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in

Chataigner J. (ed.).
Activités de recherche sur le riz en climat méditerranéen

Montpellier : CIHEAM
Cahiers Options Méditerranéennes; n. 24(2)

1997
pages 139-146

Rice production and research potential in Italy

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Résumé. *En Italie, la riziculture est essentiellement concentrée dans les régions septentrionales et s'étend sur environ 240 000 ha, ce qui ne représente que 1,4% de la superficie arable totale (16 800 000 ha). L'Italie est le plus grand producteur de riz de l'Union européenne (UE) : le pays produit les deux tiers environ du riz européen et exporte les deux tiers approximativement de sa production vers les pays de l'UE (les deux tiers des exportations) et d'autres pays du Bassin méditerranéen et d'Europe de l'Est. Le rendement moyen est de 6 t/ha, 85% de la superficie étant consacrés à des variétés du type Japonica, le reste sous Thaibonnet. Les consommateurs italiens préfèrent le riz à gros grains et à caractère crayeux, aussi la production de riz Indica est-elle exportée en totalité. Du point de vue agronomique, les principaux facteurs limitants de la production rizicole sont : les basses températures au moment des semis et de la floraison, la pyriculariose, les mauvaises herbes et le riz rouge. Le rendement potentiel peut être accru grâce à la sélection de nouvelles variétés mettant l'accent sur la résistance/tolérance aux maladies, la résistance aux faibles températures et la résistance à la verse. Les programmes de recherche sont axés sur l'amélioration génétique pour la stabilité du rendement et la qualité des grains ; la sélection de nouvelles variétés pour leur résistance au froid et aux maladies ; la lutte contre les mauvaises herbes et la biotechnologie (culture d'anthères, transformation).*

Abstract. Rice cultivation in Italy is mostly located in the northern regions and extends over about 240 000 ha which represent only 1.4% of the total arable area (16 800 000 ha). Italy is the largest rice producer in the European Union (EU): approximately two thirds of Europe's rice is produced in Italy and approximately two thirds of the national production is exported both towards the EU countries (two-thirds of the exported amount) and other countries mainly in the Mediterranean area and in Eastern Europe. The average yield is 6 t/ha; 85% of the surface is grown with japonica type varieties, the rest with Thaibonnet. Italian consumers prefer bold and chalky grain so that indica-type rice is entirely exported. From an agronomical point of view, the main constraints of rice production are: low temperature at sowing and flowering time; blast disease; weeds and red rice. The possibility exists to increase the potential yield by varietal improvement with emphasis on disease resistance/tolerance, low temperature tolerance, lodging resistance. Research programmes concern breeding for yield stability and grain quality; breeding for cold and disease resistance; weed control and biotechnology (anther culture, transformation).

Rice is one of the most economically important cereal crops in Italy, in view of foreign exchange. The cultivated rice area in Italy has increased since the beginning of the European Community policy, mainly owing to favourable market conditions for Italian paddy production.

Rice cultivation in Italy is mostly located in the northern regions (Po Valley) and extends at present over about 240,000 ha (including some small areas cropped in the Sardinia island and southern Italy) which represent only 1,4% of the total arable area (16,800,000 ha).

The rice area has continuously been increasing in the last fifteen years (Table 1). In the same period, there has been a constant trend towards a reduction of the number of farms and an increase of the surface of each farm (Table 2).

In the last years, an evolution has been taking place in so far as varieties are concerned: the cultivation of indica type varieties has started and the surface grown with these genotypes reached about 20% of the total rice area in 1995 (Table 3). For the same year, the most cultivated varieties in Italy were Thaibonnet, Loto, Balilla, Drago and Ariete (Table 4).

Italy is actually the largest rice producer in the European Union (EU): approximately 2/3 of the European rice is produced in Italy and approximately 2/3 of the national production is exported both towards EU countries (2/3 of the exported amount) and other countries mainly in the Mediterranean area and in Eastern Europe (Table 1). The expected production is approximately 1,4 million metric tons of paddy rice and the average yield is about 6 tons/ha.

An increasing rice area, about 20% during the last twenty years, is generally considered favourable to the Italian economy in connection with the export of about 60% of our production. Thus exports can counterbalance the imports of large quantities of food and feed products. In fact, Italy is becoming an important rice-exporting country, considering that its domestic consumption hardly exceeds 40% of the total rice production.

Although Italian rice production represents a very small fraction of the world production, the volume of exports reaches 5% of total rice traded in the world.

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

I – Main constraints and potential of rice production

1. Main constraints

❒ **Climate:** It remains the most limiting factor considering that the rice area is mostly located in northern Italy (> 45°N) where cold temperatures (5°C or less) can occur at sowing (in April) causing damage to seedlings and poor establishment in rice fields. Moreover, a sudden decrease of temperature or strong diurnal variations can occur at flowering time, during thunderstorms in August, causing spikelets sterility and/or more favourable conditions for blast attacks. Thunderstorms and wind during the ripening stage may cause severe lodging of the tallest varieties.

❒ **Diseases:** blast and brown spot are at present the main diseases, but they rarely cause great damage to the crop, depending on climatic conditions.

❒ **Weed populations** remain one of the main limiting factors for rice production in intensive cultivation.

❒ **Others:** red rice has become a main constraint in the last years since it accumulates in the soils, especially in the case of monoculture.

Occasionally, salinity problems can occur in the lowland soils in coastal regions.

2. Potential of the rice crop

❒ Increase of rice yield can generally be expected through the introduction of new varieties with improved traits (i.e. disease resistance/tolerance, low temperature tolerance, reduced culm length and lodging resistance).

❒ No increase of the rice area is expected; on the contrary, a decrease will probably occur if the rice price is decreasing.

II – Rice research

1. Research programs

– Breeding for grain quality, cold and disease resistance
– Adaptability to dry cultivation
– Weed control, in particular red rice
– Pest control (blast, brown spot and insects in stored rice)
– Biotechnology: anther culture, transformation.

2. Main achievements in rice research

❒ Most of the japonica type varieties released in Italy are grown throughout the Mediterranean rice area: i.e. Ariete, Elio, Lido, Balilla, Koral, Loto, Baldo.

❒ New varieties are semi-dwarf, resistant or tolerant to fungal diseases, with improved quality and high milling yield.

❒ Rice production technology for drilled crop was adjusted to local conditions with emphasis on fertilization management and weed control.

❒ Weed control is obtained with few treatments and low doses.

III – Breeding strategies

Breeding is an important activity allowing to solve some practical problems of intensive cultivation in order to meet market preferences and improve rice growers' income.

Breeding for high yields represents the traditional objective in the case of Italian rice. Unfortunately, this is an indeterminate objective. The problem is to identify the factors limiting yield in such a temperate area. Very recently, yield has been increased by cultivating semi-dwarf with erect leaves varieties. However, breeders have to face several environmental factors conditioning rice productivity.

1. Breeding for grain quality

Breeding for grain quality in Italy is a priority objective for rice improvement. Actual Italian programs are focusing on genetic improvement to isolate new rice cultivars with high grain quality. Actually, breeders take the greatest care in choosing parents with high amylose content in order to combine grain hardiness with good yield potential.

In the European market, Italian exports face increasing competition with other exporting countries. However, most of the difficulties encountered by Italian rice exports are not only quantitative, but are due to the fact that the traditional rice types do not always satisfy consumers of Central and Northern Europe, who prefer the so-called indica-type rice (long, not sticky grain) to the traditional Italian, japonica-type (large or short sized, soft cooking grain).

Actual Italian programs of genetic improvement are oriented to differentiate new rice cultivars for both domestic and foreign markets.

In recent years, to meet the needs of rice export, the production of indica-type varieties has developed in Italy thanks to the aid granted by the European Union in the years 1987-1993.

The climate in typical rice areas is generally unsuitable for growing true indica varieties. Many attempts have been made, sometimes successfully, to cross the grain characters required by the market, according to desirable agronomical features fit to the Italian environment.

At present, cv. Thaibonnet, introduced from USA (L202), represents the most important indica type variety grown in Italy. But many other cultivars are being selected from crosses in order to prevent the risks of new pathogens' diffusion and red rice accumulation due to the diffusion of a single genotype with a weak adaptability to our agronomic and climatic conditions.

Crossing indica and japonica genotypes, one of the main constraints, is generally the significant genetic distance between the two rice types: artificial crossing has to face some incompatibility and, more seriously, a severe sterility in the following generations. However, in spite of a similar barrier, the hybridation program can be realized with an appropriate use of backcross to the parent with the greatest number of useful traits.

A promising alternative approach for obtaining new indica-type varieties adapted to temperate regions may be the biotechnology method based on the *in vitro* culture, taking into account the fact that about 50% of the di-haploid plants derived from the culture of *F1* japonica x Indica pollen turn out to be completely fertile and fixed.

Regarding the grain quality of indica-type varieties, emphasis has been laid on the role of their amylose content and correlated characteristics of hardiness and stickiness, since these traits are essential, taking into account the fact that indica-type varieties are generally parboiled. The parboiling process offers considerable advantages for the slender grains of the indica type, such as higher milling yield, lower stickiness, improving cooking quality, which generally offset higher production costs.

The milling industry is showing an increasing interest for parboiled, more homogeneous products. On the other hand, increase in amylose content could be a very limiting factor for breeders. We must also hold in great consideration improvement of other market quality characteristics, such as high milling yield, vitreosity, slenderness, homogeneity and healthiness of the grain, which are the traits required for the parboling process.

A major attention for the export market requirements leads to new trends in national breeding programs in order to introduce the recommended improvement strategies:

❒ Breeding for physico-morphological traits:
– Husks and pericarp colour (that influence the colour of parboiled products);
– Grain size, shape, weight, and uniformity;
– Vitreosity and colour of grain;
– Chalkyness and damaged grain.

❒ Improvement of milling quality:
– Milling yield;
– 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 priority objectives, other genetic researches have been recently considered in order to promote the introduction of different special types of rice (aromatic, waxy, red and special rices for dietetic purposes).

Particularly, aromatic (or scented) rice is increasingly requested at present in the EU market. Although attempts for growing aromatic rices from USA have been made in Italy, these genotypes have showed poor adaptability to the local climatic conditions. One of the main difficulties in breeding for aromatic rice is the loss of aroma intensity in wide crosses between scented and local varieties because of the cumulative genetic basis of this character.

Another promising opportunity to offer new differentiated products is the isolation of genotypes with very high amylose content (over 30%) for manufactured products, like polymer compounds, utilized as a 100% biodegradable plastic materials.

2. Breeding for cold and diseases resistance

One important goal for Italian breeding programs is yield stability considering the climatic constraints due to the geographic position of Italy. Breeding for yield stability means to evaluate the environmental factors causing divergency between the potentialities of the varieties and their actual performances in farm conditions.

One of such factors is certainly low temperature during the germination and reproductive stage (at panicle differentiation and microspores formation stage) of the plant cycle. Of course, in spring damage due to cold temperatures (average of 10-12°C in the two first decades of April) may reasonably be avoided, to some extent, if sowing is delayed without risking to meet other similar difficulties at maturity. So, the agronomical approach has to be integrated with the genetical one.

The inheritance of low temperature tolerance is extremely complex, although it appears to be independent from many morphological characters, and it is obviously greatly affected by environment. Tolerance to damage at one growth stage does not necessarily relate to tolerance at other stages. We must consider that an evaluation at only one stage is insufficient.

Fortunately, many sources of low temperature tolerance are available in japonica varieties grown in Italy. Repeated cycles of natural selection under appropriate low temperatures seem to result in a progressive and cumulative advance towards cold tolerance.

Evaluation techniques for low temperature tolerance, based generally on field screening, were successful when correlated with the use of appropriate laboratory techniques for checking the rate of roots growth, at seedling stage, under controlled environment.

Other factors influencing yield are obviously disease epidemics with their variations in diffusion and intensity. In Italy, blast is the most serious and widespread rice disease and its causal organism, *Pyricularia oryzae Cav.* (*Magnaportae oryzae*), appears as the most variable pathogen. Generally, incorporating genetic factors contributing a reasonable degree of horizontal resistance is a common aspect in breeding new varieties.

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

Recently, the importance and diffusion of *Bipolaris oryzae* has been increasing in Italy. Intensive attacks in field conditions result in damaged grain and poor quality seeds.

Effective screening procedures are needed to develop successful breeding programs for resistance. Unfortunately, new improved varieties with vitreous long grain or indica-type grain seem to be generally more susceptible to brown spot disease. The widespread cultivation of the new susceptible varieties has produced conditions highly favourable to the maintenance of a high degree of natural infection in crops.

3. Breeding for adaptability to dry cultivation

Cultural methods for rice production include both flooded and upland, with large predominancy of flooded rice culture in temperate areas. However, this system requires large water quantities and may increase the difficulty and cost of applying pesticides and fertilizer and using machinery.

Permanent flooded conditions during the cultural cycle provide a continuous and adequate supply of water, nonaquatic weeds control, facilitate the use of granular insecticides and herbicides, reduce losses of ammonium fertilizers, and enhance availability of nutrients such as phosphorus, iron, manganese following reduction of the soil due to exclusion of oxygen by the floodwater.

The conventional flooding technique is very high water consuming. About 48% of the irrigation water is generally lost through evapotranspiration (ET). The remainder is lost due to runoff and infiltration. Water represents a major and necessary production cost for rice growers. On the other hand, often rice producers have to face increasing competitive uses of water. Moreover, very often the water quality is getting worse due to the pollution.

With the traditional rice system, under temperate conditions (e.g. in Italy), the direct water broadcast sowing method could not prevent some damaging effects of adverse environmental conditions on plantlets establishment.

Alternate methods of planting by drilling and aerobic cultivation (dry rice) are ideal to overcome these damaging effects. Different methods can be used.

However, reports from several areas have shown highly variable results. Following these results, further research to compare the effects of normal flood irrigation and sprinkler or other suitable irrigation system (furrow, flushing irrigation) on rice yield and quality is requested.

Experiments have been conducted in recent years on a sandy-loam soil in the experimental field of the *Sezione Specializzata per la Risicoltura*, near Vercelli, to evaluate the performance of major commercial rice cultivars and new lines in dryland conditions with minimal irrigation by flushing.

The water was supplied by flushing method from a gravity-feed irrigation system, two or three times in all during the cultivation season. The irrigation treatments were designed so that rainfall plus irrigation were enough to maintain about 20% soil moisture at least and assure no strong water stress.

Nonflooded conditions practically had no effect on seedling emergence. However, after this stage, rice development was slightly affected by stress from insufficient water supply and inadequate moisture. Generally almost all the varieties showed longer cycle duration but reached complete ripening.

Stresses which may have occurred from nonflooded conditions influenced differently the time from planting to heading in relation to the cultivars. In general, aerobic cultivation resulted in a delay in heading time. Cultivars with early or medium time to heading performed better.

Generally, cycle duration to ripening was affected more than time to heading in relation to different cultivars. Several genotypes showing low moisture at harvesting performed very well, especially the earlier varieties. Very long duration varieties showed significant yield reduction compared with the top-yielding variety indicating poor adaptability to dry conditions.

A moderate correlation seems to exist between yield capacity and a good earliness of the genotype. This can be chosen as one of the criteria for selecting well performing varieties with some tolerance to dry soil conditions.

In conclusion, experiments carried out furnished preliminary results suggesting potentials for alternate aerobic rice cultivation under nonflooded conditions. Dry rice production may be adapted to nontraditional rice areas where soil flooding is problematic or water cost is prohibitive.

Table 1. Rice area, rice production and rice market in Italy in the years 1980-1995

			Milled rice				
			Input			*Output*	
Year	**Surface** (ha)	**Total yield paddy rice** (tons)	Total production (tons)	Import (tons)	Domestic production (tons)	Export to EU (tons)	Export to others
1980	176,246	969,355	720,516	64,020	237,396	253,110	230,010
1981	169,112	903,297	692,208	201,201	261,197	254,131	176,880
1982	177,918	1,010,362	760,969	66,950	264,369	219,700	276,900
1983	184,279	1,042,566	678,325	57,582	279,268	202,734	196,323
1984	180,330	1,002,504	695,376	58,500	283,016	225,355	187,005
1985	187,187	1,194,988	810,025	22,780	305,917	235,773	268,335
1986	192,842	1,143,081	797,143	33,085	306,597	243,518	247,028
1987	190,759	1,094,509	773,966	36,648	306,837	260,973	206,156
1988	199,159	1,149,623	756,451	40,397	314,130	233,790	208,531
1989	206,480	1,311,386	790,374	3,645	302,011	320,130	168,233
1990	215,442	1,454,854	899,453	14,611	319,414	244,018	336,021
1991	206,345	1,321,043	935,644	4,935	323,370	276,657	335,617
1992	216,410	1,287,065	805,809	5,887	287,048	365,203	153,558
1993	231,740	1,316,240	833,559	22,125	313,239	396,497	123,823
1994	235,951	1,310,798	819,992	14,907	302,967	365,944	151,081
1995	239,259	1,374,002	804,945	20,000	305,000	350,613	149,332

Source: *Ente Nazionale Risi*, Milano, Italy.

Table 2. Number of farms and surface per farm

Year	Farms (N.r)	Surface/farm (ha)
1980	9,923	17.8
1981	9,248	18.3
1982	9,006	19.8
1983	8,902	20.7
1984	8,427	21.4
1985	8,298	22.6
1986	8,171	23.6
1987	7,892	24.2
1988	7,761	25.7
1989	7,517	27.5
1990	7,481	28.8
1991	6,903	29.9
1992	6,762	32.0
1993	6,720	34.5
1994	6,629	35.6
1995	6,465	37.0

Source: *Ente Nazionale Risi*, Milano, Italy.

Table 3. Yearly cultivation of different grain type varieties in Italy (% over total rice cultivated area)

Year	Short grain (%)	Medium grain (%)	Long grain A (%)	Long grain B (%)
1980	28.5	20.9	50.6	-
1981	23.5	26.0	50.5	-
1982	24.9	27.0	48.1	-
1983	15.6	32.2	52.2	-
1984	18.0	36.7	45.3	-
1985	15.7	39.7	44.6	-
1986	20.0	47.5	32.5	-
1987	17.8	47.6	34.6	-
1988	16.0	43.4	40.4	0.2
1989	22.5	39.1	37.9	0.5
1990	30.2	31.2	35.0	3.6
1991	21.3	28.3	37.2	13.2
1992	22.4	28.3	37.8	11.5
1993	22.9	22.9	41.9	12.3
1994	25.1	21.0	39.6	14.3
1995	22.6	22.3	36.1	19.0

Source: *Ente Nazionale Risi*, Milano, Italy

Table 4. Rice area and main varieties in Italian regions, in 1995

Region	Surface (ha)	Main rice varieties
Piemonte	120,244	Loto, Thaibonnet, Ariete, Drago, Elio
Lombardia	102,021	Thaibonnet, Balilla, Volano, Drago, Loto
Emilia	9,925	Arborio, Thaibonnet, Baldo, Volano, Carnaroli
Veneto	4,512	Vialone, Thaibonnet, Volano, Ariete, Arborio
Toscana, Calabria	974	Thaibonnet, Ariete, Roma, Loto, Balilla
Sardegna	1,583	Thaibonnet, Balilla, Lido, Selenio, Loto
Italy	239,259	Thaibonnet, Loto, Balilla, Drago, Ariete

Source: *Ente Nazionale Risi*, Milano, Italy.

Institutes working on rice in Italy

Names & addresses	Number of researchers	Research themes
• Istituto Sperimentale per la Cerealicoltura - Sez. Risicoltura Strada per Torino km 2,5 13100 Vercelli (Italy)	3	Breeding - Upland rice - Technology
• Centro Ricerche sul Riso Ente Nazionale Risi Strada per Ceretto 4 27030 Castello d'Agogna (Italy)	7	Breeding - Anther culture - Genetic resources - Pest control - Weed control - Grain quality - Soil and water pollution
• Istituto di Agronomia Università di Milano Via Celoria 26 20133 Milano (Italy)	3	Weed control - Crop growth models - Cropping system analysis - Rice agrotechniques
• Dipartimento di Biologia Università di Milano Via Celoria 26 20133 Milano (Italy)	2	Biotechnology (transformation, molecular markers or genotype identification)
• Istituto di Agronomia Università di Torino Via Giuria 10100 Torino (Italy)	1	Red rice control
• Istituto di Meccanica Agraria Università di Torino Via Giuria 10100 Torino (Italy)	2	Mechanization
• Istituto di Botanica e Genetica Veg. UCSC Via Emilia Parmense 84 29100 Parma (Italy)	1	Anther culture
• Istituto per la meccanizzazione agricola CNR Strada per Torino km 2,5 13100 Vercelli (Italy)	1	Land mechanization