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PRIMARY RESEARCH

Effects of Genetically Modified Organisms (GMOs) on sustainable agricultural and aquaculture production for rural development

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Abstract
Poverty, unemployment, lack of land, etc., are the most common problems in rural areas. Agriculture, by its nature, has a multi-functional role and is resourceful to operate within the environmental, social and economic dimensions. Various types of aquaculture are an important component of the development of agricultural systems. These will help reduce food scarcity, hunger, and deprivation by providing high nutritious value food, jobs, and employment growth, increasing the potential for monoculture failure, enhancing water quality, enhancing aquatic resource management, and sustainable farming. Genetically Modified Organisms (GMOs) provide an opportunity to overcome the constraints on food availability and accessibility, particularly in underdeveloped countries and those areas considered infertile, inappropriate and/or unprofitable for arable farming. In addition, GMOs modified for input characteristics (e.g., herbicide or insect resistance crops, disease resistance fish), Genetically Modified (GM) crops with improved nutritional characteristics (e.g., higher levels of beta-carotene, vitamin A precursor) and GMOs modified tolerate environmental stress (e.g., drought, cold and/or salinity) may be successfully adopted in the interest of subsisting agricultural systems. In this analysis, which is focused on general aspects of rural development, knowledge extracted from various sources is addressed.

I. INTRODUCTION

Genetic material can be modified using modern biotechnology cell technology [1]. Genetic engineering techniques can be used in order to improve livestock, poultry, and resistance to disease, as well as fish productivity [2, 3]. Biotech crops contribute to food, feed and fiber safety and self-sufficiency, including more affordable food, by sustainably increasing productivity and economic benefits at the farmer's level, by preserving biodiversity, by reducing the environmental footprint of agriculture, by helping to mitigate climate change and reduce greenhouse gas emissions, and by efficiently using nitrogen [4, 5].

The catalog of international agreements related to GM crops comprises the Convention on Biological Diversity (CBD), Cartagena Protocol of Biosafety (CPB), Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety, Codex Alimentarius, International Plant Protection Convention, World Organization for Animal Health (OIE), World Trade Organization (WTO) and Biosafety, and Aarhus Convention. The EU regulation consist of Directive 2001/18/EC (EC 2001) on Deliberate Release into the Environment of GMOs, Regulation (EC) No. 1829/2003 on GM Food and Feed, Regulation (EC) No. 1830/ 2003 on Traceability and Labeling of GMOs, Regulation (EC) No. 1946/2003 Transboundary Movements and Co-existence [6]. Regulations addressing the safety/risk assessment of GM animals are guided by the independent agency European Food Safety Agency (EFSA) which acts in the European Union [7] and by the U.S. federal government agency Food and Drug Administration (FDA)

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which includes approval procedures, post-approval responsibility and safety environmental issues [8].

With the noteworthy exception of the United States, most countries have enacted laws and established new regulatory systems regarding production, cultivation, consumption and commercialization of GMO. Regulatory processes ensure accurate evaluation of the impact of using GMOs on biosafety, food security, as well as socio-economic and ethical implications [9].

Poverty, unemployment, lack of land and agriculture are the main problems faced by poor people living in rural areas. The production of GMOs can be considered as an important factor for the sustainability of agriculture and aquaculture. There will be some dramatic changes in the social life of villagers in the growth of agricultural techniques [10, 11].

Although many countries are against to production of GM and GMOs, it is aimed to discuss the possible role of GM and GMOs on the development of rural areas suitable for agriculture and aquaculture.

II. FUTURE RURAL DEVELOPMENT CONCERNS, STUDIES AND SUGGESTIONS

Human relationship with nature is the foundation for the long-term strategies proposed by the international community to achieve sustainable development. [12] reported that it is important for the community to decide what needs to be developed and maintained. An essential condition for rural development is the creation of a diverse range of social and economic goods and services to meet the heterogeneity of marketing and demand [13]. The paradox of living standards throughout the world is that the majority of poor and undernourished people live in rural areas where food is grown. It is of national and global interest to stimulate rural development, encourage poor farmers and rural dwellers to increase their incomes and improve their living standards [14]. It is anticipated that modern agriculture is distinctly nuanced with the applications developed by modern biotechnology and molecular biology; in these fields of knowledge the strongest trend is represented by GM crops. Maize, soya, cotton, canola, sugar beet, alfalfa, papaya, cabbage, poplar, tomatoes and sweet pepper are the most commonly grown biotechnological plants worldwide [4]. Soybean, maize, oil seed rape and cotton herbicide tolerance (particularly to glyphosate, sulfonylureas, imidazolines and dicamba), cotton and maize insect resistance, maize drought tolerance, soybean and other oilseeds with enhanced levels of linolenic acid or stearidonic acid, rice with elevated levels of beta carotene, tomatoes with high levels of the antioxidants anthocyanin and flavanols [15], crops with improved nitrogen use efficiency are some of the transgenic traits obtained in crops [16]. The developers of GMOs have supported their market launch with important deductive arguments, such of protect the environment by, for instance, reducing the use of pesticide, increasing profits by reducing inputs, mitigating climate change by using improved plant-based energy sources and increasing the nutritional value of food, and solving hunger and poverty. Access to information, credits and infrastructure constraints are, however, barriers that cannot be easily overcome and thus should be targeted [17].

III. AQUACULTURE'S POTENTIAL ROLE IN RURAL DEVELOPMENT

Various types of aquaculture are an important element in the development of agricultural and agricultural systems that create another bio-producing subsector. These can contribute to alleviating food insecurity, malnutrition and poverty by providing food with high nutritional value, income and job creation, reducing the risk of monoculture failure, improving access to water, improving water resource management and increasing farm sustainability [18, 19]. Fish is an important part of the diet all over the world, whether developed, underdeveloped or developing. Fish meat is the main source of protein, essential long-chain omega-3 polyunsaturated fatty acids, vitamins (especially vitamin A, E) and minerals (calcium, iron, zinc, iodine) acting in the development and maintenance of intellectual performance and in the protection of the heart [20]. Since the mid-1980s, when gene transfer research on fish began [21, 22], over 50 ornamental and food species of fish have been GM. More than 400 new trait combinations have been made for a variety of purposes [23]. The traits developed by the genetic modification of fish have been designed to improve the profitability of the aquaculture industry. Most of the genetic "adjustments" were made for increasing cold tolerance and freezing resistance, disease resistance, low oxygen level tolerance, feed conversion efficiency and cost reduction (carbohydrate-based) diets, especially for those fish species that dominate the food industry, such as Atlantic salmon, tilapia and common carp. Improvements in morphological vision, freshness of color, flavor, texture, fatty acid composition and the production of pharmaceutical compounds have also been addressed in the process of genetic modification [24]. Sustainable aquaculture development requires due consideration of the interactions between environmental, social and economic factors that accompany any development [18, 25, 26]. Describing processing and marketing strategies with a particular

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emphasis on niche marketing, selecting a species, a production system and a market, and writing an aquaculture business plan are also important factors for sustainability [27]. A number of technological, administrative and financial challenges have limited the complete implementation of aquatic farming systems [28]. It is argued that consideration should be given to the sustainability of supply and the quality of inputs in determining the sustainability of any enterprise or technology; the social, environmental and economic costs of input supply; long-term continuity of production; financial viability; social impact and equity; environmental impact; and the efficiency of resource conversion into new useful products[29, 30]. The development of linking aquaculture to agriculture system has been driven by the desire to increase in farm productivity, profitability, and diversification, using valuable resources more efficiently and effectively, without significant increases of external inputs [10]. An effective aquaculture system should have only waste-free by-products to make a positive contribution to the ecosystems and economy around it [31]. Aquatic agricultural systems are widespread in rural areas dominated by aquatic ecosystems along rivers, large deltas or coastlines. Although they are highly productive natural systems are dependent on seasonal climatic changes, and in addition, there are numerous constraints that limit improving the lives of poor and vulnerable people in rural areas. The widening sphere of applicability of GMOs in aquatic agriculture systems in poor rural areas to counterbalance major investments in urban areas can be sustained mainly on political line and by developers of GMO, as a long-term investment.

IV. DISCUSSION ON THE EFFECTS OF GM PRODUCTS

Although the productivity of GM crops may vary greatly from region to region, farm to farm as well as from year to year, depending on the level of infestation and/or weather, the increase in yield and higher economic performance offered by GM crop adoption is significant for farmers in developing countries and present but less significant for developed countries [32, 33]. It is important to note that reports that the decrease in productivity was characteristic of GM crops compared to non-GM counterparts have been sporadic [34], while more recent and relatively recent reports have highlighted increases in yield. For example, a minimal increase in yield was reported for Argentina [35] and the US [36], and significant economic profits were recorded for HT soybean crops in Romania [37] and HT canola in western Canada [38]. To date, for both GM crops and GM fish, the process of genetic modification involves transgenes that encode biosynthesis proteins. Genes used in transgenic fish lead to GH biosynthesis (growth hormone), lysozyme, cecropin, antifreeze proteins and some other proteins (e.g., beta-galactosidase enzyme, chloramphenicol acetyl transferase) encoded by reporter genes [39]. The assessment of transgenic proteins toxicity must be fulfilled according with standardized guidelines established by [7], including molecular and biochemical characterization, up-to-date description of homology to toxic proteins, stability of proteins or protein fragments resulted under specific processing and storage conditions for the food and feed derived from the GM animal, and in vitro digestibility of transgenic proteins. Since 1996, Alestrom stated that GM fish do not present health hazard. Likewise, according with [40] toxic or allergenic effects of transgenic proteins biosynthesized in GM crops have not been indicated so far. Risk assessment of food or feed derived from GM crops is also directed by [41], as a phase of commercialization approval process of GM crops.

A strategy for public understanding of GM technology should be planed and promoted as well. Nourishing the prejudgment that the transmission of knowledge and their understanding, including those related to GM technology is difficult for poor small holders, lead to loss of battle against poverty. Intellectual arrogance must be counteracted in order to act in favor of village life improvement. Increasing of standard of living was always associated with high class technology. Implementation and use of GM technology by poor farmers may require a careful education and training at the same time, but considering the potential to secure food supply and generate income, farmers' receptivity to new ideas can be a bewildering one. Information on the consumer acceptability of GMOs and GM food, respectively, shows that it is highly dependent on indubitable social, economic and environmental benefits [42].

For the biodiversity decline the GM crops cannot be incriminated, but only modern agricultural practices (monocultures, especially those dominated by perennial plants, intensive combat of pests and diseases). The usage of many cultivars with the same GM trait means increasing the diversity of cultivars. In 2011, Carpenter appreciated that for a period of 15 years the positive impact of GM crops on biodiversity and sustainability have been significant.

Like any other new technology, the evaluation of the application of transgenic technology to improve fish species in terms of environmental and biodiversity risks is inherently dynamic. A major environmental hazard is the escape of GM fish, which may interbreed with their wild relatives, leading to the establishment of a wild feral population of GM fish

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[39, 43]. It was estimated that GM males are advantaged by their increased fitness in the mating process spreading the transgene to the wild population. [44, 45, 46] stated sterile GM fish should be used in aquaculture to resolve the increased fitness advantage of males genetically engineered for growth enhancement on escape. Triploid fish or transgenic fish obtained using antisense techniques [47, 48] offer a number of significant benefits for aquaculture [48]. [49] showed that a highly adapted species to the homogenous environment exhibits the greatest efficacy in the production of biomass.

Developing the modern aquatic agricultural system using GMOs is justified by the new researches in the way to obtain GM crops which produce essential omega-3 long-chain fatty acid (PUFA), namely DHA and EPA. These GM crops would be used as food and feed without increasing the pressure on depleting fish stocks. A number of studies show the efficiency of transgenic oilseed camelina, rapeseed oil and yeast containing high level of DHA and EPA in as feed ingredients. High retention of long-chain omega-3 polyunsaturated fatty acids in the fish flesh without accumulation of undesirable fatty acids is the most important benefit for aquaculture production [50, 51, 52]. Being a sustainable source of fatty acids, GM plants that can produce DHA and EPA may have other enhanced benefits, by increasing productivity and product quality, as well as to human health [53].

V. CONCLUSION AND RECOMMENDATIONS

There is a large pool of genetic variability for each variety or species that grows larger through genetic recombination, as well as intra-specific, inter-specific and/or inter-generic hybridization. These are arguments that a kind of genetic engineering is implied in the evolution of our lives, whether dependent or independent of our will. Without considering the large number of successive generations required for plants with improved character selection, as well as the lack of certainty of the appearance of a favorable mutation under the influence of a mutagenic factor, conventional plants undergoing improvement processes also involve changes in the genetic material. Therefore, all modified plants through conventional methods or genetic engineering techniques must be tested before being widely used in agriculture for food or feed production, before being commercialize.

Dissemination of modern biotechnological applications in climate zones affected by drought and desertification, floods or extreme temperatures may prevent the production system from being hindered due to these extremes of climate variability in the short term and to long-term climate change (temperature rises and changes in patterns of rainfall, respectively). Chronological evidence of a numerical increase in human population has given rise to an ever-present interest in food security and poverty alleviation. In a world where the exhaustion of natural resources is a visible reality, concerns about the world of welfare inherited from our children and grandchildren are also grounded. Modern agriculture brings social, cultural and economic benefits, but poor smallholders must have access to information and financial support, farm insurance and government support to implement it in rural areas.

Goal-directed application of aquatic agricultural systems using GMOs in impoverished rural areas could bring multiple benefits. Poverty, insecurity and marginalization of poor smallholder farmers and fishing communities are conditions that require the dissemination of sustainable agriculture technologies that are appropriate for use in rural areas. Governments must be involved in the reform, reprioritization and implementation of policies related to agriculture and sustainability. Empowering rural communities in decision-making processes as well as in implementing, monitoring and evaluating programs would improve the effectiveness of rural development and income generation strategies.

The development of aquatic agricultural systems using GMOs should not simply be neglected or abandoned. GMO with all their benefits and estimated potential risks are a future challenge for sustainable rural development, and we should take a positive approach.

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