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Biodiversity and technology for agro-food [1]

Feeding the planet in an era of climate change

1. *Introduction*

The concentration of human population in urban areas and the rising demand for food have created a situation in which highly efficient production has been given priority over diversified one. The introduction of selection on scientific basis has allowed reaching highly productive crops and breeds; genetically improved material and technological innovations, such as mechanisation, fertilisation, irrigation, more nutritional feed, control of pests and diseases, together with the expansion of the crop and pasture area have allowed meeting the global demand for food. During the last 60 years, global food production (grain, milk and meat) has more than doubled, greatly reducing food shortages. But this has not occurred without costs, including increase in greenhouse gasses and release of input residues, conversion of natural ecosystems to agriculture, loss of heterogeneous traditional farmers' varieties and breeds.

Can agriculture continue along this path?

The group has decided to draw up a balance sheet for the past century, showing where and when there have been successes and failures. Two different time horizons have been considered: the first, to 2015, date of EXPO 2015 and closing date for Millennium goals, and the second to the middle of century. Differences in agricultural typologies, geographical areas, and differences in agriculture relevance in different countries were also considered.

The group is convinced that facing agricultural problems just in terms of million tons of foodstuffs will not help in finding the most suitable solutions. Rather

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[1] Intervento al Convegno per la candidatura di Milano all'EXPO 2015. Roma 27 Giugno 2007.

agriculture should be visualised in terms of long term livelihood security for every human being, extending the concept to include not only production but also more environmentally sustainable procedures and more direct benefit for rural people. The need for a new strategic orientation including both developmental policies and agricultural research emerges from the above considerations. What should be the directions of change?

2. *Challenges*

Many challenges that affect the prospects for sustainable agricultural development must be faced: high consumption of non renewable resources, environmental degradation, including soil and water pollution, and erosion of biodiversity; to which rapid population growth, social and economic iniquities, such as poverty, hunger, must be added in a number of countries.

Is the technical know-how to face these problems available? It seems so, as emerged from discussions in national, regional and international conferences. Problems lie in the difficulty of promoting a harmonious approach to agriculture and rural development. Due to its dimension, agriculture can generate considerable employment, income, and global economy growth.

3. *Agricultural policies*

Global trends in agricultural research and development show the existence of the capability to produce adequate food for present and future generations. It is also clear that new technologies provide opportunities for higher production through vertical productivity growth rather than expanding the cultivated area, opening up avenues for providing ecologically sound practices. Recent advances in biotechnology, ecology and other life sciences and technologies create confidence that improvements in agriculture production will have long-term sustainability: sustainability in the management and use of soil, water, flora and fauna, and other life support systems.

In most agricultural systems, development is very much a human enterprise. Therefore, the human values that stimulate and guide its pursuit are central to the definition of the problem. When actions, plans, programmes, new technologies are translated into better quality of life for people living in rural areas then these elements acquire a human development value. Better quality of life does not mean only adequate income and food, but also access to safe water, diversified and more nutritional food, in line with local traditions and culture.

Agricultural development needs a farming system perspective, which means understanding how farming is done by those who have learnt to live through its practice. This constitutes a requisite for integrating traditional with emerging and potential technology options. In this view soil management deserves greater atten-

tion than in the past. Where soil and water cannot be adjusted to flora and fauna, research should adapt these latter to soil and water regimes. Soil fertility conservation and management will have to be given greater attention. Production systems should have a regenerative capacity. Passive biodiversity conservation is not enough; studies should be devised to uncover the secrets of natural *equilibria* and to identify genetic determinants of resistance and/or tolerance to pests, diseases, and stresses; water resources should be recognised as scarce and precious; their shortage and uncertain availability are likely to become serious in many areas. Appropriate integration of traditional and modern technologies is urgently needed. Full use should be made of frontier areas of science, such as microbiology, biological pest control, bio fertilisers, microelectronics, computer science, etc.

4. *Report and group working plan*

The group has started to examine resources, technology development, farming systems, management implications, etc., as well as total costs and benefits of agriculture, including goods and services, as potable water and biodiversity, it provides. Comments which follow do not represent a working programme for the group itself; rather they are ideas to be further explored, in cooperation with national and international research institutions and networks, and stimulate proper action, so that in 2015 MI_EXPO can show progress achievements and not only options. The group considered this a great opportunity for an effective action.

Major trends and forces. Population size and *pro capite* consumption are the two greatest drivers of global environmental changes. Humans currently appropriate more than one third of the production of terrestrial ecosystems and about half of usable fresh waters. Agriculture has contributed to about 30% of main greenhouse gases, has doubled terrestrial nitrogen and phosphorous supply, has released globally significant quantities of agrochemicals and has initiated erosion of biodiversity and extinction events. How might all this influence environment, including biodiversity? How can biodiversity and technology revert the trend?

Agriculture and climate change. Conversion of forests to agricultural land, expansion of rice and livestock production and increased use of nitrogen fertilisers have been significant driving forces for climatic change. It is assumed that about 3.5 million ha of new cropland would be needed annually before 2015 to satisfy food needs, with present day technology; a great part of it would derive from forest conversion, with emission of carbon dioxide and erosion of biodiversity, and very often desertification. New technologies are urgently needed to avoid this to happen.

Agriculture is responsible for about 40% of methane emissions, a gas about 20 times more powerful than carbon dioxide. About 25% of the methane emissions come from livestock, mainly from enteric fermentation of ruminants. Intensification

of animal rearing will offer the opportunity of improving animal performance, so that the same production can be obtained by a lower number of animals, while analysis of microbial biodiversity will allow the identification of micro-organisms for improving enteric fermentation and treatment of waste.

Climate change will have a range of positive and negative impacts on agriculture both directly and indirectly. The rise of carbon dioxide concentration has been having a positive effect in tree and crop growth and biomass production in temperate plants, like wheat and rice. It stimulates photosynthesis in these crop plants and improves their water use efficiency. For some time ahead this will compensate the yield reduction due to temperature and rainfall changes. Higher latitudes will experience some increases in temperature, with milder and shorter winters, thus increasing the suitability of large areas for crop production and promoting greater gains in crop yield, whereas middle latitude may have land loss and severe yield reductions. Important changes are expected also in pest dynamics with increases in pest carry-over and population dynamics, since life cycles of some major pests are very temperature dependent.

Input use and sustainable agriculture. The main issues are excessive use of fertilisers that may lead to disruption of soil biological processes, ground water pollution and eutrophication of estuaries. The consequences of high *fertiliser* use are both positive and negative. Fertilisers help to replace the nutrients removed by crops. High yields require high inputs of plant nutrients and it is difficult to conceive how most countries could ensure food security without them. If nutrients are not replaced soil fertility goes down with consequences for soil erosion, soil structure and carbon sequestration. However, attention tends to be focused on the negative aspects in the form of groundwater nitrate contamination and eutrophication of surface waters. For the last 30-40 years groundwater nitrate contamination has become an issue in most developed countries. Substantial gains in fertiliser use efficiency and hence a relatively modest growth rate in fertiliser application is expected. Biotechnology exploitation of the biodiversity would in the long term alleviate the problem, by enlarging the number of crop plants able to harbour or to have Nitrogen fixing micro-organisms in their phylloplane. Increases in temperature will also make possible the exploitation of mycorrhizae diversity.

Pesticide use has increased considerably over the past decades and it is projected to continue its growth 1.5 times by 2015 and 2.7 times by 2050, also due to greater dynamics promoted by temperature increases. However, research in smart pesticides, using advances in biology, meta-genomics, and biotechnology, knowledge of insect hormones and ecological bases of pest control, are likely to result in safer control methods. On balance overuse of pesticides will go down and their environmental impact may decline.

Water use. About 40% of the grain area in developing countries is irrigated and about 70% of water consumption is utilised in agriculture. There is a major potential for meeting agricultural and overall water needs by rising the water use efficiency, e.g. through more frugal crop plants and/or innovations in irrigation systems. These would reduce the environmental damage from water logging and salinization. Over extraction in coastal areas causes saltwater to intrude into fresh water aquifers making them unfit for irrigation, but research results indicate the possibility of exploring biodiversity to breed tolerant plants. Genes from Mangroves have endowed rice plants with tolerance to salt water.

Biological diversity. Agricultural main impact on biodiversity falls into different groups. First, land conversion has been causing the loss of natural forests and grasslands, mangroves and wetlands and possibly of species they contain. This has promoted air pollution and erosion and/or disappearance of wild crop relatives. There is the general decline in species richness in managed crop fields, pastures, forests and field margins, and destruction of habitats of beneficial insects and birds that help to keep crop pest populations under control. Some crop species and livestock breeds are becoming almost universal at the expenses of more traditional crops and breeds, which differ from area to area.

The losses of genetic resources – both crop land races and farmers livestock breeds – have been serious. This material and crop wild relatives have provided the genes for breeding disease resistant and stress tolerant varieties and livestock. Some discarded crop species are very rich in nutraceutical compounds and provide essential nutrients to human beings. To preserve these invaluable genetic resources, national and international collections and *ex situ* conservation programmes have been organised and *in situ* preservation action is being promoted. Thorough analysis of these materials is urgently needed to ascertain their characteristics and structure, as gene transfer and advanced breeding tools have opened up new possibilities for genetic improvement. Very little is known about the equilibrium existing in the semi-natural systems, and intense study programmes are urgently needed to explore the secrets of natural equilibrium to be utilised in the management of the agricultural systems.

5. *Conclusions*

Over 2000 years ago, the Roman writer M.T. Varro, in his *Rerum Rusticarum Libri,* wrote «*Agricultura …est scientia quae sint in quoque agro serenda ac facienda quo terra maximos perpetuo reddat fructus*». Agriculture is the science on what crops plant in a land and how to manage them so as to obtain the highest possible production in perpetuity.

The sentence contains three messages that the group feels proper to comment as closing remark.

– Agriculture is science, it is knowledge, and not simply irrigation, seeds, fertilisers, livestock, pesticides etc. Production systems must be knowledge-intensive, and knowledge to some extent must become a substitute for capital. For this purpose full use should be made of frontier science. Consequently education and research are urgently needed.

– Agriculture is knowledge of where and how to grow crops. Technology has been developed for improving the growing and/or rearing environment, so as to allow many diverse plants and animals to be present and productive in different parts of the world. Sometimes this has been promoting inefficiency, pollution, resources degrade and other environmental impacts. The attitude should be reverted to modify flora and fauna, when environment cannot be adjusted in an ecological and economic cost effective manner. For this reason, special attention should be given to disclosing and exploiting the secrets of biodiversity.

– *Maximos perpetuo reddat fructus*. Agriculture is an economic activity and farmers practice agriculture to gain income for their livelihood, and that should be done in such a way that the activity can be continued forever. Production systems should have a regenerative capacity and take into consideration the necessity for long term practice, in spite of environmental changes.

But technologies are by themselves not enough. Nothing can be done without political commitment.

In conclusion science can play a very important role in transforming agriculture and gearing it to productivity increases in perpetuity and without associated ecological harm. But that may only occur if it is coupled with economic and social policies rooted in human values.