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Place and role of biotechnologies in the agricultural research system of Italy

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SUMMARY - Yield stability, and sanitary and organoleptic qualities of food, are two major objectives of Italian Agriculture. In both fields, biotechnologies are to play an essential role. Under the auspices of the National Research Council (CNR), of the Ministry of Agriculture and Forestry (MAF) and the Ministry of University and Scientific and Technological Research (MURST), a strategy for the application of biotechnologies has been developed in the universities and in a number of institutes. Integrated and pluridisciplinary projects have been carried out for 5 years, since 1988. From 1991 on, the "RAISA" program, funded by CNR, is to launch new projects in plant production, animal breeding, and food technology; all concrete activities are specifically listed in the tables. Tree projects have been proposed, for the future, which refer to the Mediterranean regions: establishing data banks (agricultural productions, list of laboratories and their programs), training for scientists, and bilateral research programs between Mediter-ranean and E.E.C. countries.

Key words: Biotechnologies in Italy - Micropropagation - In vitro selection - Haploids - RFLP diagnostics - Genetic transformation - Somatic hybridization - Training in biotechnology - Data banks.

RESUME - "La situation et le rôle des biotechnologies dans l'organisation de la recherche agricole en Italie". Deux des grands objectifs de l'agriculture italienne concernent la stabilité des rendements agricoles et les qualités organoleptiques et sanitaires des aliments. Dans ces deux domaines les biotechnologies sont appelées à jouer un rôle essentiel. Sous l'égide du Conseil National de la Recherche (CNR), du Ministère de l'Agriculture et des Forêts (MAF) et du Ministère des Universités et de la Recherche Scientifique et Technologique (MURST), une stratégie de mise en oeuvre des biotechnologies a été développée dans les Universités et dans de nombreux instituts. Des projets intégrés, pluridisciplinaires, ont été soutenus, pour une durée de 5 ans, depuis 1988. A partir de 1991, le programme "RAISA", financé par le CNR, doit développer de nouveaux projets dans les domaines de la production végétale, de la sélection animale et de la technologie alimentaire ; des tableaux donnent les listes précises de toutes les opérations. Pour l'avenir, dans un cadre méditerranéen, trois propositions concernent : l'établissement de banques de données (productions agricoles, listes de laboratoires et de leurs programmes), la formation de chercheurs, des programmes bilatéraux de recherche entre pays méditerranéens et pays de la C.E.E.

***Mots-clés** : Biotechnologies en Italie - Micropropagation - Sélection in vitro - Haploïdes - Diagnostic RFLP - Transformation génétique - Hybridation somatique - Formation en Biotechnologie - Banque de données.*

Introduction

Yield improvement has been the main objective in Italian agriculture up to 10-15 years ago. Today other aims are considered equally or even more important. The overproduction of several crops in Europe and the concept of sustainable agriculture, that is of an agriculture compatible with the environment, have determined other objectives in the Italian research, such as improvement of quality and yield stability. Italian scientists are requested to give a better food quality in terms of organoleptic traits and of alimentary safeness, which means the need to produce with a lower amount of chemical substances (pesticides, fertilizers, hormones, etc.).

To improve yield stability, two ways are followed, both in line with a sustainable agriculture: the first one is the reduction of the damages due to both biotic (diseases, pests) and abiotic (cold, high temperatures, drought and others) factors, which are naturally present in the environment, and the second one is a better use of

the factors usually added during the cultivation (mainly water and fertilizers).

The present priorities of the Italian agriculture sciences can also change in the near future according to other political needs, as it happened in the past. As scientists of public organizations, we know the difficulty in changing continously the objectives of our researches and for this reason the best is to have as top priority of our research not some specific objectives in the agriculture production and management but a better knowledge of the physiological and genetic processes, which are at the basis of agriculture; only in this way we will have sufficient flexibility to face different needs.

In this context, the role of biotechnology becomes prominent, especially if integrated with traditional and conventional techniques, as a powerful technique to better study and understand basic and fundamental aspects of the agriculture process.

As far as private organizations in Italy are concerned, it is clear that they are mainly interested in applied research that can be patented in some way.

Biotechnology is considered a research area which can fit very well the Italian economic system, due to a low need of raw material, of energy and of economic inputs.

The place of biotechnologies in Italy

The important presence of Universities and research Centers, with a good level of biological, physiological, genetic, in vitro and molecular research, offers a high possibility for training of biotech scientists and for carrying out biotech research. In fact we know that biotech is the obvious development of already existing fields of high level research and that it is based on the development of these different sciences and on their integration. This is why the strategy of biotechnology in the public sector in Italy is to have these researches spread in several Universities and research Institutes belonging to the Research National Council (CNR), to the Ministry of University and of Scientific and Technological Research (MURST), to the Ministry of Agriculture and Forestry (MAF), to ENEA and to other public Institutes.

At present there are three national programmes that are in course in Italy funded by MAF, CNR and MURST. The procedures of the 3 programmes were practically the same, that is firstly the aims of each programme were previously identified in a feasibility study and then the Institutes and the Research Centers were invited to join in groups, whatever their origin, and to present integrated projects which were submitted to scientific commissions. Only a part of the projects was accepted; contracts with each Institute were therefore signed. A check is performed each six months.

The advantage of this procedure is that is stimulates the research Institutes on biotech activity, and pushes them to collaborate in joint projects; the forced collaboration among different Institutes is in Italy as in many Mediterranean countries, a rather difficult task, which is now a rule, at least in the last ten years, since the National Research Council started this action with some special projects, called "Finalized Projects".

The biotechnology programmes

Of the three projects that at present are concerned with biotechnology in agriculture the first is the one funded by MAF. One hundred and thirty three Institutes submitted 42 projects of which only 22 were accepted involving 91 Research Institutes, belonging to MAF, University, CNR and other public and private centers. The project started in 1988 and will last about 5 years, with a total budget for the first three years of about 13 million USA dollars. The topics of this programme are listed in Table 1.

The Ministry of University and of Scientific and Technological Research (MURST) is funding a National Research Programme on Biotechnology which covers also the area of Agriculture and Food Science. Only few topics are considered as biological N fixation, seed quality, probes for food quality, disease resistance and transformation. This programme is limited to industries which anyway have the possibility of subcontracts with Universities and public research Institutes. The programme started in 1989, will last 4 years and for the area of our interest has a budget of about 40 million USA dollars.

In 1991 a new project, called RAISA, will start funded by the Research National Council (CNR). Four hundred Institutes submitted about 120 collaborative projects of which only 50 were accepted with a total of 170 Institutes. The programme lasts 5 years and for the first year there is a budget of about 15 million USA dollars. Three are the areas of interest (Plant Production, Animal Breeding and Food Processing) and the topics for each area are listed in Table 2.

Research programmes in the field of agrobiotechnologies have been carried out at ENEA (The Italian Agency for Research and Development of Nuclear and Alternative Energies) since the beginning of the 70's. For the 90-92 period, ENEA is mainly devoted to the characterization and cloning of useful genes, particularly to genes coding for resistance to diseases and pests; special emphasis will be given to

their gene expression. The main topics of the programmes of ENEA are listed in Table 3.

Many private companies are operating in Italy in the field of biotechnologies in agriculture, some of which are listed in Table 4. The Metapontum Agrobios is a research institution, located in the South of Italy in the Basilicata Region, which was formed in 1985 by ENI and the Basilicata Region itself. At present 36 scientists are working there, mainly involved in molecular and cell biology with a particular emphasis to biotic and abiotic stress tolerance. Table 5 reports the main projects carried out at this Institution.

Nuovo CRAI is the central research laboratory of Gruppo SME, where biotechnological research is carried out mainly for quality improvement of tomato and wheat. The main topics are listed in Table 6.

Strategies for the Future

A great effort is at present made in Italy on biotechnology and several research Institutes are devoting increasing attention to research in this field. Nevertheless, some problems still exist which limit a higher activity in this area. On some occasions biotechnologies were used per se and not to solve some specific problem; sometimes they were applied where conventional techniques can still be exploited. Except for micro-propagation, biotechnologies are very time-consuming although they were presented as a very fast tool for solving otherwise unsolved problems. The fields in which certainly the biotech approach can play a powerful role in the public Institutions are the genetic and physiological processes which are at the basis of our agriculture. This aim implies a strong role of private biotech companies that should be involved in applied research and a good integration between public and private sectors. Very important also is the definition of an Italian regulatory policy on new biotech products and on their release into the environment, a problem that is now under discussion at the EEC level.

Concerning specifically plant genetic engineering is concerned, the limiting factor is at present the lack of suitable genes to transfer; because of the larger efforts which are necessary for the identification and the isolation of genes, collaboration between public and private organizations and/or specific projects funded at international level (i.e. at the EEC level) should start.

Biotechnology for the Mediterranean countries

Italy is already involved in several research projects with developing countries directly or through the CGIAR system. In the Mediterranean area, Italy is supporting ICARDA in some biotech activities, but certainly more could be done with other research institutions.

Three are the actions that can be proposed in this area, information, training and research. A data bank can be made on the Mediterranean crops and on the state of the art of biotechnologies on these crops, including Institutes, their research objectives, and an up-to-date information which can be essential to strenghten this kind of research on the crops that are typical of this area. Training of scientists is very important and Italy is available to host persons in the research Institutes. As far as the research activity is concerned, EEC is funding a special project for the developing countries and in this framework we could suggest to prepare a set of proposals (say between 10 and 20) of bilateral research programmes between EEC countries and Mediterranean developing countries to be submitted to EEC all togeth-er, in order to have an integrated network of these advanced research activities in the Mediterranean. All efforts should be made to integrate information, training and research activity in only one Mediterranean biotech project.

Table 1 - Programme of "Biotechnology in Agriculture Research". Ministry of Agriculture and Forestry of Italy.

Topics of researches

1. In vitro techniques for cells, tissues and plants
   - 1.1. Micropropagation
   - 1.2. In vitro selection
   - 1.3. Haploids
2. Control of plant reproduction
   - 2.1. Male sterility
   - 2.2. Incompatibility
3. Plant physiology through molecular biology
   - 3.1. Genes for herbicide resistance
   - 3.2. Genes for abiotic stress
   - 3.3. Genes for disease resistance
   - 3.4. Genes for insect resistance
   - 3.5. Genes for improvement of quality traits
4. Advanced techniques for genetic selection
   - 4.1. Development of diagnosis products for detecting the presence of disease or stress
   - 4.2. Construction of genomic maps via RFLP
5. Improvement of symbiotic microorganisms
   - 5.1. Rhizobium
   - 5.2. Non symbiotic microorganisms
   - 5.3. Transformation
6. Development of crops for industrial purposes, production of biomass and new products

Table 2 - RAISA - A research programme for biotechnologies in agriculture funded by the Research National Council. Topics of research are listed.

A. Biotechnology in plant production

A.1. Physiological and molecular basis of resistance to biotic and antibiotic stresses

Mechanisms of induced resistance
Virus-plant molecular interactions
Plant response to low temperature
Plant response to high temperature

A.2. Quality regulating mechanisms

Seed formation and development
Seed quality
Senescence and quality
Fruit quality in relation to cultural and climatic systems and factors
Growth and qualitative traits of vegetative structures

A.3. Interaction between plant and other organisms

Biology of Mycorrhiza fungi
Molecular basis of the interaction between Rhizobium and Leguminosae
Physiology of the biocenosis between Azospirillum and non-Leguminous plants
Mechanisms of cyanobacteria - Azolla functional interaction
Plant virus analysis and epidemiologic behaviour
Recently identified phytopatogens (mycoplasms, etc.)
Arthropods and nematodes as vectors,
of other pathogenic agents

A.4. Monitoring of environment resources and crop management

Forestry resources

A.5. Development of cellular and subcellular methodologies

Genetic manipulation of reproductive system in crops
Differentiation mechanisms
Origin and characterization of somatic genetic variability in "in vitro" culture
Development of methodologies for gene transfer into higher plants
Gene identification, isolation and characterization methodologies
Manipulation of plant - insect interaction
Molecular hybridization for DNA sequences recognition

B. Biotechnology in animal breeding

B.1. Innovative biotechnologies for animal breeding in animal production

Possibilities for asexual reproduction development

Improvement of reproductive efficiency

Genetic manipulation

Genetic evaluation of parents

C. Biotechnology in food procesing

C.1. Biological bases for development of transformation technologies applied to agricultural products

Yeast selection and improvement for food use

Biology of lactobacteria as food starter

Yeast malolactic fermentation gene: cloning and expression

Biology of photosynthetic micro-organisms related to food processing

Production of metabolites, of microbic enzymes and of other components in food processing

Cellular and non-cellular immobilised systems

Microbiological processes in food processing

C.2. Raw material characteristics and innovative processes for storing and processing

Innovative processes for fresh fruit and vegetable storage

Table 3 - Projects for biotechnologies in agriculture at the ENEA

- Production of transgenic plants with genes coding for antibodies against virus and fungus diseases
- Production of transgenic plants resistant to parasitic fungi and to viruses
- Isolation of genes for the biosynthesis of carotenoids
- Improvement of regeneration and transformation in artichoke and in Pisum radiata
- Genetic transformation of potato with Bt gene
- Somatic hybridization among Citrus species and among Solanum species
- Vegetative reproduction of recalcitrant species

Table 4 - Some private biotech companies acting in Italy

AGRIMONT S.r.l. - Brescia

ENICHEM AGRICOLTURA S.p.A. - Palermo

FARMITALIA CARLO ERBA S.p.A. - Milan

ISTITUTO G. DONEGANI S.p.A. - Novara

NUOVO CRAI S.p.A. - Napoli

ORIS S.p.A. - Milano

PIONEER HI-BRED ITALIA S.p.A. - Sissa (PR)

SHELL ITALIA S.p.A. - Milano

SNAMPROGETTI BIOTECNOLOGIE S.p.A. - S. Donato Milanese (MI)

Table 5 - Projects for agrobiotechnological innovations of Metapontum Agrobios

- Genetic transformation of potato for introduction of virus- and insect-resistance genes
- Genetic transformation of tomato for introduction of CMV-resistance genes
- Biotechnological improvement of sunflower for disease-resistance
- Biotechnological improvement of sweet sorghum
- Biotechnological improvement of fruit-trees

Table 6 - Main topics of biotechnology research at NUOVO CRAI

TOMATO

- Control of virus disease (CMV) through cross protection of plants by transgenic products (viral coat protein and viral satellite RNAs)
- Fruit maturation and senescence through controlling the rate of deterioration of important quality attributes during fruit ripening

WHEAT

- Improvement of quality characteristics through direct selection of doubled haploids

PLANT TRANSFORMATION METHODS

- Use of biolistic device (gene gun) to deliver naked DNA to meristems of crop plants which are intransigent to be transformed by current methods