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Transgenic Foods as a Tool for Malnutrition Elimination and Their Impact on Agricultural Systems

Transgenic foods are reported as the best solution for fighting hunger and malnutrition in Developing Countries. This big challenge was, in the reality of agricultural and nutritional programme, not accomplished. Did biotechnologies represent a solution or are just the results of economic pressure by the multinational corporations? Giovanni Monastra and Laura Rossi of the National Institute for Research on Food and Nutrition (Rome, Italy) discuss this topic from a comprehensive point of view.

Key words. GMOs, food security, poverty reduction, micronutrients.

Abstract. *GMO crops were introduced for commercial production in 1996. Since then, their use has increased rapidly. GMOs have primarily benefited large farms and multinational companies in Industrialised Countries and*

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now is more and more debating their utilisation in Developing World. The objective of the present review is an analysis of this subject from a comprehensive point of view; in addition to that, the changes related to the nutritional content of transgenic foods will be treated. Despite the progress that has been made, the world food situation is still marked by mass hunger and chronic malnutrition. In particular micronutrient malnutrition, that means vitamin and mineral deficiencies, represents an important public health problem in several areas of the world. The "golden rice", bioengineered to contain beta-carotene, as a source of vitamin A is the most famous example of GM food used for reduction (or even to solve) of a public health problem. The expected results of this approach have presently not been achieved. Further studies are necessary to increase the general knowledge about GMOs and their long-term effects on human health. Collaborative attitude of different research sectors (private and public) and involvement of different sectors of society will be an added value for comprehension of the real impact of the application of modern biotechnology to food and agriculture systems.

1. INTRODUCTION

Genetic engineering applied to agriculture is one of the most disputed field of modern biotechnologies. The transgenic food world market, with more than 4 billion dollars of sales, is at the moment controlled by big international companies (Capozzi [2003]).

Biotechnologists are considered scientists willing to create new products breaking the natural barriers among species and genera following the industrial criteria of innovative productions out of the nature laws and cycles.

Engineered plants are not assumed as a development along the way of the classical breeding, but a radical novelty. The majority of people in Italy, where food has cultural and historical value, prefer a traditional approach to agriculture more focused on quality than quantity. So often the agrobiotech project is considered as an effect generated by the exasperation of the "philosophy" underlying the *Green Revolution*, with its massive use of chemicals and the large diffusion of monocultures, which contributed hugely to a drastic reduction of agrobiodiversity. It is noteworthy that these concerns are common among people with a high level of education (Bucchi and Neresini [2002]; Bucchi [2003]; Neresini, Bucchi and Pellegrini [2003]). Also several scientists, mainly ecologists, microbiologists, agronomists, physicians, but also some biotechnologists have considerable reservations about GM plants and food (Ewen and Pusztai [1999]; Holden [1999]; Ho [2000]; Domingo [2000]; Bizzarri [2001]; Buiatti [2001]; Schubert [2002]; Altieri, Antoniou, Cummings, Goodwin, Pusztai, Quist, Ho *et al.* [2003], Gurian-Sherman [2003]). Some criticisms also point out the hard reductionist vision of life related to genetic engineering (Kay [1993]), contrasting the new scientific trends towards a systemic approach to nature (Kitano [2002]). Despite these widespread opinions, we see that GMOs are increasingly becoming a dominant feature of the agricultural landscapes of some countries where they are concentrated. Engineered agriculture started officially producing foodstuff during 1996 in the United States. In 2002 the USA had still the largest areas of GM crops (68%), followed by Argentina (23%) Canada (6%) and China (4%) (ISAAA [2003]). So far the only crops grown are soybean, maize, cotton and canola. All these crops showed a continuous increase in production in the USA and Argentina, but had a considerable reduction in Canada between 1999 and 2000 mainly due to problems connected with genetically modified canola (see table 1). Estimations for 2003 production indicate an increase in GM crops. *Herbicide tolerance* is still in 2002 the most frequent characteristic (75% of GMOs global area), followed by *insect resistance* (17%) and the stacked genes of herbicide tolerance and insect resistance (8%). As shown by these data only cultivars with two new functional characters have been introduced into market (other GM products, such as *Flav Savr* tomato, were retired from the market due to poor organoleptic characteristics): these genetic manipulations are very simple with respect to any change of the plant metabolism to improve its nutritional level, and useful mainly for the Western system of agriculture, especially for countries like the USA, Canada, Australia. Clearly the positive results of these agrobiotechnologies can be an enhancement of profits for some farmers, with large properties (more than 100 hectares), who can reduce the costs of management and increase the crop yields, but also they can have, at least theoretically, benefits in the field of human health and well-being. The possibility of reducing the application of chemicals in agriculture, i.e. herbicides or pesticides using plants herbicides tolerant or pests resistant, is an important issue used by the biotech companies to justify their production. Paradoxically this point is also the most controversial and is inducing scepticism. A report by Charles Benbrook released in November 2003 evaluated the impact of all major commercial GM crops on agrochemicals use in the United States over the first eight years of trade. The analysis was done on official U.S. Department of Agriculture data on pesticide use. The results are that for GM soybeans, maize and cotton planted in the USA since 1996 there was an increase in pesticide use of about 22,700 tons (50 million pounds) (Benbrook [2003]). This picture enfeebles the hope to help the human health and the environment by engineered plants. Now a new generation of GM crops is going to be produced, with the characteristic of growing in drought or saline soils, or with an increased nutritional value, or without allergens or toxic molecules. Clearly the achievement of well-being and health plays a

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pivotal role in solving the problem of malnutrition in poor countries. Thus for many supporters of transgenic food one of the most attractive goal of GM plants is strictly related to the possibility of fighting hunger in the Third World. This issue, rich of ethical implications and moralistic significance, has different and more complex aspects also in the perception of people living in those countries (Masood [2003]).

The objective of the present review is an analysis of this subject from a comprehensive point of view; in addition to that, the changes related to the nutritional content of transgenic foods will be treated.

2. THE PROBLEM OF HUNGER IN THE WORLD, DEMOGRAPHIC TRENDS AND GMOS

Despite the progress that has been made, the world food situation is still marked by mass hunger: according to the FAO (the Food and Agriculture Organization of the United Nations), around 840 million people in developing countries suffer from hunger and chronic undernutrition (FAO [2004]). In sub-Saharan Africa and in South Asia the deficits are especially dramatic – so dramatic that even a slight shortfall can have catastrophic consequences: Ethiopia – for many years one of the few success stories in the agricultural development of Africa – slipped to the brink of starvation in the spring of 2000 as a result of a single dry period. In Zimbabwe, for decades one of the few "corn granaries" of Africa, a despotic regime with no regard for human values is depriving many people of the minimum of food availability for surviving. While there is growing pressure on rural areas to produce food in sufficient quantities, of good quality and at low prices, the natural resources that are needed for food production are declining.

Chronic undernutrition impairs the mental and physical development of children, keeps people from leading healthy and productive lives and hinders the economic development of countries. As a result, hunger, a consequence of poverty, is also a cause of it.

> The objective of the present review is an analysis of agrobiotechnologies from a comprehensive point of view; in addition to that the, changes related to the nutritional content of transgenic foods will be treated.

Most of us think that people die of starvation or are malnourished as a result of a gap between population and food production. Scarcity of food with respect to growing population rate is often considered the cause of the present situation. In this perception, famine would be inevitable because populations grow at a faster rate than food production. But this Malthusian view of the world is not strongly enough supported. In fact it is not a problem of quantity of food but a problem of disparities, exacerbated by catastrophic events such as wars or natural disasters (drought, earthquake, etc.)

or negative consequences of colonization (e.g. India or many countries of Africa) or despotic government that maintain, or worsen, an unequal distribution of lands for agricultural production.

This leads to a bizarre contradiction with the higher prevalence of malnutrition in areas of evident foodstuff overproduction.

We could quote the example of India, a nation devastated by malnutrition but with a great production of cereals mainly utilised for exportation.

The levels of rural poverty in the so-called "developing countries" average between 50 and 70%: these people live in marginal environments, on hillsides and in semi-arid areas, almost untouched by the *Green Revolution*, which was a real chance to improve the production only for the agricultural system of the Western farmers. Furthermore, we cannot forget that most of the food production is used for feeding cattle: 70% of grains grown in the USA are for animals, and Africa, South America and Asia also have huge amounts of land dedicated to soybean production for export to Europe mainly to feed cows. This situation is clearly abnormal and unbalanced, due to the imposition of *a western model of diet*. In South America, 20% of farmers are the owners of 80% of cultivable land; the remaining 20% percent of the land is in the hands of 80% of the small farmers. Paradoxically the first ones export their crops for feeding cattle in Europe, while the others produce 50% of the potatoes, 60% of the corn, and 70% of the beans for human nutrition. It is clear, thus, that the main problem in these areas is not only the food per se but the need for a general improvement of the economic systems.

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Any kind of evolution from this situation should be pursued without suffering the imposition of extraneous models, but following the proper identities and traditions without any kind of cultural destabilization and estrangement.

Development processes should be self-centred and self-directed, not hetero-centred and hetero-directed on the basis of Western parameters: science, technology and economy are not neutral and aseptic, but strongly related to a cultural and social background.

For this reason populations should be free (and helped) to evolve their conditions according to their environment, history, culture and psychology. Asia, Africa and Latin America have not a unique agricultural scenario, but a mosaic of different, various and heterogeneous components. In developing countries, lands should be reconverted in order to mainly produce food for their inhabitants and reduce areas devoted to producing fodders for exportation. In this situation no benefit can be derived from the introduction of GM cultivations; their high cost due to patents owned by international corporations does not give any additional benefit to the local economy and farmers. Also in the projects aimed to help African Countries involving big biotechnology companies, the market, as expected, represents the first priority. On this point it is interesting to mention the position of William Neibur, Dupont's vice-president of product development saying that "There will be royalty-free agreements, but they may also be ones that incur royalties" (Hoag [2003]).

The *large scale* introduction of engineering plants in these countries will lead to dependency and not to a sustainable system. Farmers will be obliged to buy high price seeds from biotech companies without any possibility of their own production.

In this way only a few big Corporations will control the agricultural system and the market, limiting the freedom of People and States. Furthermore a food supply based on too few varieties, i.e. the GM varieties, widely planted constitutes the worst option for food security. But there is an other important issue. New demographic data gave us a different scenario for the future with different trends, far from the catastrophic view characteristic of the previous projections. Since short time there was the idea that it was not possible to keep under control the demographic growing; in that situation, engineered food was supposed to be *indispensable* in order to avoid the collapse (Kishore and Shewmaker [1999]). These statistical projections did not take into account the profound changes occurring in many societies of transition economies such as the increasing involvement of women in the labour market, even in the Islamic Societies, leading to a reduction of birth rate or the general increase of mortality in Africa as a result of terrible disease like AIDS, presently a Third World disease.

Thus, on the basis of the most reliable data recently delivered by the *United Nations Department of Economics and Social Affairs – Population Division* (Population Division [2002-2003]), the world, from 6.3 billion people today, in 2050 should have 8.9 billions instead of the previously expected 11 billions, and, even, within 2075 the world population could decrease by half billion. Obviously every demographic expectation can be overthrow, but in this case it is very difficult to imagine an inversion of this trend, at least for the next few decades.

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If there is a reason for the introduction of GMOs in developing countries, with present scenarios, the overcrowding of the population is not an issue.

3. MICRONUTRIENT MALNUTRITION IN DEVELOPING COUNTRIES

Micronutrient malnutrition is a term used to refer to diseases caused by a dietary deficiency of vitamins or minerals. More than 2 billion people in the world today may be affected by Micronutrient malnutrition.

Vitamin A deficiency, iron deficiency anaemia and iodine deficiency disorders are the most common forms of Micronutrient malnutrition.

People of all population groups in all regions of the world can be affected by Micronutrient malnutrition. Although the most severe problems of Micronutrient malnutrition are found in developing countries, people in developed countries also suffer from various forms of these nutritional problems. Micronutrient malnutrition is a major impediment to socioeconomic development and contributes to a vicious circle of underdevelopment, to the detriment of already underprivileged groups. It has long-ranging effects on health, learning ability and productivity. Micronutrient malnutrition leads to high social and public costs, reduced work capacity in populations due to high rates of illness and disability, and tragic loss of human potential. Overcoming Micronutrient malnutrition is a precondition for ensuring rapid and appropriate development. Poverty, lack of access to a variety of foods, lack of knowledge of optimal dietary practices and high incidence of infectious diseases are some of the factors which lead to Micronutrient malnutrition. Policies and programmes must be developed to assure availability and access to an adequate variety and quantity of safe, good-quality foods for all people of the world.

> The *large scale* introduction of engineering plants in these countries will lead to dependency and not to a sustainable system. Farmers will be obliged to buy high price seeds from biotech companies without any possibility of their own production.

Vitamin A deficiency (VAD) primarily affects children; worldwide, some 250 million children are at risk (WHO [1996]). It causes night blindness and, eventually, permanent blindness (xerophthalmia). It also contributes to retarded physical growth and impaired resistance to infections, resulting in high rates of sickness and death among young children. Every year, a quarter to half a million children go permanently blind as a result of VAD; two-thirds of these are likely to die.

Anaemia and iron deficiency affect more than 2 billion people in virtually all countries (WHO/UNICEF/UNU [1998]). Those most affected are women and pre-school-age children (as many as 50 percent of whom may be anaemic), but anaemia is also seen in older children and men. Anaemia in infants and children is associated with retarded physical growth, reduced resistance to infections and slow development of learning abilities. In adults it causes fatigue and reduced work capacity and may cause reproductive impairment. Blood loss in childbirth is very dangerous for anaemic women and is the main cause of about 20 percent of maternal deaths. Maternal anaemia also leads to foetal growth retardation, low infant birth weight and increased perinatal mortality (death in the first week of life).

Iodine deficiency disorder (IDD) is a threat to more than 1.5 billion people who live in areas where the soils are iodine deficient; more than 200 million people have goitre and 20 million suffer mental impairments (resulting in significant reduction in IQ) caused by iodine deficiency (WHO [2001]). IDD is the most common cause of preventable mental retardation. In severe cases it leads to deaf-mutism, cretinism and other serious disorders, as well as reproductive impairment, which results in increased rates of miscarriage, stillbirth and birth defects.

Despite its link to poverty, not all micronutrient malnutrition will simply disappear as development occurs. Moderate levels of IDD still exist in some high-income European countries which have failed to take adequate measures to eliminate it on a sustainable basis.

> If there is a reason for the introduction of GMOs in developing countries with present scenarios, the overcrowding of the population is not an issue.

Effective methods exist to overcome micronutrient malnutrition, but they require concrete, comprehensive, cost-effective efforts by governments to be successful. The unnecessary human suffering and hindrance to economic development caused by micronutrient malnutrition can be eliminated in large part by improving the nutritional quality of the food supply and by educating people about good dietary practices.

The public health approaches to fighting micronutrient deficiencies in a population could be different and related to the magnitude and severity of nutritional problems.

Supplementation of nutrient in pills has the advantage of rapid improvements of nutritional status and the possibility of concentration on high-risk groups of the population, but often with poor compliance, low long term efficacy, external dependence and high cost-effectiveness. Food fortification, the addition of nutrients to a commonly eaten food, is an effective long term approach to improving the nutritional status of population but requires the cooperative efforts of governments, food industries and consumers. Dietary improvements represent the most desirable and sustainable method of preventing micronutrient malnutrition. Educational efforts aimed at changing feeding practices to lead to an increasing in micronutrient-rich food consumption are crucial for successful strategies.

A novel approach could be considered the one related to bioengineering; in fact the possibility of enhancement of nutritional value of food through biotechnology can be an issue not only for developing countries but also for developed countries (Kishore and Shewmaker [1999]).

> Vitamin A deficiency, iron deficiency anaemia and iodine deficiency disorders are the most common forms of Micronutrient malnutrition.

That was the big promise of the introduction of transgenic technology in the agricultural production of the poorest countries.

In the same way as other dietary strategies aimed to reduce micronutrient deficiencies the use of genetically modified foods also has advantages and disadvantages. Examples more than theoretical dissertations could help in the understanding of this complex topic.

As previously stated, vitamin A deficiency is an important problem of public health affecting billions of people around the world and especially targeting vulnerable groups of population such as children and women in fertile age.

4. BIOTECHNOLOGY: ANSWER OR ECONOMIC INTERESTS?

With the aim of solving this important public health problem, a team of Swiss and German researchers announced in 1999 the development of a “golden rice” genetically engineered to produce beta-carotene, supplying in this way vitamin A (Gura [1999]).

The "new rice" was considered as a prodigious therapy for vitamin A deficiency and a great expectation was made on its utilisation.

Several considerations have to be made on the introduction of this transgenic food. First of all its production, completely innovative, done by the insertion of three foreign genes – two from the daffodil and one from a bacterium – into Japonica rice, a cultivar living in temperate climates (Burkhardt *et al.* [1997]). At the moment it is not possible to predict the impact on human health of the presence of a three-gene complex trait, instead of the constructs normally used in GMOs like Bt maize or Roundup Ready (RR) soybean. Further studies are necessary in order evaluate the effects of this new genetic technique on the presence of allergens

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and/or in the production of toxic compounds; in addition to that, an evaluation of the environmental impact of this new engineered plant has to be done before the introduction in open field. Once the safety of this "golden rice" has been proved, an in depth evaluation of the real impact of its consumption on human vitamin A deficiency should be completed. With the "golden rice" presently produced it is possible to reach the concentration of 1.6 micrograms per gram (μg/g) of beta-carotene; probably in a short time it will be possible to increase this content up to 2.0 μg/g. But also attaining this objective, if golden rice is the only source of the nutrient, an adult would need 7-8 kg of cooked rice every day to have sufficient Vitamin A intake, while a child should eat 5,5 kg to reach the adequate dose. These dietary intakes are not realistic and an estimation of golden rice human consumption in developing countries leads to a value of 300 g per day.

This amount corresponds only to 10% of daily Vitamin A requirement, and, in the case of lactating women, the vitamin A intake will cover no more than 6% of the needs.

This problem of limited coverage of vitamin A requirements is even further exacerbated when one considers that the utilisation of beta-carotene is affected by the global nutrient content of the diet. In particular adequate amounts of macronutrients such as lipids and proteins and the presence of other micronutrients such as zinc, positively affect the beta-carotene metabolism (Nestle [2001]). So an appropriate diet, often uncommon in poor regions, is an important issue in the evaluation of the efficacy of this method of nutrient enrichment. Another complication is related to the presence of diarrhoea, common in poor areas. In this case gut functionality is impaired and the absorption of micronutrient from the GM rice is also compromised.

Golden rice is a significant example of a reductionist approach to the complex problem of nutrient deficiencies.

It has been demonstrated that a single nutrient approach to solve nutritional problems is not the most appropriate public health strategy (Nestle [2001]). In addition to that it should be pointed out that the increase of vitamin A intake could also be reached by promotion of consumption of locally produced foods such as mango (Drammeh *et al.* [2002]), or palm oil (Zagre *et al.* [2003]; Benade [2003]; Radhika *et al.* [2003]), naturally rich of beta-carotene. This approach will be definitely less expensive and more sustainable for native people than the introduction of a patented GMO.

The same approach of food enrichment explained for golden rice was also followed for other micronutrients important for human health. We already mentioned the impact of iron deficiency anaemia on population health. Foods such as red meat, legumes and dark leafy vegetables are rich in iron, as are iron-fortified food products. However, because of the low bioavailability of iron in plant foods and the high cost of red meat, prevention and cure of iron deficiency anaemia is not an easy task for poor sectors of the society, even in developed countries. Currently only experimental studies on animal models are available with the use of transgenic rice as a source of iron for iron depleted rats (Murray-Kolb *et al.* [2002]).

Another important point is related to the problem of monocultures that still represent an effect of last Century neo-colonialism. A reduction of extension of monocultures will contribute to diversification and enrichment of food production.

> The “new rice” was considered as a prodigious therapy for vitamin A deficiency and a great expectation was made on its utilisation.

The *Green Revolution* with the introduction of new wheat and rice varieties tried to increase the production through the development and expansion of monoculture systems, with a further reduction of the diversification of food production.

Another disadvantage of this kind of cultivation is related to the use of chemicals necessary for their production which have adverse effects on other organisms important for human nutrition, not only other vegetables but also fishery products due to water contamination. All these aspects lead to a general decrease of food availability for populations.

5. CHANGES IN THE NUTRITIONAL LEVEL OF TRANSGENIC FOOD

As a consequence of the previous considerations on the need of a global approach with respect to human feeding, a lot of researches aimed to improve the nutritional quality of foods through a biotechnology approach showed their futility or, at least, a small impact especially on Western diet.

In this case the genetic manipulations are not an added value but the consequences of their introduction will be only a perturbation of diet with an unjustified high intake of nutrients without any evaluation of the real requirement of the target population.

> Golden rice is a significant example of a reductionist approach to the complex problem of nutrient deficiencies.

Even if the genetic modifications directly increase the nutritional quality of food, these changes could interfere, by pleiotropic effects of the transferred gene (or genes), with the cell metabolic pathways, altering or modifying molecules such as poliphenols, carotenoids, anthocyanins, tannins, terpenes, alkaloids, phytoestrogens and other bioactive substances. These compounds have important biological properties and play different fundamental roles such as antioxidant, immunomodulation or hormonal effects: their modification could influence the positive/negative balance of GM foods in relations to these properties. In addition to that, the presence of a new gene could induce a new pattern of molecules production in the engineered food, different from the isogenic conventional food; these new products could contain increased quantities of anti-nutrients and/or toxins, like sinapsin, sinigrin, progoitrin, arachidosid, solanine, tomatine, lectins, oxalate, protease-inhibitors, saponin, tannins. Specifically in transgenic plants, where several foreign genes are transferred to modify many metabolic pathways the production of new molecules could be uncontrollable. For example, even in a simple GM plant like the Bt maize expressing the Cry1Ab protein of *Bacillus thuringiensis* that confers it insect resistance, an unpredictable alteration of a plant fundamental structural component was found. All samples of Bt maize had significantly higher levels of lignin than respective isogenic non-GM lines: this increasing is remarkable ranging between 33 and 97% (Saxena and Stotzky [2001]). Lignin presence could interfere with other important metabolic pathways, so that the content of useful substances and micronutrients could be modified, with repercussions on the nutritional value of the transgenic food.

For these reasons GM crops that are developed and brought to market should be regulated by the precautionary principle based on the need for transparent and inclusive decision making that allows for a broader set of determinants to be considered in the risk decision-making process (McCullum *et al.* [2003]).

> The *Green Revolution* with the introduction of new wheat and rice varieties tried to increase the production through the development and expansion of monoculture systems, with a further reduction of the diversification of food production.

Despite the importance of safety, at the moment, few studies on these aspects were carried out and the same agrobiotech companies were responsible for many of them without the control of a *super partes* Authority (Novak and Halsberger [2000]).

6. CONCLUSIONS

If we have to decide about the introduction of GMOs in the human diet we should first ask some pivotal questions: "Are they safe or do they contain new, unintended allergens and/or toxic compounds, which are difficult to identify with the present tests?"; "Are they really useful for human nutrition?"; "Are their benefits based on solid convictions?"; "Can we reach the same public health results using different strategies and more tested technologies?".

> The genetic manipulations are not an added value but the consequences of their introduction will be only a perturbation of diet with an unjustified high intake of nutrients without any evaluation of the real requirement of the target population.

Some of the answers to those questions may not be in favour of GMOs production and commercialisation.

But there are some peculiar situations and particular GM plants for whom discussion on their utilisation remains open. The experience from the last few years shows that scientists coming from industry research have a more positive attitude towards the benefits of genetically engineered food with respect to its risks. Obviously, the position of independent researchers, working in public laboratories, is more critical toward inappropriate tests and inadequate procedure.

It is important that scientific research, academic, public and private, will be proactive on this point, suggesting new experiments, new trials and alternative strategies to solve general problems without any ideological preclusion.

In addition to that, it is important to stimulate a more informed dialogue and debate on the application of biotechnologies for food and agriculture involving relevant groups within society such as stakeholder groups, policy makers, biotechnology advocates and nutrition educators (McCullum *et al.* [2003]).

> GM crops that are developed and brought to market should be regulated by the precautionary principle based on the need for transparent and inclusive decision making that allows for a broader set of determinants to be considered in the risk decision-making process.

Before changing the nature of nature, we must be sure that all its potential has been used.

On this issue it is noteworthy to remember that 30,000 species of vegetables with edible parts exist of which 7,000 were used in the past for human nutrition, while now we cultivate only 120 species and 9 of them are giving us 75% of food but from the cultivation of 3 only species we get 50% of food. As we can see there is still a huge latent capacity in agricultural systems for resource production. Recovering well selected species, fit for different environments, like sorgum and millet in Africa (Vecchio [2002]; De Vries and Olufowote [1997]; Almekinders, Louwaars and De Brujin [1994]), could be a good and alternative strategy for a more comprehensive and fecund approach.

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Giovanni Monastra e Laura Rossi

L'USO DEGLI ALIMENTI TRANSGENICI NELLA LOTTA ALLA MALNUTRIZIONE E IL LORO IMPATTO SUL SISTEMA AGRICOLO

Riassunto

Le coltivazioni di piante transgeniche per scopi commerciali sono iniziate nel 1996 negli USA, estendendosi poi ad altre nazioni, come l'Argentina, il Canada e, più recentemente, la Cina, con una crescita quasi continua, salvo il caso del Canada, dove si è avuta una flessione tra il 1999 e il 2000. Nel 2002 l'area globale coperta da OGM è stata di 58,7 milioni di ettari, ripartita tra soia (36,5 milioni di ettari), mais (12,4 milioni di ettari), cotone (6,8 milioni di ettari) e canola (3,0 milioni di ettari), ingegnerizzati per la tolleranza all'erbicida o per la resistenza agli insetti infestanti o, ancora, per ambedue i caratteri. Contrariamente a quanto previsto questo incremento di coltivazioni geneticamente modificate non ha portato a un decremento dell'uso di agenti agrochimici, ma a un loro aumento. Da più parti si sostiene che gli OGM possano contribuire alla eliminazione della fame nel mondo. Si ritiene, infatti, che non ci sia sufficiente cibo per alimentare la popolazione mondiale, in costante crescita. In realtà invece il flagello della fame deriva dalla povertà esistente nei paesi del Terzo Mondo, in cui esistono, e sono in costante crescita, gravi situazioni di degrado a vari livelli. Anche la diffusione crescente delle monocolture, con l'impoverimento della biodiversità – diffusione incrementata dalla stessa Rivoluzione Verde – provoca danni sul piano alimentare. È tra l'altro grave che tali monocolture vengano spesso adibite alla produzione di mangimi animali per le Nazioni Occidentali, togliendo la terra alle produzioni di beni alimentari per le popolazioni dei Paesi in Via di Sviluppo. Recenti proiezioni hanno infine ridimensionato il problema della crescita demografica in continenti quali l'Asia e l'Africa, rendendo così ancor meno convincenti le argomentazioni malthusiane spesso addotte per supportare l'introduzione degli OGM nelle agricolture del Terzo Mondo. Inoltre, le trasformazioni dei sistemi agricoli dei Paesi in Via di Sviluppo hanno provocato e/o accresciuto l'impoverimento della dieta di quelle popolazioni, che ha determinato anche il diffondersi della piaga della carenza di micronutrienti, cioè la malnutrizione determinata dalla deficienza di vitamine o minerali nella dieta. Vitamina A, ferro e iodio sono i principali micronutrienti coinvolti in queste problematiche a livello mondiale. L'approccio teso a ri-

solvere tali problemi di salute pubblica, basato sugli alimenti transgenici, si dimostra già oggi assai poco convincente ed efficace. Tale strategia è ben esemplificata dal caso del "golden rice", il riso geneticamente modificato che si vorrebbe introdurre per rimediare alla carenza di vitamina A. Si tratta di una falsa soluzione che risente di una concezione riduzionista del problema della malnutrizione. Infatti non si deve operare su un singolo nutriente, ma sulla dieta complessiva, arricchendola di vari componenti. Infine va ricordato che qualsiasi manipolazione ingegneristica – e in particolare quelle dove vengono introdotti vari "geni di interesse" – può dar luogo, come "effetti collaterali", a variazioni, anche rilevanti, della concentrazione dei micronutrienti e degli stessi antinutrienti, così come delle tossine. Non si tratta di una semplice ipotesi, in quanto nel mais Bt è aumentato inaspettatamente il contenuto di lignina (dal 33% al 97%) rispetto alle cultivar convenzionali, in conseguenza dell'inserimento di un solo gene esogeno, derivante dal *Bacillus thuringiensis*. In conclusione, prima di introdurre nelle coltivazioni e nel mercato gli OGM è doveroso chiedersi se esistano strade più sicure per risolvere i problemi della alimentazione umana e se sia possibile mettere meglio a frutto le enormi potenzialità della natura, tuttora non adeguatamente considerate.

Table 1 – AREAS WITH TRANSGENIC CROPS

Data presented in million hectares with the annual per cent increase by nation and crop

(INRAN elaboration from ISAAA statistics)

By nation:

Nation	1996	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%
U.S.A.	1,5	8,1	+440,0	20,5	+153,0	28,7	+40,0	30,3	+5,6	35,7	+17,8	39,0	+9,2
Argentina	0,1	1,4	+1.300,0	4,3	+207,0	6,7	+56,0	10,0	+49,0	11,8	+18,0	13,5	+14,4
Canada	0,1	1,3	+1.200,0	2,8	+115,0	4,0	+43,0	3,0	-25,0	3,2	+6,7	3,5	+9,4
China	0	<0,1		<0,1		0,3	+200,0	0,5	+67,0	1,5	+200,0	2,1	+140,0
S.Africa	0	<0,1		<0,1		0,1		0,2	+100,0	0,2	0	0,3	+50,0
Australia	0	<0,1		0,1		0,1	0	0,2	+100,0	0,2	0	0,3	+50,0
World	1,7	11,0	+547,0	27,8	+153,0	39,9	+43,0	44,2	+10,7	52,6	+19,0	58,7	+11,6

By crop:

Crop	1996	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%
Soybean	0,9	5,1	+467,0	14,5	+184,0	21,6	+49,0	25,8	+19,4	33,3	+29,0	36,5	+9,6
Maize	0,6	3,2	+433,0	8,3	+159,0	11,1	+34,0	10,3	-7,2	9,8	-4,8	12,4	+26,6
Cotton	0,1	1,4	+1.300,0	2,5	+79,0	3,7	+48,0	5,3	+43,0	6,8	+28,0	6,8	0
Canola	0,1	1,2	+1.100,0	2,4	+100,0	3,4	+42,0	2,8	-17,6	2,7	-3,6	3,0	+11,0
World	1,7	11,0	+547,0	27,8	+153,0	39,9	+43,0	44,2	+10,7	52,6	+19,0	58,7	+11,6