Rice in the Global Food Supply

By T.H. Fairhurst and A. Dobermann

Rice (*Oryza sativa* L.) has supported a greater number of people for a longer period of time than any other crop since it was domesticated between 8,000 to 10,000 years ago (Greenland, 1997). At present, rice is the staple food for more people than wheat, and 90 percent of total rice production is grown and consumed in Asia (Evans, 1998). Unlike maize or wheat, less than five percent of total rice production is traded on world markets, mainly within Asia and from Asia to Africa and Europe. Thus the emphasis in all rice economies is on self-sufficiency. In many Asian countries, rice self-sufficiency and political stability are interdependent issues.

Wetland or paddy rice production has been sustained over millennia and can be considered one of the world's most sustainable and productive farming systems. On an annual basis, irrigated rice is often 100 times more productive than upland rice, over 12 times more productive than deep-water rice, and five times more productive than rainfed rice (**Table 1**). Irrigated rice accounts for 55 percent of the global harvested area and contributes 75 percent of global rice production, which is about 410 million tonnes (M t) of rice per year (Dobermann and Fairhurst, 2000). Rice is now the staple food of 2.7 billion people, almost half the world's population, and is grown by more than half the world's farmers. The enormous productivity of intensified paddy rice systems accounts for the very high population densities and rich cultures that have developed alongside the major river systems of Asia. Rice culture is thus the cornerstone of cultural, social, and economic development in Asia.

Until the middle part of the last century, yields increased slowly but steadily and crop failure became less frequent as improved methods to control water supply were developed and farmers selected varieties adapted to specific agroecological conditions. Rice was adapted to fit a wide range of growing conditions, from the equatorial tropics to the high altitudes of Japan, from the tropical lowlands to the mountain terraces of the Himalayas, and from deep-water swamps to the uplands. This explains why over the past 35 years it has been possible to collect more than 80,000 local varieties now

Table 1. Comparison of the productivity of four different rice systems (von Uexküll, 1996).

System	Yield, t/ha	Crops/yr	Fallow period	Productivity, t/ha/yr
Irrigated rice	5.0	2.5	0	12.5
Deep water rice	1.0	1	0	1.0
Rainfed rice	2.5	1	0	2.5
Upland rice[1]	1.0	1	8	0.12

[1] Grown in slash and burn systems where long bush fallow periods between rice crops are required to replenish soil fertility.

Table 2. Population, total rice consumption, and per capita milled rice consumption (IRRI, 2001).

	Population, million		Rice consumption, '000 t rough rice equivalent		Milled rice consumption, kg milled rice/capita/yr	
	1998	2020	1990	1998	1990	1998
Asia	3,585	4,545	413,723	464,143	88.9	86.6
Latin America	504	665	16,998	18,271	26	24.5
Africa	749	1,187	15,129	20,269	16.5	18.1
Europe	729	712	2,781	4,296	3.7	3.9
Australia	18	22	170	258	6.8	9.3
U.S.	274	317	2,595	3,679	6.8	9.0
World	5,901	7,502	454,349	511,675	57.5	58.1

stored at the International Rice Research Institute (IRRI) germplasm collection.

Change in demand for rice is driven by population growth, level of per capita income, and changes in the price of rice relative to substitute crops (Hossain, 1997). Another factor may be the effect of recent increases in body size on per capita food requirements in much of Asia (von Uexküll, 1996). Worldwide, rice consumption increased by almost 60 M t (about 12.5 percent) between 1990-1998 (**Table 2**).

Table 3. Changes in rice trade, 1990-1998 (after IRRI, 2001).

	'000 t milled rice					
	1990			1998		
	Imports	Exports	Balance	Imports	Exports	Balance
Asia	4,834	7,765	+2,931	15,398	21,311	+5,913
Latin America	1,479	584	-895	3,428	1,765	-1,663
Africa	3,062	101	-2,961	4,723	450	-4,273
Europe	1,931	1,087	-844	2,614	1,413	-1,201
Australia	27	424	+397	37	552	+515
U.S.	148	2,474	+2,326	279	3,113	+2,834
World	12,184	12,471	+287	27,040	28,605	+1,565

Increases in consumption were driven mainly by population growth in Asia, Latin America, and Africa, and by increased per capita consumption in Europe, Australia, and North America. A positive trade balance for rice has been maintained by Asia, Australia, and the U.S. (**Table 3**) whilst deficits have increased in Latin America, Africa, and Europe.

An increase in total production may result from an increase in the area planted, increased yields, and increased cropping intensity. Worldwide, both area expansion and yield increases contributed equally to the increase in rice production of almost 80 M t between 1990 and 1998. In Africa, Europe, and the U.S., more than 80 percent of increased production was explained by an increase in the area planted. The largest increases in yield were in Latin America...about 44 percent...and Australia, 15 percent (**Table 4**).

Until the early 1960s and before the introduction of herbicides, tall varieties were preferred because they gave rice a competitive advantage against weeds. Also, tallness was an advantage because farmers valued rice straw for use as fuel, animal bedding, mulch, and because tall rice plants were considered easier to harvest.

Improvements in nitrogen (N) fertilizer manufacturing technology led to dramatic decreases in the cost of N in the late 1950s, but tall rice varieties were poorly responsive to N fertilizer due to their susceptibility to lodging. Improvements in crop protection, herbicides, and water control, combined with the advent of cost effective N fertilizers, led

Table 4. Rice production, area, and yield (after IRRI, 2001).						
	Production, '000 t		Area, '000 ha		Yield, t/ha	
	1990	1998	1990	1998	1990	1998
Asia	479,480	540,621	132,328	138,503	3.6	3.9
Latin America	15,565	24,045	6,183	6,611	2.5	3.6
Africa	12,407	17,602	6,099	7,842	2.0	2.2
Europe	2,404	3,238	449	581	5.4	5.6
Australia	924	1,410	105	140	8.8	10.1
North America	7,080	9,546	1,142	1,442	6.2	6.6
World	520,053	596,485	146,933	155,128	3.5	3.8

breeders to select plants with short, stiff straw that were less prone to lodging and produced a larger harvest index (the ratio of grain to total above-ground biomass production).

Perhaps the single most momentous event in the history of rice production was the crossing of the Taiwanese variety Dee-geo-woo-gen with the Indonesian variety Peta to produce IR8, which, with its release in 1966, began the Green Revolution. Since then, there have been spectacular increases in grain yields. With support from international lending agencies, local governments have made major investments to improve water control in irrigated rice systems that have led to greater cropping intensity (crops/ha/yr) and an increase in the area planted to rice. The combined effect of these changes has allowed rice production to keep pace with the dramatic increase in demand driven by increases in world population over the past 30 years.

The factor that has contributed most to exploiting the yield potential of modern varieties, however, has been the increase in the use of N fertilizers. In most locations, increased use of phosphorus (P) fertilizers was also required before a substantial response to N could be obtained. In countries with large deposits of oil and natural gas, these energy resources are used to manufacture N fertilizers. Manufactured P fertilizers are either imported or produced from local or imported phosphate rock and sulfuric acid and/or phosphoric acid.

In contrast to N and P, potassium (K) fertilizer has been used only sparingly in Asia's rice fields. Several studies have reported large negative balances for K and a depletion of soil K reserves. In a nutrient balance calculation for a typical rice-rice-bean rotation, the overall balance for N and P is positive. By contrast, whilst the relatively small percolation losses of K are balanced by additions in rainfall and irrigation water, 42 kg K_2O/ha is required to replace K removed in grain, and 235 kg K_2O/ha must be added if both the straw and grain are removed from the field (Greenland, 1997). Fertilizer K is now considered a key production factor in many areas as a result of past soil mining, and straw removal for industrial use. There is also a growing body of evidence on the importance of K in plant health and pest resistance.

Rice accounts for more than 40 percent of caloric intake in tropical Asia, reaching more than 65 percent in many countries and for many poor people. It also accounts for more than 60 percent of protein consumption in countries such as Bangladesh and Myanmar, and from 30 to 40 percent in Indonesia, Thailand, and the Philippines. Furthermore, rice production accounts for more than 25 percent of gross domestic product (GDP) in countries such as Vietnam and Bangladesh. Yields must continue to increase by 1 percent per annum until 2020 (Rosegrant et al., 1995) to keep up with demand. Rapid growth in rice production in Asia will help to alleviate poverty because faster growth leads to lower rice prices for poor rural and urban consumers. In addition, lower rice prices will encourage farmers to diversify into higher valued crops and thus provide more income for farmers and improved nutrition for consumers (Dawe, 2000).

There is very little opportunity to increase the area planted to rice and further crop intensification is constrained by limited supplies of water. Therefore, the increase in supply must mainly be met by increasing crop yields through better crop, nutrient, pest, and water management and the use of germplasm with a higher yield potential. Such approaches require much greater farmer knowledge. A major challenge during the coming decade is to develop cost effective technology transfer methods to increase the ability of farmers to manage the resources at their disposal more efficiently. **BCI**

Dr. Fairhurst is Director, PPI/PPIC East and Southeast Asia Program (ESEAP), Singapore; e-mail: tfairhurst@eseap.org. Dr. Dobermann is Associate Professor, University of Nebraska, Lincoln, and formerly Soil Nutrient Specialist with IRRI.

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