Rice Production and Fertilization in China

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Cooperative field research during the last two decades has quantified the contribution of balanced fertilization practices for rice in China. Despite large improvements in yield and quality, it is clear that great potential still exists.

Rice is a major grain crop grown in China…the country is the world's leader in rice production. The area sown to rice in 1999 was 31.3 million hectares (M ha). This land accounts for 28 percent of China's total grain crop area and 39 percent of the country's total grain production (**Table 1**).

The area sown to rice has been relatively stable since 1980. However, total paddy production has increased from 139 million tonnes (M t) in 1980 to 198 M t in 1999 (42 percent increase). The yield per hectare increased from 4,120 kg in 1980 to 6,345 kg in 1999 (54 percent increase), contributing greatly to the increase in total grain production in China.

Many factors have contributed to this stable increase of rice yield and production during the last 20 years. Increased fertilizer input and improvements in fertilization technology are considered as keys to this success. From 1980 to 1999, total inorganic fertilizer consumption in China increased from 12.7 to 41.3 M nutrient tonnes. Considering a total arable land area of 133.3 M ha with a multi-cropping index of 156 percent (total sown area is 208 M ha), the average plant nutrient application rate from inorganic fertilizer in 1999 was estimated as 198 kg/ha.

There is no official information available in terms of fertilizer use by crops in China. In 1996, the Soil and Fertilizer Institute of the Chinese Academy of Agricultural Sciences conducted a fertilizer use survey among nearly 2,000 farmers in seven representative provinces. Most cropping systems were represented, including those involved in rice production. The survey indicated that farmers paid good attention to fertilizer

Table 1. Rice production in China from 1980 to 1999.

	1980	1985	1990	1995	1999
Sown area, M ha	33.8	32.1	33.1	30.7	31.3
Percent of grain crop area	29.0	29.5	29.1	27.9	27.7
Production, M t	139.0	169.0	192.0	185.2	198.0
Percent of grain production	43.8	44.5	42.3	39.7	39.0
Yield, kg/ha	4,120	5,250	5,800	6,020	6,340

Source: China Agriculture Year Books.

Table 2. Average rice yields and fertilizer rates in selected provinces in 1995.

Province	Rice type	N	P_2O_5	K_2O	Total	N:P_2O_5:K_2O ratio	Yield, kg/ha
		kg/ha					
Guangxi	Early	200	51	119	366	1.7:0.4:1	6,300
	Late	179	46	110	329	1.6:0.4:1	4,720
Hubei	Early	157	50	45	232	3.5:1.1:1	5,290
	Late	160	48	54	232	3.0:0.9:1	6,030
	Mid	178	59	61	263	2.9:1.0:1	6,930
Jiangsu	Mid	274	68	56	348	4.9:1.2:1	7,640
Jilin	Mid	217	69	66	315	3.3:1.0:1	8,560
Shaanxi	Mid	227	67	69	278	3.3:1.0:1	7,860
Shandong	Mid	215	58	66	335	3.2:0.9:1	7,050
Sichuan	Mid	152	63	61	211	2.5:1.0:1	7,530
Average		196	58	71	291	2.8:0.8:1	6,790

Source: Liu Rongle, 2001.

use in rice production. The mean weighted average use of plant nutrients by the surveyed farmers was 291 kg/ha for their rice production, which is significantly higher than the 198 kg/ha of plant nutrients for the country average (**Table 2**).

Nitrogen (N) fertilization rates were found to vary greatly from province to province, ranging from 152 kg/ha in Sichuan to 274 kg/ha in Jiangsu, the surveyed province with the most developed rural economy. A relatively small variation in terms of phosphorus (P) application rates was found among the provinces and rice types, with average P_2O_5 rates ranging between 46 to 69 kg/ha. As for potassium (K), farmers in Guangxi used more K than other provinces, probably due to low soil K levels and the effect of a longer history of good K-promoting educational activities targeted at farmers in this region. Guangxi was where the Canpotex balanced fertilizer demonstration program was initiated. It was successful in showing large numbers of farmers, government officials, and others the benefits of including appropriate rates of K in a balanced fertilizer crop production system.

The N:P_2O_5:K_2O ratios varied widely, in the range of 1.6-4.9:0.4-1.2:1 among the various provinces and rice systems. The average ratio was 2.8:0.8:1, although the ratios recommended by the local agricultural technicians were in the range of 1.2-2.5:0.3-0.6:1. This indicates significant opportunities for further improving balanced fertilization in rice, especially by increasing P and K use to increase yields and quality (**Table 2**).

To improve agricultural production through balanced fertilization technology, the PPI/PPIC China Program began cooperative research and educational activities with Chinese institutions through coordination by the Ministry of Agriculture (MoA) and financed jointly by Canpotex and the Canadian International Development Agency (CIDA). Initiated in 1982 in two southern provinces, this cooperative effort expanded to all mainland provinces and covers more than 40 different crops, including rice-based cropping systems in both the southern and northern regions of China.

In the 1980s, a total of 1,858 field

Rice growth response to K is shown in plot at left, compared to no-K plot at right, in Heilongjiang.

trials on balanced fertilization on rice were conducted and results summarized. An average 11.5 percent yield increase was achieved by applying 50 to 90 kg K_2O/ha to the traditional N and P rates used by farmers. Average yields in the NP treatment ranged from 4,500 kg/ha to 6,500 kg/ha, meaning that one kg K_2O increased paddy yield by 5 to 10 kg.

By the early to mid 1990s, rice yields had generally increased, the result of improved varieties and other management practices. At the same time, it was recognized that the agronomic requirement for balance among fertilizer nutrients demanded increased rates of P and K to assure high rice yields of good quality.

Results of the PPI/PPIC China Program cooperative fertilization trials on rice are summarized in **Table 3**. Average of best yields achieved with all plant nutrients balanced and the corresponding N, P_2O_5, and K_2O fertilizer rates and ratios, as well as average net benefit of K fertilizer use, are noted.

Results clearly indicated that overall rice production and farmer income were significantly improved by balanced fertilization. The average best yields achieved with balanced NPK fertilization for rice grown in southern China, regardless of planting season, increased substantially. Omitting K (NP treatment) from the balanced fertilization treatment resulted in significant paddy yield reductions of 13, 22, and 9 percent for early, late, and middle rice, respectively. Average paddy yield of all trials (including early, late, and middle season rice) with the best treatments was 8,150 kg/ha, with a 13.3 percent yield reduction if K was not used. The average net benefit from K application ranged from 459 Chinese yuan (RMB) per hectare for middle season rice to 1,690 RMB/ha for late season rice (8.2 yuan = US$1).

To achieve high yield rice production, rational input of inorganic fertilizers is a key management practice. The weighted mean of N,

Table 3. Rice yield responses to balanced fertilization in the 1990s in China.

Region	Rice type	Fertilizer use, kg/ha N-P_2O_5-K_2O	N:P_2O_5:K_2O	Paddy yield, kg/ha NP	NPK	Yield increase %	kg paddy/kg K_2O	Net benefit RMB/ha[2]
South China	Early (32)[1]	142-57-161	0.9 : 0.4 : 1	6,610	7,500	13.3	5.1	569
	Late (23)	188-66-198	0.9 : 0.3 : 1	8,230	9,970	21.7	8.7	1,690
	Mid (42)	194-96-171	1.1 : 0.6 : 1	7,070	7,650	8.8	3.3	459
	Mean (97)	176-76-174	1.0 : 0.4 : 1	7,197	8,150	13.3	5.2	796
North China	Rice (16)	202-112-127	1.6 : 0.9 : 1	6,700	7,801	16.3	10.7	1,515
	Grand mean (113)	179-81-168	1.1 : 0.5 : 1	7,130	8,102	13.8	5.9	1,030

[1]Numbers in parentheses indicate the number of trials conducted.

[2]Average prices of early, late, and middle rice from the south and rice from the north were 1.0, 1.2, 1.4, and 1.6 RMB/kg, respectively; cost of K_2O was 2.0 RMB/kg.

Source: PPI/PPIC China Program.

In demonstration plots in Liaoning, rice with balanced fertilization (at right) showed superior growth compared to usual farmer practice (at left).

P_2O_5, and K_2O rates in the best treatments from southern China were 176, 76, and 174 kg/ha, respectively. With a ratio of 1.0:0.4:1 (**Table 3**), these rates were much more balanced than farmer practice (survey data), with a ratio of 2.8:0.8:1 (**Table 2**). As a result of rational rates and balanced use of inorganic fertilizers, yield and farmer profit were remarkably improved (**Table 3**).

Balanced fertilization field research on rice in northern China did not begin until the early 1990s. Results show that an average best yield of 7,800 kg/ha using soil test-based balanced fertilization recommendations required 202 kg/ha N, 112 kg/ha P_2O_5 and 127 kg/ha K_2O, giving a ratio of 1.6:0.9:1 (**Table 3**). Omitting K from the balanced fertilization treatment resulted in a 16 percent yield reduction. Stated another way, one kg of K_2O produced 10.7 kg of paddy grain. The average net benefit from K application in the north was 1,515 RMB/ha.

The approach taken by PPI/PPIC in developing the balanced fertilization technology was to use soil testing as a basis for identifying all plant nutrient deficiencies and assuring these nutrients were applied. Since this is a site-specific technology, it must be made clear that fertilization practices at the different sites reported in these discussions were not equal.

As well, secondary and micronutrients were applied as needed. It is important to note that it is highly unlikely that the magnitude of yields obtained would have been achieved had these additional plant nutrients not been applied. Unpublished data in reports of field trials at the various sites support this statement.

In summary, it is clear that great potential remains to further increase rice production in China through adoption of improved fertilization techniques. If the research evidence had been implemented and 10 percent higher yield levels achieved, in 1999 China would have produced an extra 20 M t of rice (a production value of 28 billion RMB). Current PPI/PPIC China Program activities are highlighting the transfer of fertilizer technology to farmers since it is obvious this message has not been received on a widespread basis. **BCI**

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