Reading 20
Rice

Rice, *Oryza sativa*

Rice, or paddy, widely grown in Asia from Afghanistan to the East Indies and north to Japan, is the principal food for 60% of the world's people. It is also a staple in parts of Africa, South America, and to some extent in the southern United States. World production exceeds 350 million metric tons annually, mostly from the Far East (China, India, Indonesia, Bangladesh, Japan, and Thailand are the major producing countries).

The research on rice genetics has been considerable, but details of domestication and discernment of species still remain unclear. The cultivated rices are generally regarded as belonging to the species *Oryza sativa*, a sort of catch-all complex. The various kinds of rices are generally regarded as varieties of *O. sativa*, although some botanists consider them to be separate species. The Asiatic forms are often called *O. sativa* var. *fatua*, *O. sativa* var. *nivara*, or *O. sativa* var. *rufipogon*; the American forms, *O. sativa* var. *perennis* (a name of doubtful validity); and the annual African forms, *O. sativa* var. *barthii* or *O. sativa* var. *glaberrima*. Some systematists have grouped rices into a *fatua* (or *rufipogon*) series and a *perennis* complex (of which the American forms are designated *O. sativa* var. *cubensis*, the Asiatic forms *O. sativa* var. *balunga*, and the African ones *O. sativa* var. *barthii* or *O. sativa* var. *longistaminata*). The wild forms of the *fatua* series generally grow in shallow swamps as annuals; the *perennis* forms (at least the Asiatic *O. sativa* var. *balunga* and the perennial African *O. sativa* var. *longistaminata*) generally grow in deep swamps. Floating rice can grow in water that is several meters deep, elongating as much as 30 centimeters (about 12 inches) per day. All rices are customarily grown as annuals, although under tropical conditions they may be perennial, perpetuated by new tillers or even rhizomes. Indeed, "ratoon rice" growing from the crowns of harvested plants may prove to be quite profitable (considering the limited input required of the farmer), even though a ratoon crop seldom yields even half the grain of a primary planting. In Africa, wild forms often volunteer in cultivated plantings, and there is some harvest and marketing of them.

Rice has been cultivated in China for 5000 years, and in the Niger delta of Africa at least since 1500 BCE. The cultivated forms are thought likely to have originated from wild *O. sativa perennis* types in Southeast Asia. But so widely has rice been spread that it is entirely, possible that wild rices from other tropical parts of the world have contributed to *O. sativa*. The diploid chromosome number of most rices is 24, but several forms (species?) are tetraploid ($2n = 48$). Triploid hybrids are often fertile. The International Rice Institute estimates that there are about 18 recognizable rice species, any of which may have made a contribution to *O. sativa*.

For practical purposes, rices are generally classified as long-grain, medium-grain, or short-gram. The long-grain types need a longer season to mature, and hence are grown mostly in tropical regions, such as Southeast Asia. Many people in the West prefer the long-grain type, which is nonglutinous and does not turn so soft and sticky when cooked. Medium-grain rices, somewhat softer, are most frequently grown in America. Short-grain types, even more sticky when cooked, are well adapted to more northerly climates, such as that of Japan.

Most rice is grown in paddy fields of standing water, the usual practice in Asia (Fig. 1). However, various forms of upland rice are grown in dry fields in much the same way as any small grain, the more common custom in Africa and Latin America. Yields of upland rice tend to be lower (0.5 to 1.5 metric tons per hectare in the Ivory Coast, for example) and its overall importance is not great; for example, in Indonesia and Bangladesh about 80% of the rice is grown on irrigated land. The best rice land is level, conveniently diked for alternating irrigation and drainage.

Only a little more than 1% of the world's rice is grown in the United States, but it is grown in a technologically advanced fashion. Rice was first introduced into the Virginia colony about 1609, and it was an established crop in the Carolinas by 1690. Major production has since shifted to the lower Mississippi Valley (principally Arkansas, eastern Texas and Louisiana) and to northern California. The more humid conditions of the Gulf Coast and Mississippi Valley areas are advantageous to rice production, requiring less irrigation water, which is becoming increasingly more difficult to provide in California. Immense fields are precisely flooded and drained to permit heavy equipment to prepare the land, plant the crop, and later harvest the grain in the field. Sometimes rice is sown, fertilized, and given pesticide protection by aircraft, especially in California. Elaborate research has elucidated soil behavior under irrigation and has determined optimum timing for fertilization under the anaerobic conditions that prevail in rice cultivation. Crop rotation is generally practiced, better to avoid physical deterioration of the soil and infestations of weeds and other pests.

Japan has the most progressive rice-growing practices in the Orient. Yields average more than 4 metric tons per hectare (about 2 tons per acre) and can be as high as 10 metric tons per hectare (about 4.5 tons per acre). Fertilization of rice fields in Japan is as intensive as on North American corn land (Fig. 2). A complete fertilizer is generally plowed down prior to flooding and hand planting of the seedling rice plants. Another topdressing is applied just before heading to increase yields. The fields are drained for harvesting and threshing, typically accomplished with small portable machines on the site. A green manure (vetch) is sometimes planted and plowed down. The paddy fields may also be used for a winter crop, such as barley, wheat, or rape.

Under more primitive circumstances, such as those that prevail in many tropical countries, rice growing is an exceedingly laborious and time-consuming hand operation. As noted in Fig. 2, even fertilization is quite limited in many places, although compost and sewage have been used since ancient times to fertilize paddy fields. Symbiotic nitrogen fixation by blue-green algae growing in association with the water fern *Azolla* commonly maintains fertility in Asiatic paddy fields.

Fig. 1. Paddy rice culture in the Philippines. [Photograph by Edwin B. Hoffman, courtesy World Bank.]

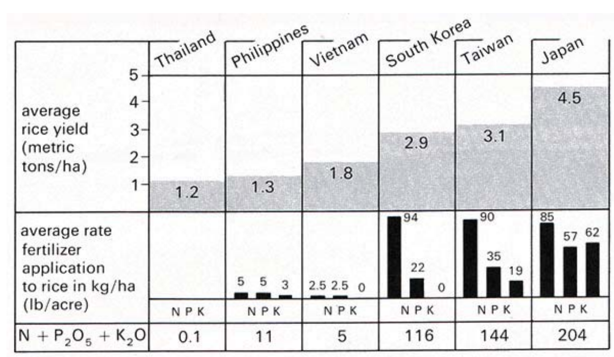

Fig. 2. Rice yields related to fertilizer usage in several Asiatic production areas. [After Kemmler, World Crops 14:117, 1962.]

Typically, after the paddy is flooded to soften the soil, the ground is worked, often by a water buffalo pulling a forked stick (small hand tractors may be used in more advanced countries, such as Japan). The rice seedlings are started elsewhere, sometimes under government auspices, and are transplanted by hand into flooded paddies, usually between November and January in Southeast Asia, to take advantage of the winter monsoon. Transplanting from a nursery allows for better weed control in the paddy, giving transplants an edge over paddy seedlings that could not be weeded. A few months later, depending upon length of season required by the cultivar, the paddies are drained and the stand is harvested-another laborious job, accomplished chiefly by women. The rice stalks are cut individually with a small, sharp sickle, banded together, and laid out in the sun to dry (Fig. 3). If there is sufficient water, either a second rice crop or some other crop may then be planted on the same land.

Various means are employed to clean and dehull newly harvested rice. In some countries the sun-dried heads are threshed in the field by treading, either by people or by livestock (of course, with considerable loss of grain). In Afghanistan, green rice is mixed with heated sand to harden and "crisp" the hulls, which are then separated by crude milling on water-powered devices that pound the grain against the soil. Screening and winnowing follow (Fig. 4). In Ecuador, much of the rice is fermented by massing it on the floor while it is damp and covering it with a tarpaulin for a few days. Upon subsequent drying it cooks more quickly than unfermented rice in the high altitudes of the Andes. Fermentation may also provide healthful by-products.

The processing that rice undergoes in the so-called advanced countries removes no small part of its nutrients. After the hulls are removed, the grain is polished to remove the brown outer layers, which are rich in protein and B vitamins. The insistence on a pearly white grain carries with it the penalty of reduced nutritional value.

An outstanding crop breakthrough has occurred in rice cultivation, thereby extending the "green revolution" begun by Norman Borlaug's work with Mexican wheats into the Oriental tropics. An extensive breeding program by the International Rice Institute in the Philippines has yielded improved cultivars, notably the double-recessive dwarf cultivar 'IR-8' and its pest-resistant successors, which are capable of markedly higher yields that can help to feed the dense populations of the Orient more adequately. 'IR-8' is a short, stiff-stemmed cultivar with an ample panicle that can be traced back to the maternal parent 'Cina'. It responds well to nitrogen fertilization.

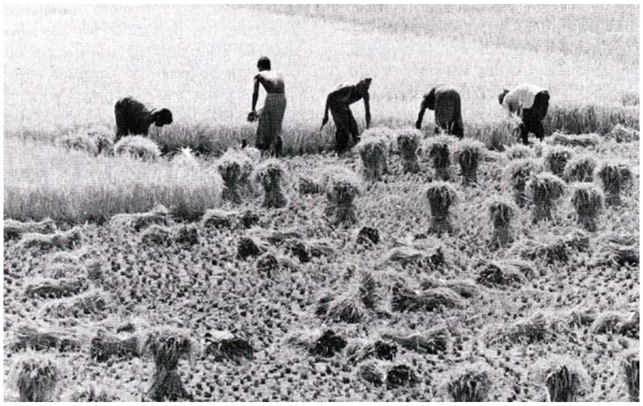

Fig. 3. The way most rice is harvested throughout the world. [Photograph by Tomas Sennett, courtesy World Bank.]

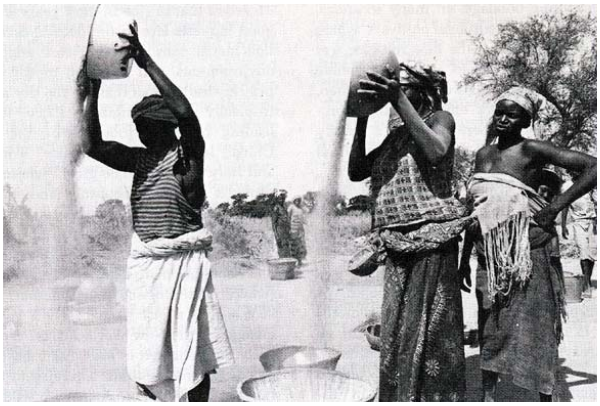

Fig. 4. Winnowing rice (to separate the grain from chaff and dust) in Upper Volta. Upland rice is grown in much of Africa. [Photograph by Ray Witlin for IDA, courtesy World Bank.]

The traditional taller cultivars would lodge if similarly fertilized for high yield. Although it is no longer widely planted, 'IR-8' is still very influential as an ancestor of most modern semidwarf rice cultivars. However, because so many modern cultivars bear 'Cina' maternal heredity, and thus have similar cytoplasmic inheritance, a potentially hazardous situation has been created that could conceivably lead to disease epidemics as devastating as the one that struck the U.S. corn crop in 1970.

The introduction of high-yielding cultivars has not eliminated all problems attendant to rice-growing. Their use has even brought about a few new complications. In the Philippines, for example, where almost 70% of the plantings are of improved types, the peasant landholder is often unable to afford fertilizer. Thus the introduction of high-yielding rice has proved a boon to the advantaged but not necessarily to the masses, who can become caught up in a web of economic bondage. In many locations, the growing season of the traditional cultivars, which is often different from that of the new releases, was more suitable for the established custom of double cropping. In less developed parts of the world, then, improved methods that work efficiently in technically advanced countries (where research is readily accepted by a well-informed farming population) may not live up to expectations.

Indeed, imposition of "improved" growing techniques in technologically less advanced countries is fraught with difficulties and hazards. In the 1970s an extensive government-sponsored rice-spraying program was undertaken in Indonesia. Insecticide was applied from the air to hundreds of thousands of hectares to control a stem borer (the larva of a moth) that was said to cost the nation one-quarter of its crop. Aerial spraying was decided upon because it was deemed unlikely that peasant growers could be induced to practice preventive spraying for an "invisible" affliction (the borers are susceptible soon after the eggs are laid on the leaf surface and before the larvae hatch out, enter the stem, and cause damage). A spot check of moth abundance was used to determine the best time for the spraying, which could be done only by trained personnel available through a government contract with a European firm. Spraying was correlated with an "extension" program that included provision of the fertilizer in exchange for a sixth of the crop. Apparently, rice yields were increased by 25% or more, but it is difficult to assess whether the savings (primarily manifested as reduced need for rice imports, although acquainting the peasant populous with improved technology is an intangible gain) justified the drain on the public purse that resulted from contracting for such a tremendous program. The influence on the local ecosystem of massive spraying such as this is seldom considered, and after the foreign technologists leave, most peasants slip back to the traditional way of doing things.