

Case Study 9.1-4 Managing fertilizer phosphorus by soil test level improves food production and environmental performance in China.

China is a country with a large population and a limited land resource. To ensure food security and sustained increase in crop production, China has paid strong attention over the past 60 years to building up soil fertility.

With a history of several thousand years of reliance on soil organic matter and recycling of crop residues as nutrient sources for maintaining soil fertility, by the early 1950s most arable land in China was low in fertility and had low crop productivity. Since then, use of N fertilizer became a common practice and crop yield increased, removing more P and other nutrients from the soil. Since a large portion of crop-absorbed P is in the harvested part (about 80% for grain crops), soil P was quickly depleted, and low soil P became a severe yield-limiting factor for crop production. By the 1980s, based on the results of the second national soil fertility survey, about 48% of the arable land was very low in Olsen P (below 5 mg/kg), and another 30% was considered low (below 10 mg/kg).

Given that soil P condition, and with the national objective to ensure food security and to build up soil fertility, P fertilizers became an important part of the fertilization program throughout China, starting from the south and gradually spreading to the north. It has been estimated that from 1981 to 2000, a total of about 133 million metric t of P_2O_5 has been applied to arable lands in China as chemical fertilizers. Assuming the accumulated utilization rate (recovery efficiency) of that applied P was 50%, about 480 kg/ha P_2O_5 accumulated in the soil, on average. If organic P sources were taken into consideration, the P accumulation in the soil would be even greater (Li, 2003).

The overall soil P balance (i.e. P input – P output) changed quickly after the extended period of large negative balances that continued from the 1950s into the 1960s and 1970s. By the 1980s, the P balance in arable lands became positive and P began to accumulate in soils. It has been estimated that soils in China received a P surplus of about 79 kg P_2O_5 /ha in 2005. With this high P balance in soil-crop systems, it was expected that available soil P would build up gradually and that soil P fertility would be improved. Although there is no direct national survey data to verify this, it is now generally believed that the percentage of total arable land with P deficiency (i.e. Olsen P level below 10 mg/kg) has declined to less than 50%. The results of P analyses performed by the CAAS-IPNI Soil and Plant Analysis Laboratory on 43,156 soil samples collected from 1991 to 2007 also showed that 48% of soils tested were deficient in P.

In recent history, the high rate of P fertilization helped China to increase crop production and to build up soil P fertility. However, at the same time, with the increased accumulation of P in the soil, the risk of P losses from crop land and its effect on the environment cannot be ignored. Although there is only limited information available about the contribution of P losses from crop land to surface water pollution, it has been reported that 14% to 68% of the total P in selected lakes came from agricultural lands (Li, 2003).

With these changes in soil P fertility levels in China, for both economic and environment benefits, the following points may be considered when strategy for P fertilization is developed:

1. Application strategy for P should be according to soil test. Apply enough to build soil P levels when the Olsen soil test is below 20 mg/kg for most crops. Replenish crop removal on soils above this level, and apply no P on soils with very high levels of soil test P.
2. For all conditions, attention is needed to control soil P losses through soil erosion.
3. A P fertilizer program should be developed for the entire crop rotation with attention to increasing overall P fertilizer use efficiency. Pay attention to long-term accumulated P recovery efficiency for different cropping systems.
4. Realize that different crops (i.e. vegetables vs. grain crops) have different requirement for soil P levels. Different critical levels of soil test P for different yield levels may also need to be identified.



Soybean response (right) to P due to an “optimum” (OPT) fertilization treatment applied in Heilongjiang Province, Northeast China.

The change of fertilizer efficiency in China followed the Law of Minimum and other related principles in plant nutrition. Before the 1950s, Chinese farmers mainly used organic manures to maintain the nutrient balance in soil/crop systems with relatively low production capacity. After the 1950s, with increase of crop yield and increased use of N and P, higher crop removal of K resulted in depletion of available K in the soil and negative balances for K in soil/crop systems. Based on the study and nutrient balance estimated by Li Jiakang in 2003, the input-output balance of N and P in the soil/crop system turned from negative to positive in the mid 1980s, but the balance for K was still negative in 2000 (**Table 1**).

Table 1. Nutrient input-output balance in agricultural land in China (in 1,000 tonnes).

		Year	1965	1975	1985	1995	2000
	Organic Manure	N	2,930	4,100	5,030	6,110	6,520
		P ₂ O ₅	1,380	1,940	2,560	3,300	3,440
		K ₂ O	3,060	4,620	6,210	7,600	8,320
	Inorganic Fertilizer	N	1,210	3,640	12,590	22,240	25,140
		P ₂ O ₅	550	1,610	4,190	10,350	9,730
		K ₂ O	3	130	980	3,360	6,590
Output		N	5,220	7,490	11,140	13,730	16,620
		P ₂ O ₅	2,370	3,340	4,790	5,770	6,640
		K ₂ O	5,600	8,130	12,080	14,550	17,390
Balance		N	-1,690	-1,570	190	3,500	2,470
		P ₂ O ₅	-600	-280	710	4,890	3,610
		K ₂ O	-2,540	-3,380	-4,890	-3,550	-2,480

Source: Li Jiakang et al. 2003.

References

- Jin, J. Y. 2008. In Li, H.D. (ed.) “Plant Nutrient Management in Sustainable Agriculture.” Jiangxi People’s Press. Nanchang, China. p 9-18.
- Lu, R. 2003. “Phosphate and Compound Fertilizer”, Vol 18, No 1, 4-8. (in Chinese)
- Li, J., B. Lin, and G. Liang. 2003. In Lin Bao (ed.) Chemical Fertilizer and No-pollution Agriculture. China Agriculture Press. 2003, 175-188. (in Chinese)

Submitted by J. Jin, IPNI, China, January 2012.