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Breeding and Genetical Research in Italian Rice

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Rice is one of the most important cereal crops in Italy as regards its contribution to foreign exchange. The cultivated rice area in Italy has been increasing since the beginning of the European Community policy, due namely to favourable market conditions for the Italian paddy production.

This area located in the Po Valley (Northern Italy) for a great part, was around 131,000 ha in the 1956-1965 decade, before the Community rules; 182,000 ha in the 1971-1982 decade; and increased up to 200,000 ha in the last decade. Presently rice area occupies about 232,000 ha, with an expected production of approximately 1.3 million metric tons and a national yield average of about 5.5 tons/ha (1993).

Such an increasing rice area, by about 20% during the last twenty years, is generally considered favourable to the Italian economy as about 60% of this production is exported. This export can counterbalance the import of large quantities of food and feed products. In fact, Italy has become an important rice-exporting country, considering that local consumption hardly exceeds 40% of the total rice production.

Italian rice is directly exported towards EC countries (about 50%) and to other foreign countries. Although Italian production represents a very small fraction of the world production, the exported Italian rice represents 5% of total amount of rice traded in the world. Italy remains the most important rice EEC's producer and exporter.

Rice cultivation in Italy is highly specialized; it occupies 70-80% of the rice farming surface. In the last years, soybeans and maize have been successfully and increasingly grown as annual rotation crops in the rice fields.

I – Breeding strategies

1. Breeding for grain quality

On the European market (but not only) Italian exports have to face increasingly the competition of other rice exporting countries. Most of the difficulties for Italian rice exports, however, are due to quantitative reasons, but also to the fact that traditionally cultivated rice types do not always suit the taste of the consumer from Central and Northern Europe, who prefer the so-called *Indica* type (with longer not sticky grain) as contrasted with the traditional Italian type (generally large or short sized, with a soft cooking grain) (*Japonica* type).

Actual Italian programmes of genetic improvement aims are to differentiate new rice cultivars both for home consumption and for exports because Italy is the major rice EEC's producer and exporter (rice covers about 60% of its total grown area), followed by Spain, Portugal, France, and Greece (Eurostat, 1993).

Italian consumers prefer the *Japonica* type (grain size of medium class or long A). For this type a certain degree of stickiness is tolerated or requested (low amylose content—generally between 14% an 19%—and high water-absorption capacity best adapted for the preparation of the typical "risotto" dish. On the contrary, the consumers of Northern and Central Europe prefer translucent, slender grains (long B or *Indica* type), which keeps their shape and cook dry with low stickiness (high value of amylose, more than 21%), because they use rice as a cool food or as a side dish for accompanying other food.

In order to satisfy rice exports, in recent years Italian rice growers have modified the distribution of cultivated rice varieties by increasing the hectarage for the long B and *Indica* type varieties; this is also a consequence of measures of economic aid for the cultivation of these varieties. Nevertheless, Italy cannot meet the demand of the European market which imports a great part of this type of rice from the USA, Thailand and other countries.

Climatic conditions in Italian rice-plantations are generally inadequate for authentic *Indica* varieties. For this reason there has been several attempts—some of them have been successful—to transfer by cross the typical characters of authentic *Indica* grains to *Japonica* lines, generally more adapted to a temperate climate of Italian type.

At present, Thaibonnet (introduced from USA [L202]) represents the most important *Indica* type variety grown in Italy. But many other local cultivars are being selected to prevent the risks of new pathogens' diffusion and red rice accumulation by avoiding the introduction of genotypes from different foreign countries, with a weak adaptability to our agronomic and climatic conditions.

The development of new promising varieties with satisfactory grain quality characteristics (*Indica* type) is the result of a combination of the conventional Pedigree and Bulk method of selection for yield and quality (modified Bulk) in segregating heterotic populations.

One of the difficulties in combining *Indica* and *Japonica* genotypes is generally the significant genetic distance between the two types: artificial crossing is likely to encounter incompatibility, but worse, in the following generation, severe sterility. However, in spite of a similar barrier, the hybridation programme can be realized with an appropriate use of backcross to the parent or a type with a great number of useful traits.

A promising alternative approach for obtaining new *Indica* type varieties adapted to temperate regions may be the biotechnology method—the *in vitro* culture—which takes into account the fact that the dihaploid plants derived from the culture of F1 *Japonica* x *Indica* pollen turn out for about 50% completely fertile and fixed.

In our Institute some emphasis have been put in recent years on the use of this haplo-diploid method in breeding programmes for high quality traits. Naturally doubled genotypes obtained from the i*n vitro* culture of hybrid anthers (Anseatico x Sequial) have been evaluated considering several morphological and agronomic traits in comparison with the parental genotypes in field replicated tests. In our case, progenies of the anther derived plants proved to be generally completely fertile and genetically uniform (homozygous). On the other hand, significant differences have been observed among doubled haploid lines in the following characters: plant height, panicle, seed and caryopsis length, grain sterility, protein content. Phenotypic variations were wider than those observed between the parental lines. Some lines performed better than the parents in the panicle, seed and caryopsis length, and protein content (up to 12-13%).

In order to explain the higher protein level found in some lines derived from pollen culture, we can take into consideration a positive effect of selection pressure from the *in vitro* culture medium.

As for the commercial qualities of *Indica* type varieties, the role of the amylose content and correlated hardiness and stickiness characteristics has been probably emphasized in order to improve promising genotypes with satisfactory quality traits, taking into account the fact that *Indica* type varieties are generally parboiled. The parboiling process offers really considerable advantages for the slender grains of *Indica* type (higher milling yield, lower stickiness, improving the cooking quality) and normally offsets the higher costs of production.

There is actually an increasing interest (on the rice market and on the part of the milling industry) for the parboiled, more homogeneous products. On the other hand, having to increase amylose content in slender grain by breeding at critical values, could be a very conditioning factor for the breeder. So, improvement of other market quality characteristics more suitable for the parboiling process (high milling yield, vitreousity, slenderness, homogeneous and healthy grain) have also to be considered.

In Italy, a major attention in favour of export market requirements is producing new trends for the national breeding programmes in order to introduce the following improvement strategies:

- ❑ **Breeding for physico-morphological traits**
  • Husk and pericarp coloration (which influences the colour of parboiled product) • Grain size, shape, weight, and uniformity for trade needs • Vitreousity and colour of grain • Chalkyness and damaged grain.
- ❑ **Improvement of milling quality**
  • Rice milling yields • Broken grain degree • Uniformity of milled rice.
- ❑ **Cooking and processing quality**
  • Amylose-amylopectin ratio • Alkali spreading value • Gelatinization time • Degree of cohesiveness • Degree of stickiness • Water uptake, grain elongation, and expansion after cooking.
- ❑ **Nutritive quality and healthy components**
  • Improvement of protein content • Cholesterol-lowering effects of rice bran.

Besides these prioritary objectives, other genetic researches are now being considered in order to promote introduction of different special types of rice, as aromatic rices, waxy, red rice, and special rices for dietetic purposes. A wider offer of differentiated products can be very promising for successful rice crop.

II – Breeding for resistance to low temperatures and diseases

One important goal of rice genetic improvement in Italy—considering its climatic constraints—is yield stability which, actually, is becoming more and more interesting for obvious reasons. This, of course, is, at least in a great part, equivalent to evaluate the environmental factors responsible of the divergence between the potentialities of the different varieties and their actual performances under farm conditions.

Among these factors so difficult to control are low temperatures, in temperate regions like the Po Valley, at germination and reproductive stages (precisely in Italy at the stage of panicle differentiation and microspores formation) of the plant cycle. Of course this problem of low temperatures (10-12° C being the average for the first 20 days of April) may be avoided, to some extent, if plantation is delayed by a few days only in order not to meet the same problem of low temperatures at maturity stage. So, an agronomic approach has to accompany the genetic rice improvement in Italy. Therefore, varieties having the best low-temperature tolerance (mainly of *Japonica* type) and the most convincing expressions of the technological characters (mainly of *Indica* type) are selected in Italy.

The inheritance of low-temperature tolerance must be extremely complex, although it appears to be independent of many morphological characters, and is obviously greatly affected by the environment. A variety's tolerance to cold at growth stage does not necessarily implies its tolerance at other stages. Consequently, an evaluation of the materials at only one stage is not sufficient.

Fortunately, many varieties with low-temperature tolerance are available among the *Japonica* varieties grown in Italy. Natural selection under appropriately low temperature occurring at repeated cycles results in the progressive and cumulative obtention of varieties tolerant to cold.

Evaluation techniques for low-temperature tolerance, generally based on field screening, can be combined with the use of appropriate artificial techniques for checking the rate of roots growth at the seedling stage under controlled environment.

Another factor influencing yield is obviously the outbreak of epidemic diseases with their variation as regards diffusion and intensity. Blast is in Italy the most serious and widespread rice disease and its causal organism *Pyricularia oryzae* Cav. appears as the most variable pathogen. Generally, incorporating genetic factors which contribute to a reasonable degree of horizontal resistance is a common aspect in breeding new varieties.

The blast nursery method of screening from IRRI is highly efficient for identifying vertically resistant parents and breeding lines. Because neckblast causes the most serious yield losses (in connection with favourable meteorological conditions), and resistance at seedling and neck stages may differ substantially, breeding lines should be screened at both stages.

The genetics of blast resistance has been studied in several countries. But only international cooperation can successfully control blast.

In Italy the importance of another pathogen, *Helminthosporium oryzae* (actually *Bipolaris oryzae*), which is the causal organism of the brown spot disease has been increasing recently. Intensive attacks in field conditions result in damaged grain and bad seeds.

Effective screening procedures are needed in order to obtain a breeding programme for resistance. Unfortunately, new improved varieties with vitreous long grain, or of *Indica* type, appear generally more susceptible. The widespread adoption of the new susceptible varieties has produced conditions that are highly favourable for the maintenance of high degree of natural infection in crop.

Table 1. Areas cultivated with *Indica* type rices in EEC countries (ha)

Countries	1988	1989	1990	1991	1992
Italy	193	343	3 318	17 158	21 355
Spain	18 913	10 302	29 702	39 947	36 907
France	49	-	15	430	2 261
Portugal	47	71	447	2 567	3 334
Greece	3 333	2 556	2 081	2 760	3 765
EEC	**22 536**	**13 272**	**35 562**	**62 863**	**67 622**

Source: *Ente Nazionale Risi*

Figure 1. Rice classification and cropped area in Italy (hectares)

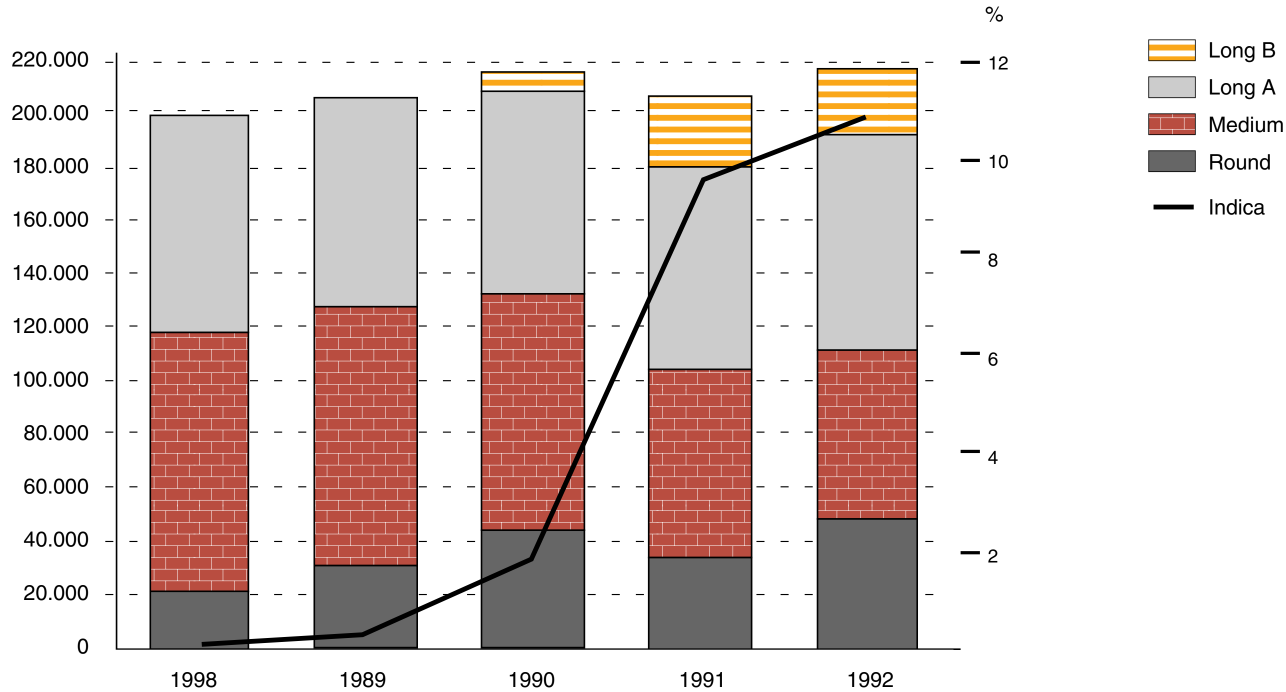

Figure 2. Surface distribution (%) of Indica type rices in EEC countries