Rice Production and Nutrient Management in India

By K.N. Tiwari

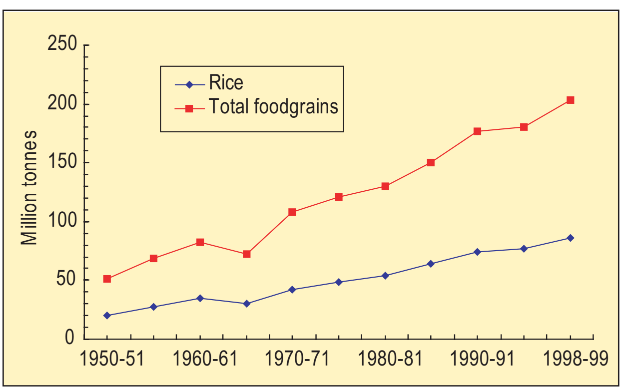
The demand for rice in India is projected at 128 million tonnes (M t) for the year 2012 and will require a production level of 3,000 kg/ha...significantly greater than the present average yield of 1,930 kg/ha. This low level of productivity can be increased substantially by growing high yielding varieties/hybrids and by increasing both the area under balanced fertilizer use and application rates.

India is the seventh largest country in the world by area, with 329 million hectares (M ha). It is also the second-most populous country (1 billion people). Demographers indicate that by 2012 India's population will reach 1.2 billion.

The net area sown is nearly 142 M ha, of which only 39 percent is irrigated, while the gross cropped area is approximately 189 M ha. There are about 106 million operational holdings with an average size of 1.57 ha. About 78 percent of the holdings are less than 2 ha, belonging to small and marginal farmers, and cover 32 percent of the total cultivated area. Despite this, the success of Indian agriculture has received worldwide appreciation as foodgrain production increased from 50.8 M t in 1950-51 to 203 M t in 1998-99.

The 189 M ha of cropped area is normally allocated accordingly: 126 M ha to foodgrain crops, including 44.6 M ha in rice, 26.0 M ha in wheat, 32.4 M ha in coarse cereals, and 23.3 M ha in pulse crops. About 63 M ha are planted to other crops. The 203 M t foodgrain production in 1998-99 was comprised of 86 M t of rice, 70.8 M t of wheat, 31.4 M t of coarse cereals, and 14.8 M t of pulses. Of the total rice area, only 51 percent is irrigated, so 49 percent is rainfed. Total foodgrain production has followed the ups and downs of rice production in India (**Figure 1**).

Figure 1. Rice versus total foodgrain production in India.



Rice continues to hold the key to sustained food security in the country, so even if rice production areas stabilize or register negative growth, future rice production targets must be achieved exclusively through yield improvement. Given many under and unexploited crop production technologies, sustainable productivity can be accomplished.

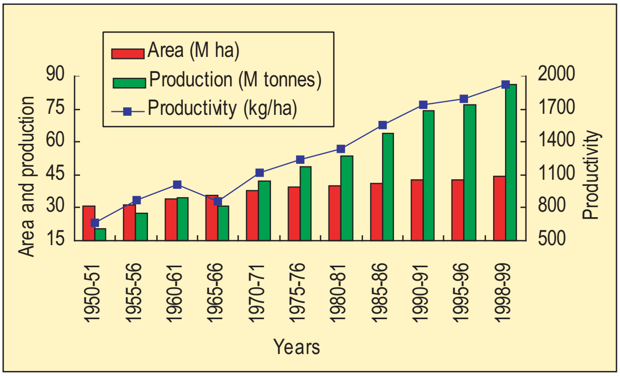


Figure 2. Area, production and productivity of rice in India.

Production – Productivity Growth

The state-wise area, total production, and productivity (i.e., average yield) of rice are given in **Table 1**. As shown in **Figure 2**, all three factors have changed over the past 50 years. Average rice yields vary from 1,010 kg/ha in Madhya Pradesh to 3,440 kg/ha in Tamil Nadu, with the national average being 1,930 kg/ha. Production and productivity have increased substantially from 1960 to 1990, while the area planted to rice has increased only slightly.

India is still amongst the countries with the lowest rice yields. Seventy percent of the 414 rice-growing districts report yields lower than the national average, clearly indicating that well after the advent of high yield technology, a sizable area is categorized as low producing. Sixty percent of the low productivity rice areas are in Bihar, Orissa, Assam, West Bengal, and Uttar Pradesh. Surprisingly, 32 percent of the irrigated rice areas produce low yields. Yield gap analysis further reveals that 30 to 40 percent of the potential yield is yet to be tapped with available high yielding varieties (HYV) sown on highly productive irrigated soils. This gap is likely due to degraded and less fertile soils, pockets of endemic pests and diseases, low input use, defective cropping systems, and a low adoption rate by farmers of high yielding technologies. Diagnostic and then corrective measures will substantially increase yield levels. Hence, the theory that low yields are a function of lack of irrigation (unlike in

Table 1. State-wise area, production, and yield of rice in India (1998-99).

State	Area, M ha	Percent of total area, %	Production, M t	Percent of total production, %	Yield, kg/ha
Andhra Pradesh	4.11	9.4	11.40	13.3	2,770
Assam	2.42	5.5	3.25	3.8	1,340
Bihar	5.10	11.7	6.63	7.7	1,300
Gujarat	0.62	1.4	1.02	1.2	1,640
Haryana	1.08	2.5	2.43	2.8	2,250
Jammu and Kashmir	0.27	0.6	0.59	0.7	2,180
Karnataka	1.43	3.3	3.60	4.2	2,520
Kerala	0.35	0.8	0.66	0.8	1,890
Madhya Pradesh	5.31	12.2	5.37	6.2	1,010
Maharashtra	1.48	3.4	2.47	2.9	1,670
Orissa	4.45	10.2	5.39	6.3	1,210
Punjab	2.52	5.8	7.94	9.2	3,150
Tamil Nadu	2.39	5.5	8.22	9.6	3,440
Uttar Pradesh	5.93	13.6	11.60	13.5	1,960
West Bengal	5.90	13.5	13.30	15.5	2,250
Others	1.24	1.0	2.08	2.4	1,680
All India	**44.60**	**100.0**	**86.00**	**100.0**	**1,930**

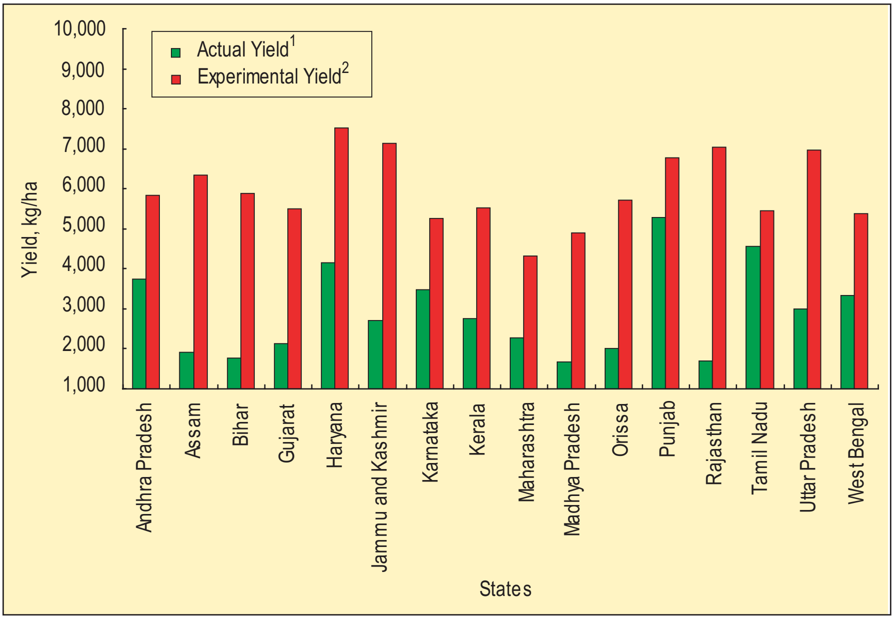


Figure 3. Yield gap between actual and experimental yields (irrigated), in India.
[1]Actual Yield = State Average Yield over Seven Year Period.
[2]Experimental Yield = Mean Yield of Best Entry at ACICRIP Test Locations over Seven Year Period.
Source: Siddiq, E.A. (2000) Survey of Indian Agriculture: The Hindu, p. 43.

China, Korea or Egypt, where over 95 percent of rice is irrigated) is not justifiable. India's yields even in irrigated fields are too low by comparison (i.e., 4.2 t paddy/ha in India compared to 6.1 and 8.3 t for China and Egypt, respectively).

Yield Gaps

Fortunately, instances of farmers harvesting yields as high as 8 to 10 t/ha occur throughout India. Rather than dismissing these as random occurrences, it would be wise to take them as pointers to what is achievable. The yield gap, derived as the percent difference between achievable (experimental) and average farmer yield in India reveals the bridgeable gap to be quite wide. With the exceptions of Tamil Nadu (15 percent) and Punjab (22 percent), it is in the range of 35 to 75 percent (**Figure 3**). If the gap itself were taken as an opportunity and research/development efforts to narrow it are given priority, the production target goal would be attainable.

To sustain the share of rice in total foodgrain production, as well as ensure sufficiency, minimum rice production and productivity required in 2006-07 are estimated as 100 M t and 2,450 kg/ha (based on a population growth at 1.9 percent and income growth at 5 percent). The production/productivity growth trend in the 1990s was one-half of realized gains in the 1980s. The zone-wise compound growth rate data given in **Table 2** indicate the range varying from 1.15 in

Table 2. Zone-wise compound growth of rice production and productivity in India.

	Annual compound growth, %		
Zone	1970-80	1980-90	1990-97
		Production	
East	0.10	6.51	1.90
North	6.81	5.03	2.11
South	2.04	2.19	1.15
West	0.69	1.42	2.34
India	1.98	3.63	1.84
		Productivity	
East	-0.02	4.06	1.97
North	-4.10	4.20	1.29
South	-0.98	2.88	0.80
West	0.41	0.96	2.12
India	-1.10	3.25	1.60

south to 2.34 in the west. Stable and high growth rates can be attributed to a) steadily increased adoption of high yielding varieties in rainfed systems, b) increased consumption of fertilizer nutrients, c) access to and timely availability of quality seed (largely facilitated through farmer to farmer spread from frontline demonstration sites), and d) adoption of production/protection practices.

Nutrient Management

Fertilizer responsive, high yielding rice varieties developed in the 1960s made it possible to produce 7.5 to 10 t of plant biomass per hectare per year. Initially, this level of production was sustained by nitrogen (N) fertilizer additions with soil and manure being the other nutrient sources. Within a few years, applying only N gradually exhausted nutrient reserves in many soils, making it impossible to produce high yields. There is now a large mass of experimental data (on-farm as well as on-station) showing that application of N, phosphorus (P), and potassium (K) fertilizers produce higher yields than either the application of N or N and P. The contribution of P and K to yield is substantial and proves that India's soils generally suffer from multi-nutrient deficiencies. Productivity, therefore, can only be sustained by planned applications of nutrients that the soil cannot provide.

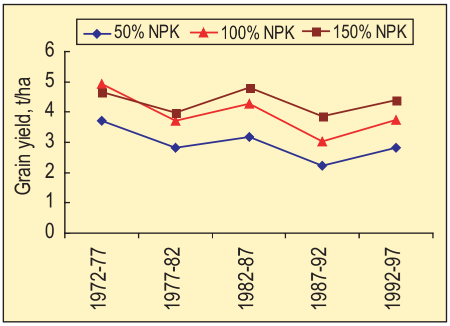


Figure 4. Long-term data (25 years) on rice yield in the alluvial zone of West Bengal with a jute-rice-wheat cropping sequence. Source: Saha et al. 1998. Long Term Fertilizer Experiments Proceedings.

Long-term fertilizer experiments clearly show a) intensive cropping with only N input is a short-lived phenomenon, b) omission of a nutrient (be it macro or micro) leads to progressive deficiency as a result of removal by the crop, c) sites initially well supplied with P, K or sulfur (S) become deficient when continuously cropped using N alone or S-free fertilizers, and d) fertilizer doses previously considered as "optimum" result in soil nutrient depletion because of high productivity levels.

As an example, data from a jute-rice-wheat cropping sequence in an alluvial soil from West Bengal (**Figure 4**) indicate the present state-recommended dose of NPK was inadequate to sustain optimum yields in an intensive cropping system. The results of long-term fertilizer experiments conducted with rice-based cropping system at several stations confirm the inadequate nature of so-called 'optimum' fertilizer recommendations (**Table 3**). Results of hybrid rice experiments conducted at C.S. Azad University of Agriculture and Technology, Kanpur, taking into consideration all

Table 3. Sub-optimal status of optimum fertilizer recommendations, India.

	Mean rice grain yield (1972-96), t/ha		
Location	Optimum NPK	1.5 x Optimum	Extra yield, %
Barrackpore	4.0	4.4	+11
Bhubaneswar	3.0	3.3	+11
Hyderabad	3.6	4.3	+19

Source: Swarup, A. (1998), Long Term Fertilizer Experiments Proceedings.

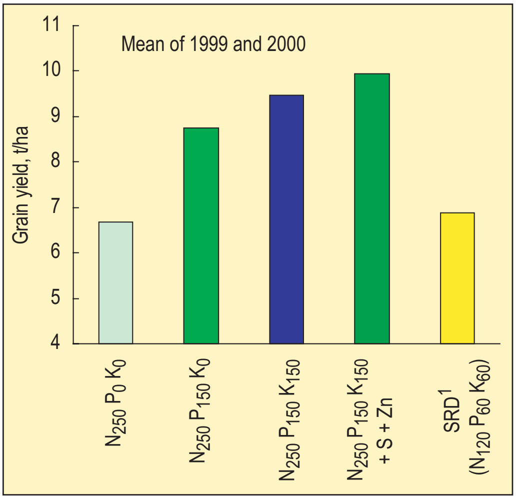


Figure 5. Effect of balanced fertilization on grain yield (paddy) of hybrid rice in Gangetic alluvium of Uttar Pradesh. Source: Pathak, R.K. 2000. Annual Report PPIC–IP Sponsored Research Project. [1]State recommended fertilizer dose (N_{120} P_{60} K_{60}).

nutrient deficiencies, reveal that yields of nearly 10 t/ha can be obtained through site-specific nutrient management involving the use of 250-150-150-40-5 kg N-P_2O_5-K_2O-S-zinc (Zn)/ha. The yield obtained with the state recommended fertilizer dose ($N_{120}P_{60}K_{60}$) was only 6.87 t/ha (**Figure 5**).

From these various research and demonstration trials, it can be concluded that: (a) efficient nutrient management in high yielding rice varieties/hybrids substantially increases the crop's productivity and (b) the current general use of P and K is very low and to the point where P and K requirements by rice exceed total fertilizer consumption. To achieve rice production targets by 2012, balanced and adequate use of P and K fertilizers as well as N, S, and Zn is essential.

Yield plateauing in irrigated areas has necessitated turning the focus to rainfed rice ecology. Improved rice production and productivity in rainfed areas may not only help the resource-poor farmers, but also substantially increase food production. Eastern India is the major rice-growing region of the country. It accounts for about 63 percent of the total rice-cropped area, but produces only 48 percent of the total yield.

About 80 percent of the rice area of eastern India is rainfed and exposed to abiotic stresses such as drought, low soil fertility, flood, and stagnant water. Farmers do not want to spend scarce resources on fertilizers and generally apply only N fertilizers. Thus, yields are constrained by poor soil fertility, leading to nutrient deficiencies and low income for farmers.

It has now been well established that rice in rainfed areas responds well to P and K applications which provide drought and disease-pest resistance to the crop. In fact, even in rainfed areas, extensive over-exploitation of soil nutrient reserves has already occurred. Therefore, to increase productivity under rainfed conditions, balanced fertilization would be essential and inevitable. There is urgent need to educate farmers about the importance of balanced use of fertilizers in increasing yields and profits in rainfed rice ecology. **BCI**

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