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in

Chataigner J. (ed.).
Perspectives agronomiques de la culture du riz en Méditerranée : réduire la consommation de l'eau et des engrais

Montpellier : CIHEAM
Cahiers Options Méditerranéennes; n. 15(1)

1996
pages 93-98

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I – The IRC and its 18th session

The fourth Session of the Conference of the Food and Agriculture Organization of the United Nations (FAO), having considered the recommendations of the Rice Meeting held in Baguio, Philippines, in March 1948, as approved in principle by the Council of the FAO at its meeting in April 1948, approved the establishment of an International Rice Commission (IRC). The Object of the IRC, which is established within the framework of the FAO, shall be to promote national and international action with respect to production, conservation, distribution, and consumption of rice, except for matters relating to international trade.

Every four years, a meeting of the IRC is organized in a different continent to help the member countries to discuss, review, and reorient their national rice research and production programmes. The 17th Session of the IRC was held in Brazil in 1990. The 18th Session was held at the FAO headquarters in Rome, Italy, from 5 to 9 September 1994. The Session was attended by 62 delegates from 38 member countries and 5 observers from FAO member countries. There were also 28 participants from 5 international organizations.

II – Main activities during the 18th session of the IRC

Twenty papers/articles focused on the World Rice Situation and Outlook, New Technology Development, Sustainable Rice Production, Post Harvest Technology and Nutrition, Achievements and Innovation in Rice Research. Regional Networks on Rice and Rice-based Farming Systems together with Statements on Issues and Opportunities for Rice Research and Development from 29 National Programmes were also presented and discussed during the 18th Session. The delegates and participants of the 18th Session travelled to Vercelli for field visits during the period (7 September at noon to 8 September 1994 in the evening), during which various aspects of Rice Research, Production, and Marketing in Italy were presented and discussed. Following are main the observations obtained from the presentations and discussions during the 18th Session:

1. The global rice output is projected to increase at an annual rate of 2% to 408 millions tons by the year 2000. World trade is projected to grow at around 3% annually to reach 17.1 million tons and international rice prices are projected to be higher in real term by the year 2000. There would be some changes in production and trade structure in future, as a result of the agreement reached at the Uruguay Round of Multilateral Trade Negotiations.

2. The world rice stocks are expected to rise to about 68.5 million tons. As a result, by the year 2000 the ratio of projected stocks to consumption at the global level would be around 16.5 percent. In the year 2000, however, the problem of hunger would remain primarily because of the inability of a large sector of the population to have an adequate access to rice.

3. The intensive monoculture of rice in irrigated ecology has led to the build-up of salinity and water lodging, micro-nutrient deficiencies, the formation of hardpan, and increased pest build-up. Another concern of the sustainability of irrigated rice production systems is the increasing limited water availability for rice production, the clogging up of waterways with aquatic weeds, and the plateauing in yield potential of conventionally bred varieties of the Green Revolution Generations (IR8). The sustainability of rice production in irrigated rice ecology, however, will be more and more dependent on the yield increase and cropping intensity as there is a limited scope for the expansion of the net area.

4. Population pressure had led to the exploitation of areas under deep water and mangroves for agricultural production, including rice to be environmentally hazardous; sustainability of natural resource bases are also becoming serious issues. For example, in some part of Africa, natural ecologies are being irreparably damaged due to the change in land use pressures and the adoption of upland rice production without an adequate fallow period.

5. The international concern has shifted from production *per se* to sustainable production where income of farm families are optimized while natural resource base is protected. The long term productivity of the lowlands is not independent of watershed degradation. The Green Revolution has to a large extent relieved the pressure on uplands. However, if the current trends towards stagnation and decline in lowland productivity persists, then decline could be expected in employment opportunities in the lowlands, with consequent increased pressure on the uplands.

6. The yields of modern varieties have become stagnant. The International Rice Research Institute (IRRI) has been working to raise the yield potential of irrigated tropical rice varieties from 10 to 15 tons/ha. The quantum jump to break yield barrier is focused on the next generation of New Plant Types and Hybrid Rice. The New Plant Types will be available to the National Agricultural Research Systems by 1998.

7. At present, Hybrid Rice is the only available technology to transgress the yield barrier, with yield increase of about 20 to 30% over the yield of best high yielding varieties. Therefore, hybrid rice offers an excellent opportunity to increase food production and security, especially in countries where labour to land ratio is high, where labour costs are reasonably cheap, land scarce and the population growing at an alarming rate. The adoption of hybrid rice technology would depend on the pace at which heterotic rice hybrids are developed, reduction in cost of hybrid rice seed production, and improvement of grain quality and pest resistance.

8. New Plant Types needed for the rainfed, upland, and flood prone ecosystems are being conceptualized by IRRI and cultivars with tolerance to abiotic and biotic stresses are being developed to suit different rainfed ecosystems. Existing progress is being made on new cultivars for mechanized cultivation in tropical savannas in Latin America which could double the historical farm yields to 2.5 tonnes/ha on about 3 million hectares over the next 5–10 years.

9. Biotechnology utilising cell and molecular procedures could significantly strengthen rice breeding programmes. Regeneration of fertile rice plants from protoplast through cell and tissue culture opens up the possibility of genetic engineering of rice using both Japonica and Indica varieties via direct uptake of DNA into protoplasts. It also opens up opportunities for gene flow by fusion of protoplast and production of rice somatic hybrids thereby extending the range of hybridisation, both nuclear and cytoplasmic, for the introgression of useful genes.

10. Efficiency of fertilizer use in rice cropping systems, especially in Asia, has sharply declined and unbalanced fertilizer use has resulted in depletion of plant micro-nutrients reserve in the soil. Integrated Pest Management for intensified Asian rice growing areas has become the world's primary model for IPM in other countries and cropping systems. In Latin America and the Caribbean region, the adoption of water seeding, submergence tolerance, allelopathy and early season vigour helps reduce weed control by 30 percent.

11. Mechanization is relevant in crop intensification and labour scarcity. The IRRI has made significant contributions to rice mechanization with special focus on small scale production systems. In Italy, the use of machinery and equipment is in excess of the requirement to meet the critical optimal time of various field operations. The high costs, however, are sustained by high yields combined with optimal characteristics.

12. About 9 million hectares of deep water rice offer a suitable environment for integrated rice-fish culture. However, little effort has been made for the development of appropriate technologies for fish culture integrated with deep water rice cultivation.

13. Rice biomass such as straw, hulls and husks, bran, broken rice, has several usages. Utilisation of rice biomass increases farmers' income and employment opportunities as well as reduces harmful effects on rice environment due to the disposal of rice biomass. The technologies for rice biomass utilisation introduced by the FAO's programme on “Thriving with Rice” in four African countries have generated great impact on farmers' income and rural employment in these countries.

14. Rice is a rich source of energy. It is also a good source of protein, containing reasonable amount of thiamine, riboflavin, niacin, and vitamin E. Nutritional deficiencies in low-income rice eating countries are not caused by rice consumption *per se* but are largely the results of diets that lack nutrient diversity. Improved access to more varied diet, including diversification of family food production, and increased awareness would contribute to improve nutrition.

15. The European Union (EU) is 85–90% self-sufficient in rice. Three main sectors of rice consumption are: home (79%), catering (18%), and industry (3%). Overall, rice is seen as a versatile, economic and healthy food and has a positive image.

16. Although there is a real potential in the Mediterranean basin, output has not kept pace with the steep rise in rice consumption. In 1992, production has risen to 7,184 million tonnes while consumption has climbed to almost 11 million tonnes. Per capita rice consumption rose from 7.15 kg/year in 1966 to about 14.8 kg/year in 1992.

17. In the Mediterranean region, only few countries have undertaken a significant research effort on rice. The establishment in FAO in 1990 of the Interregional Cooperative Research Network on Rice in the Mediterranean Climate Areas is designed to help focus regional research to the challenges facing Mediterranean production. FAO and the French government have been supporting the Network since its establishment. The Network is still young and there is tremendous goodwill in the scientific community. However, with two or three exceptions, the attention given by the authorities in most countries to rice research and resources allocated to it fell far short of even minimum requirements.

III – Agronomic issues of rice production in Mediterranean climate areas

Rice production in the Mediterranean basin needs to improve both its productivity and its grain quality. Traditionally, Europe has been a consumer of Japonica rice. However, consumers' tastes have been increasingly shifted to long grain and aromatic Indica rice. In Italy, several "Indica" rice varieties have been developed and introduced, but farmers' adoption of these varieties is still limited in comparison to Thaibonnet (L202), an imported variety. Advances in the field of rice genetic improvement and biotechnology as mentioned above could be utilized to improve both yield potential and the grain quality of rice varieties planted in the region. The higher yield of most of the semi-dwarf rice varieties is due to a high harvest index (0.5 compared to 0.2–0.3 of tall traditional varieties). Raising harvest index above 0.5 would require stiff straw to sustain more grain on top. Biomass of semi-dwarf varieties is not greater than that of the traditional tall ones. Therefore, one should attempt to increase the total plant biomass first, before improving the harvest index to 0.55–0.6. New traits for improving the yield potential of rice varieties could come from wild rice such as *Oryza latifolia*, *Oryza glaberima*, etc., or even from C4 species.

Wide hybridisation and advanced biotechniques could also be used to improve blast resistance and the grain quality of cultivated rice varieties in the Mediterranean basin. In addition to the creation of long grain of type A (L>3 and L/W<3) or type B (L>3 and L/W>3) with Basmati qualities, the Iranian rice germ plasm, highly resistant to heat, with a long grain and special cooking quality, like Basmati or US long grain, should also be studied and exploited.

In addition, higher productivity of rice production in the region could also be obtained by maintaining the gains already made and closing the gap between potential and achieved yields. Average Japonica yields in the region currently vary from 3 to 8 tons/ha while the potential yields of most improved Japonica rice varieties exceed 13 tons/ha. Spectacular results have been achieved in Egypt whose national average yield has increased steadily from 5.8 tons/ha in 1987 to about 7.66 tons/ha in 1992 (Balal, 1994). Egyptian results underline the scopes for improvement of rice production in the Mediterranean basin. However, due attention must be paid to economic and ecological concerns for sustainable resource management and producers' incomes.

Water availability will be the dominant limiting factor of rice production in the region. The dry and hot Mediterranean summers indicate that rice plants need to be provided with adequate water. The potential evaporation in the Mediterranean basin amounts to about 1,200 mm but total rainfall is only about 275 to 900 mm with more than 65% of precipitation occurring in winter. The rice irrigation in the Med-basin, mainly in order to stabilize crop growing conditions and to reduce weed competition, has adopted the flooded systems which require large amount of water. Most of the high costs of the development of irrigation infrastructures in the Mediterranean climate areas have been subsidized by concerned governments. Appropriate technology for better water use efficiency, therefore, needs to be developed to reduce the rather high production cost.

Sprinkler irrigation has been used on 50,000 hectares of upland rice in Brazil (Stone et al., 1990). Furrow irrigation, surge flow irrigation and even drip irrigation have been tried in Pakistan (personal communication from Dr. B. Dokri, Pakistan Rice Research Station). Practices such as underground piping system for water delivery, land forming, multiple inlets, reduced level intervals, are promising for reduction of water uses in rice production (Kandiah et al., 1990). Raised bed experiment on furrow irrigation for rice production tested in Missouri showed that water was saved (50 cm instead of 101 cm); at the same time other advantages (e.g. elimination of level construction, use of less expensive ground equipment instead of airplane for chemical applications, quicker field drying before harvest) were obtained without yield reduction (Tracy et al., 1988). In Australia, saturated soil culture (SSC) method in which rice is planted on raised beds with a permanent water table some 10cm below the surface of the beds maintained grain yield and total dry matter production but reduced water used by 32% compared to the traditional flooded system, as evaporation of water is much less in wet bed than in flooded water surface (Borrell et al., 1994).

Experiments in sprinkler irrigation water in upland rice in Brazil seems to indicate that neither existing upland varieties nor lowland varieties are suitable. New rice plant types for non-flooded conditions must be bred. New rice varieties may need a root system which is more similar to that of wheat and/or barley. Also, a major knowledge gap still exists in areas of soil reactions under the non-flooded system, especially where salination and alkalinization prevail as in many Med-climate countries, evolution of weeds and pests, and interactions of water regime with fertilizers, notably nitrogen.

Unbalance fertilizer application has caused low efficiency of fertilizer use, increasing deficiencies of minor elements (Zn and S), and possibly yield decline in irrigated rice production in several Asian countries (Angé, 1994). There is a need to develop efficient method to monitor crop fertilizer requirement and soil nutrient supplying capacity to minimize over-dose fertilizer application. The Plant Area Board, which is based on the concept that rice plants must develop sufficient growth by key development stages to produce maximum yield, is a quick and easy methods for monitoring rice plant development and adjusting mid season N rate application (Slaton et al., 1994). Chlorophyll measuring meter such as Minolta 502 SPAP has been used in the prediction of N requirement of rice in farmers' field (Turner and Jund, 1994).

Crop rotation systems integrating rice and leguminous crops could substantially improve N supplying capacity of rice soils. In northern Italy, rice-soybean and rice-pasture systems have been tried by the Rice Research Center of *Ente Nazionale Rizi* at Mortara and seed growers in Vercelli. Legume-based pasture provide subsequent rice crops in Australia with fixed soil N resulting in considerable savings in production cost by reducing the need for N fertilizer (Lattimore, 1994). Annual pasture based on Subterranean clover *(Trifolium subteranneum)* are well adapted to typical Med-climate.

Weed competition greatly reduces rice yield. Weed control with herbicides is not only costly but also environmentally harmful. In fact, environmental concerns, especially on water quality and increasing regulation have slowed down the development and registration of herbicides in USA. Repeated use of herbicides may lead to the development of weed biotype resistant to herbicides. Propanil resistant *Echinochloa crusgalli* has been identified in USA after 30 years of propanil use and bensulfuron resistance has been found in a number of broadleaves and sedge weeds in California after only 4 years of continuous uses (Hill et al., 1994).

The Integrated Pest Management approaches used for pest control in Asia need to be promoted in Med-rice production, especially for weed control. Integrated Weed Management approaches could include water management, utilization of rice varieties with submergence tolerance, early season vigour, allelophatic characteristics, and biological agents. A combination of good land preparation, seeding in flooded soil, early vigour and crop rotation was recommended for controlling red rice in Latin America (Winslow, 1994). A number of rice varieties from Afghanistan, Brazil, China, Dominican Republic, India, Philippines, Taiwan, and USA have been found to possess allelophatic properties which protect them against certain weed species. Technology for anaerobic seeding was recently developed by IRRI (IRRI, 1994). In Australia, endemic fungus which caused necrotic lesions on leaves and inflorescence of *Alisma lanceo - latum* and *Damasonium minus* has been used as biological agent for controlling these weed species (Cother and Gilbert, 1994).

IV – Conclusions

There is a potential in Mediterranean climate countries to increase rice output. Technologies achievements presented during the 18th Session of the IRC could be applied for addressing major issues on rice production in the region. Rice production in the region could enhance its productivity by improving the yield potential and the grain quality of rice varieties as well as by preserving gains made and making progress in the fields of water management, fertilizer application, especially nitrogen fertilizer, and weed control. Higher productivity is really needed by rice production in the region for reducing production cost to be competitive in an evoluting world rice market after the Agreement reached at the Uruguay Round of Multilateral Trade Negotiations. In particular, rice production in Mediterranean climate countries need increasing efforts to:

(a) develop appropriate methods for improving water use efficiency. More tests on sprinkler irrigation, saturated soil culture, etc., are needed.

(b) generate suitable methods for monitoring fertilizer requirement of rice plants and nutrient supplying capacity of rice soils for improving the efficiency of fertilizer use and develop crop rotation systems for restoring soil health and improving soil reserves in nutrient elements. Rice-legume-based pasture integrating with animal production as found in Vercelli, Italy, should be improved and promoted.

(c) elaborate effective Integrated Weed Management integrating biotic and abiotic means for low cost and environmentally friendly weed control.

Higher productivity on large scale needs effective systems for technology transfer. The Rice-Check systems used in Australia's rice production deserves to be closely examined for further improvement of the extension service in Mediterranean climate rice production.

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