complex and difficult mission mentioned above. Social implications of the

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.

The revolutionary potential of GMOs has been understood by some countries since 1996 – the starting year of their cultivation (in the USA, where American farmers introduced GM soybean on 500.000 ha, GM maize and cotton on over 300.000 ha). Thus, after 11 years of GMOs cultivation, these crops have been extended to 102 million ha, with an average adoption rate of 9 percent (Badea E.M., Otiman I.P., 2006, James C., 2006), by 10 million farmers. Out of 22 countries where GMOs were grown in that year, 11 countries were industrial countries and 11 developing countries, but both categories registered significant and multiple benefits.

In the following two years (2006-2007) GMOs area grew 12 percent (12.3 mil. ha), to reach 114.3 million hectares in 23 countries (with a new adopted developing country) for the benefit of 12 million farmers (James C., 2007).

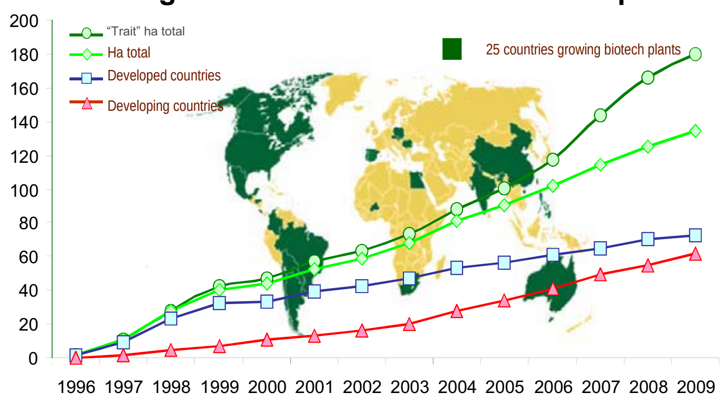
In 2007, it is estimated that of the 114.3 million hectares of GMOs grown worldwide, about 9% or **11 million hectares** were **used for biofuel production,** divided as follows: 7 million hectares of GM maize was devoted to ethanol production, 3.4 million hectares of GM soybean and 10,000 hectares of GM canola for biodiesel were cultivated in USA, 750,000 hectares of RR® soybean were used to obtain biodiesel in Brazil; about 45,000 hectares of GM canola for biodiesel were located in Canada (James C., 2007).

The extension of GMOs cultivated surface continued in 2009 up to 134 million hectares, allocated for transgenic soybean on 53% of the global surface, GM maize on 30%, GM cotton on 12% and GM canola on 5% of the total surface. The number of the farmers involved in GMOs cultivation increased to 14 million, with 2 million more farmers than in 2007 (Badea E.M., 2009).

The mentioned figures for the GMOs cultivated areas refer to the one-trait GM crops, but in the last years the multi-traits GM crops have been extended in the agricultural practice of adopting countries to reach more than 160 million hectares (Figure 1).

Figure 1

The global area of multi-traits GM crops

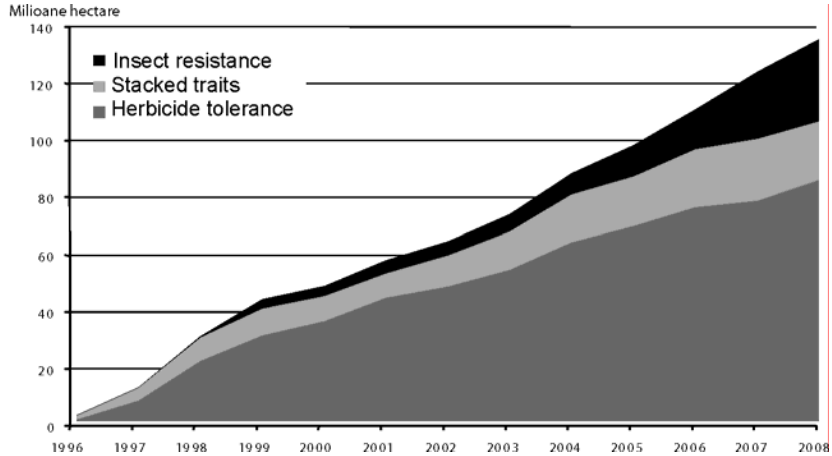


Source: James Clive, 2009.

The evolution of the GMOs with the main agronomic characteristics – insect resistance and herbicide tolerance can be observed in details in Figure 2.

Figure 2

The global evolution of GMOs cultivation with the main agronomic traits

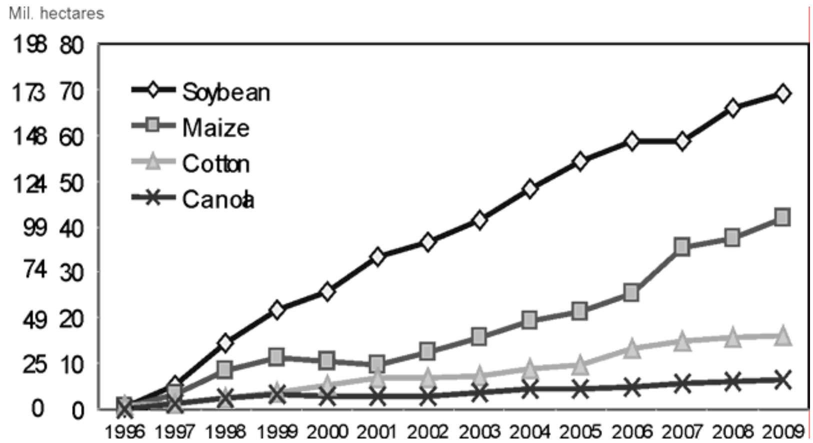


Source: James Clive, 2009.

Also, the evolution of the main plant species genetically modified is presented in Figure 3.

Figure 3

The progressive extension of main species of GMOs cultivated in the world

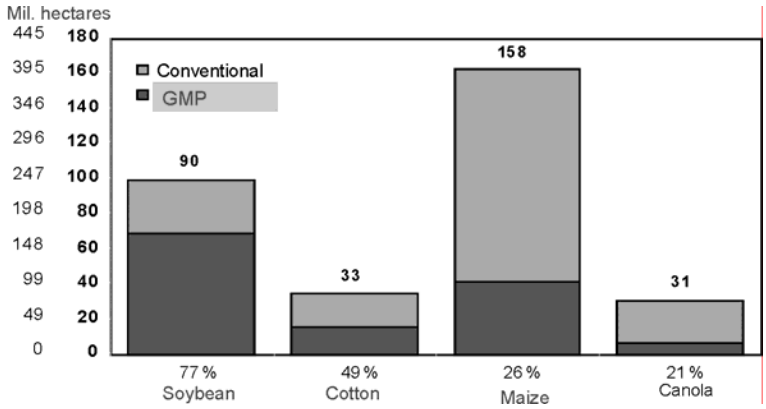


Source: James Clive, 2010.

The rate between the main species genetically modified and their conventional sources cultivated in 2009 is shown in Figure 4.

Figure 4

The rate between GMOs and their conventional sources for the main crops cultivated in 2009



Source: James Clive, 2010.

In Romania, two species of GMO were taken in culture, namely MON810 maize approved by EU and RR soybean till 2007 when the cultivation of GM soybean was banned. In the following three years as a consequence of this interdiction, the areas cultivated with the conventional soybean were reduced by 70%, and the crop yields diminished by 80%. In a single year (2008), the commercial deficit arrived at 117.4 mil. EUR, due to the supplementary imports of soybean grits, soybean seeds and oil. These losses are accompanied by other supplementary costs for chemical fertilizers and additional mechanical works (in conformity with the Ministry of Agriculture and Rural Development's data). Our farmers are convinced by the advantages of GMOs and eagerly expect the change of governmental regulation in favour of GMO cultivation.

The **rapid extension** in different countries from all continents, ***less in Europe***, represents the **fastest adoption of an innovative scientific and technical progress in the agriculture history** (Hondebine L.M., Seralini G.E., 2005), announcing the imminence of a **new great revolution**, the ***"gene revolution",*** coming **after "*green revolution*"** in the second part of the last century.

The global accumulated impact estimated in the first decade of GMOs cultivation consists in ***productivity increases*** by 5-50% and a total ***net income*** of 34 billion USD, namely 17.5 billion USD for industrial countries and 16.5 billion USD for developing countries (James C., 2008). Worthy of consideration is the fact that 90% of the beneficiary farmers were small farmers from developing countries that turned from a subsistence agriculture to a more performing one, with favourable consequences on their standard of living.

The impact on the environment exerted by the lower input requiring crops represented an accumulated ***reduction in pesticides*** of 289,000 metric tons of active ingredient, namely a 19% diminishing of the pesticide use on these crops at an environmental level.

All the presented data are reliable and are taken from annual briefs of International Service for the Acquisition of Agri-Biotech Application, a not-for-profit public charity organization working to alleviate poverty in developing countries, by the **sharing of knowledge** and ***transfer of crop biotechnology application.***

Thus, in the 13 years of GMOs cultivation a successful history has been written, offering a huge amount of data and responses to the greater part of the concerns regarding these crops.

The primordial reason of concern is represented by the risks implied by GMOs use for animal and human health. But, the primary and processed products of ***GM crops*** are **the most thoroughly analyzed feed and food products ever obtained** and they are released in fields only on the conditions imposed by the national and international regulation systems.

Risks assessments are and should be ***based on scientific research*** and are conducted in a case-by-case manner to ensure the safety use of GMOs and these products.

The information gained during the GMOs cultivation and use shows that no negative nutritional effects, *intoxications*, allergies, *signs of diseases generated* by GM agricultural products consumed, *GM food additives or compounds* have been observed and no anatomic or serological modification have been noted on animals feed with products containing GM maize or soybean.

The risks on long term could not be excluded and on these aspects *the scientific research* has still to give answers.

The concerns regarding the effect of the **three technologies of GMOs cultivated** at present: *RR/Roundup Ready*, *IR/Insect Resistance* and *VR/Virus Resistance,* on the biodiversity have received reassuring responses, **no new known harmful effect being made evident.** In the case of IR and **V**R technologies the biodiversity is less affected because of high selectivity of transgenic influence, limited to the target purposes. In the case of RR technology, the Roundup Ready herbicide has no effect on soil seed reserves, but only on the emergent weeds and those in the germinative stage within the superficial layer of soil. As regards the entomo-fauna, this is not diminished in RR crops, but is even stimulated due to the flexibility of the herbicide time-application, offering the possibility to avoid insect reproductive phases.

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 labour** and ***greenhouse gas emission into the atmosphere*** and **diminishing pollution** of air, soil and ground waters.

The estimations made in 2006 concerning GMOs implications for the ***reduction of greenhouse gas emissions*** and for the ***mitigation of climate change*** could be summarized as follow: permanent **savings in carbon dioxide emissions** through reduced use of fossil-based fuels, associated with fewer pesticides sprays raised at 1.2 billion kgrs of carbon dioxide; conservation tillage (need for less or no plowing with herbicide tolerant GM crops) used for GM food, feed and fiber crops led to an additional soil carbon sequestration equivalent in 2006 to 13.6 billion kgrs of CO_2.

Thus, the accumulated permanent and additional savings was equivalent to removing 14.8 billion kgrs CO_2 from the atmosphere or equal to removing nearly 6.6 million cars from the road.

In the future, the cultivation of GM energy crops to produce biofuels will **substitute for fossil fuels** and will recycle and sequester carbon, resulting in great savings (~ 65%) in energy resource depletion. Given that GM energy crops will likely occupy a significant additional crop hectarage in the future, the contribution of these GM crops to global climate change could be significant (James C., 2007).

The researches for risks assessments of some detrimental effects induced in short or long time by the ***direct*** and ***indirect*** **interactions** of GMOs and different plant species on biogeochemical processes, analyzed in case-by-case manner are **negligible or absent**.

GMOs release in the environment has raised doubts regarding the ***potential transfer of transgenes*** from the GM plants to the individuals of the same species (*intraspecific gene flow*) or other species (*interspecific gene flow*). It is generally accepted that the gene flow could lead to the appearance of new weeds, to the increase of existing weeds invasibility, to the genetic erosion of the receptor species, but ***no negative impact on the environment*** was observed.

In connection with the potential gene-flow the problem is the **co-existence of GM crops with conventional crops** and ecological cultures, a practice of growing crops with different quality characteristics or intended for different markets in the same vicinity without compromising the economic value. The problem is under thorough scientific investigation and at the level of European Union there are consultations for working out a recommendation on co-existence.

Summarizing in the terms of PG Economics Report – Global Impact of Biotech Crops: Socio-economic and Environmental Effects 1996-2006 (Brooks G., Barfoot P., 2008) "The technology has also made **important contribution to increasing the yields of many farmers, *raising global production and trading volumes of key crops***. World price levels of crops like corn and soybeans would also have been higher than the current (record high) levels if this technology had not been widely adopted by farmers. These economic and environmental gains have also been greatest in developing countries".

These considerations about the socio-economic and ecological impact are referring to the ***first generation of GMOs*** which are modified for one or two traits aiming to reduce the inputs in agricultural practices and the ***second generation*** – the GM energy crops for biofuels, aiming to cost-effectively optimize the yield of biomass/biofuel per hectare, which in turn will provide more affordable fuel.

The ***next generations of GMOs*** will contribute with **improved output traits, *richer in quality characteristics*** required by consumers or producers of substances utilized in medicine, pharmaceutical industry, animal husbandry.

The future contributions of GMOs are expected to give responses to the *Millennium Development Goals* and to **promote a more sustainable development of worldwide agriculture.** Five goals received consideration by ISAAA (International

Service for the Acquisition of Agri-biotech Applications) (James C., 2007) and the promoters of GMOs and these deserve to be mentioned:

1. Increasing global crop productivity to improve food, feed and fiber security in sustainable crop production systems that also conserve biodiversity

The progress made in the period of cultivation using GMOs more tolerant to the biotic stresses caused by pests, weeds and diseases was significant for crop productivity increase, biodiversity conservation and for arable land rational use.

The future progress is expected with ***control of abiotic stresses***, in near term, with **drought tolerance** available within five years and ***salt tolerance*** thereafter.

The new GMOs generations with novel input and output traits will provide more nutritious food (rich in omega-3 oil, pro-vitamin A) or food adjusted to certain population categories with dietary problems.

2. Contributing to the alleviation of poverty and hunger

In the first decade of GMOs cultivation and commercialization and further on the revenue of poor farmers who adopted these crops increased significantly with greater prospects for growing. The potential contribution of GMOs is expected to be significant for the Millennium Development Goals of halving by 2015 the share of people suffering from extreme poverty and hunger.

3. Reducing the environmental footprint of agriculture

The up-to-date progress made in reducing environmental footprint of agriculture by **savings** on ***pesticides, fossil fuels*** and ***decreasing CO_2 emissions*** will be optimized by improved technologies for soil and moisture conservation. Increasing ***water usage efficiency*** is an imperative in the future and will be performed by using new GM crops, especially those with drought tolerance of particular importance in developing countries where drought is more prevalent and severer than in industrial countries.

Also, the GM crops with increased ***nitrogen efficiency*** will reduce the possibility of soil and water nitrogen pollution and will save the energy consumption.

4. Mitigating climate change and reducing greenhouses gases

The global climate change which becomes more and more evident is one of the major challenges of the future agriculture, asking for a rapid improvement of ***crops adaptability to the new climate conditions***.

GMOs and several biotechnological tools as diagnostics, genomics, molecular marker-assisted selection are of high value for “speeding the breeding” and mitigating the effects of climate change.

5. Contributing to the cost-effective production of biofuels

Biotechnology can be used to cost-effectively optimize the productivity of biomass/hectare of the GM energy crops and, also, will develop more effective enzymes for the down stream processing of biofuels.

All these are strong reasons for use to promote a close cooperation in biotechnological research and application of its achievements taking into account the major challenges in the future.

Conclusions

In conclusion, the **open letter signed by the 40 members of the French Academy of Science, Technology and Agriculture** (Le Figaro, Jan. 12-13, 2008) is quite telling: "Already the technical, economic and environment interest of the current GMOs is clear, which, in 2006, explains their use in agriculture on more 100 million hectares in numerous developed countries and developing countries. **Current research is opening up fascinating prospects**: ***plants that consume less water***, make **better use of nitrogen**, ***resist parasites***, **use less energy**, plants whose ***nutritional*** and ***sanitary properties*** are ***improved***, producing **new molecules for the development of medicine**. Research must thus be able to express itself fully".

Let us adhere to their belief "The seriousness of scientific studies must be affirmed, respected and defended".

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