India's Soil and Crop Need for Potassium

By K.N. Tiwari

The need and importance of potassium (K) for producing crops with high yields and superior quality is greater than ever before. The first stage of implementing a balanced fertilization strategy is using, at the very least, the recommended rates of K along with other needed nutrients. At the same time, steps must be initiated to take a fresh look at the current approach and methodology for making K recommendations. These should primarily address the need for using soil- and crop-specific limits of available soil K. The recommendation system should support above average yields as well as provide progressive farmers with greater income opportunity.

Potassium consumption in India was 1.7 million tonnes (M t) in 2000, about one-seventh of the country's nitrogen (N) consumption. In the entire history of fertilizer use in India, K has been approximately 10% of total NPK usage (**Tables 1 and 2**), although K removal by crops accounts for 16.5 M t or 55% of total NPK uptake and annually exceeds N removal.

Even though India is the world's third largest fertilizer user, the current average rate of nutrient application is 96 kg/ha. This is indicative of only a few well-fertilized areas, whereas the majority of farmland receives very small rates of application. Country statistics show that of all 466 agricultural districts, 65% use less than 100 kg $N+P_2O_5+K_2O$, 28% use between 100 to 200 kg $N+P_2O_5+K_2O$, and 7% use greater than 200 kg $N+P_2O_5+K_2O$. Tapping into this potential market requires an area-wise constraint analysis to determine why fertilizer use patterns are so highly skewed.

Both food and therefore fertilizer needs of India are expected to increase consistently in the decades ahead. The net cropped area has more or less stabilized at 143 M ha. By contrast, India's population—

Table 1. Trends in fertilizer consumption in India.

Year	Consumption, thousand tonnes			
	N	P_2O_5	K_2O	Total
1959-1960	229	54	21	305
1969-1970	1,360	416	210	1,980
1979-1980	3,500	1,110	590	5,120
1989-1990	7,250	2,720	1,070	11,000
1999-2000	11,600	4,800	1,700	18,100

Source: Fertilizer Association of India (FAI) Fertilizer Statistics

Table 2. Trends in fertilizer application in India.

Year	Consumption, kg/ha			
	N	P_2O_5	K_2O	Total
1959-1960	1.5	0.4	0.1	2.0
1969-1970	8.4	2.6	1.3	12.3
1979-1980	20.6	6.8	3.6	31.0
1989-1990	40.5	16.5	6.4	63.4
1999-2000	61.3	25.4	9.0	95.7

Source: FAI Fertilizer Statistics

now over 1 billion—is expected to grow by 14 to 15 million each year. Each hectare of net sown area, which currently supports more than seven persons, will need to become more productive in the future.

India's highest policy-making body has projected annual food grain requirement at 337 M t by 2011/12 (**Table 3**). Agricultural policies, in spite of their aberrations and inconsistencies, have always depended on planning for adequate and sometimes exaggerated amounts of fertilizer to meet agricultural production targets. Currently, available estimates are for 30 M t of N+P_2O_5+K_2O by 2006/07 and 45.5 M t by 2011/12. If one examines the past trends in growth of fertilizer consumption, it becomes apparent that these targets will require massive efforts in production, importation, distribution, and application to become a reality. Fertilizer consumption increased by 3.1 M t during the decade of the 1970s, by 5.9 M t during the decade of the 1980s, and by 7.1 M t during the decade of the 1990s. The Planning Commission target of 45 M t translates into 2.5 times present levels of consumption. Will fertilizer use increase by 27 M t in the next 12 years?

Table 3. Some projections on agricultural production and fertilizer consumption in India.

Commodity	1999-2000, M t	2011-2012 Target, M t
Rice	86.0	128
Wheat	70.8	130
Coarse grains	31.4	48.9
Pulses	14.8	29.8
Total food grains	203	336.7
Oilseeds	25.2	58.9
Sugarcane	296	680
Fertilizer consumption, N+P_2O_5+K_2O	18.1	45.5

Source: Fertiliser Statistics (FAI) and Planning Commission of India.

The Fate of Balance

Balanced fertilizer use at the macro level in India is equated with the N:P_2O_5:K_2O consumption ratio of 4:2:1—a nominal requirement for grain-based agricultural systems whose crop residues are returned to the field. This ratio has been accepted for almost half a century, but is considered outdated by many scientists.

Table 4 ranks the major agricultural states of India in order of

Table 4. Ranking of Indian states according to degree of N:K_2O imbalance at two N:K_2O ratios (departure from 4:1and 2:1 ratio).

State	K_2O consumption taking N=100[1]	Departure from 25 taking N=100 (4:1)	Departure from 50 taking N=100 (2:1)
Haryana	0.7	-24.3	-49.3
Rajasthan	1.1	-23.9	-48.9
Punjab	2.1	-22.9	-47.9
Jammu & Kashmir	2.8	-22.2	-47.2
Uttar Pradesh[2]	4.1	-20.9	-45.9
Madhya Pradesh[2]	7.0	-18.0	-43.0
Bihar[2]	8.8	-16.2	-41.2
Gujarat	9.7	-15.3	-40.3
Andhra Pradesh	13.6	-11.4	-36.4
Himachal Pradesh	14.5	-10.5	-35.5
Maharashtra	19.2	-5.8	-30.8
Orissa	21.2	-3.8	-28.8
Karnataka	30.4	5.4	-19.6
West Bengal	35.1	10.1	-14.9
Assam	36.2	11.2	-13.8
Tamil Nadu	46.1	21.1	-3.9
Kerala	82.5	57.5	32.5
North Zone	3.1	-21.9	-46.9
West Zone	10.8	-14.2	-39.2
East Zone	21.2	-3.8	-28.8
South Zone	27.4	2.4	-22.6
All India	12.9	-12.1	-37.1

[1] Average of three years 1997-2000, [2] State before division. Data source: FAI Fertilizer Statistics

Table 5. Nitrogen and K response ratio (kg/kg) of crops in long-term fertilizer experiments: 1973-77 vs. 1992-96.

Location (Soil) and cropping system	Nitrogen		Potassium	
	1973-77	1992-96	1973-77	1992-96
Palampur (Alfisol)				
Maize	14.6	-1.6	2.4	20.0
Wheat	4.3	-3.1	3.6	13.2
Ranchi (Alfisol)				
Soybean	-10.4	-8.1	4.1	20.6
Wheat	-7.8	-1.4	1.0	15.9
Coimbatore (Inceptisol)				
Fingermillet	3.1	5.4	-11.4	13.4
Maize	1.7	-1.3	-1.3	14.5
Bhubaneswar (Inceptisol)				
Rice (kharif)	6.7	2.6	6.9	8.2
Rice (rabi)	11.2	3.2	2.7	5.5
Jabalpur (Vertisol)				
Soybean	26.0	8.4	2.9	13.7
Wheat	7.0	0.5	8.4	6.0

Source: Swarup, A. and Srinivasa Rao Ch. (1999) Fert. News 44(4): pp 27-30, 33-40 & 43.

departure from the traditional 4:1, and for a more contemporary comparison 2:1 ($N:K_2O$) ratios. That is, the degree of imbalance with respect to K. All major states except five have a ratio wider than 4:1. However, all states have ratios wider than 2:1. Among geographical zones, $N:K_2O$ ratios are relatively greater in the north and west zones as compared to the south and east. That unbalanced plant nutrient application is widespread in India is apparent from this data, but throughout the intensively cultivated, irrigated Indo-Gangetic plains, which contributes a large share of the total food grain production.

Concern for Soil Nutrient Depletion

The major reason for soil nutrient depletion is unbalanced fertilizer application—large N applications without matching amounts of other nutrients, particularly K. Farmers in many areas are, in effect, using N fertilizer as a 'shovel' to mine soil reserves of other nutrients, particularly K, P, and sulfur (S), and in several cases micronutrients as well. It is the depletion of nutrients that has resulted in progressively larger increases in crop response to K with the passage of time (**Table 5**).

Mining of India's soil K reserves continues at an alarming pace. One of the greatest obstacles is the continuation of a pre-1960s mindset that most Indian soils are well supplied with K and thus do not need K application. It is often forgotten that soil K levels which support crop yields of 1 to 2 t/ha may not be capable of supplying a 5 to 7 t/ha crop yield. The alarming situation is that in many cases, even the recommended rates of fertilizer application result in soil nutrient depletion because they turn out to be sub-optimal for supporting the high-yielding, intensive cropping systems that will be required in the future (**Table 6**).

Table 6. Sub-optimal status of official state recommendation for NPK application rates (example: wheat).

Location	Mean grain yield (1971-87), kg/ha State NPK rec.	1.5 x State rec,	Extra yield, %
Barrackpore	2,300	2,900	+26
Delhi	4,300	4,700	+9
Jabalpur	3,800	4,200	+11
Palampur	2,600	3,100	+19
Pantnagar	3,900	4,500	+15

Source: Nambiar, KKM (1994) ICAR-AICRP-Long Term Fertilizer Experiments.

The state of Punjab, which has one of the widest $N:K_2O$ ratios, estimated K removal by the crop is 709,000 t or 38 times the amount of K_2O applied through fertilizer. In fact, K removal in Ludhiana district alone is seven times the entire state's consumption. Looked at in different ways,

Table 7. Distribution of projected fertilizer consumption in India among N, P, and K, according to three ratios of $N:P_2O_5:K_2O$ consumption.

	2006/07, M t			2011/12, M t		
Nutrient	6.8:2.8:1 (current pattern)	4:2:1	2:1:1	6.8:2.8:1 (current pattern)	4:2:1	2:1:1
N	19.2	17.1	15.0	28.9	25.7	22.5
P_2O_5	7.9	8.6	7.5	11.9	12.9	11.2
K_2O	2.8	4.3	7.5	4.2	6.4	11.2
Total	30.0	30.0	30.0	45.0	45.0	45.0

K removal is 1.4 times N removal, and K addition is less than 2% of N applied. Punjab soils show an annual depletion of 100 kg K_2O/ha, an alarming situation for the country's most intensively cropped state and leading food grain producer. Punjab unfortunately mirrors the situation in much of the Indo-Gangetic belt, including Haryana, Uttar Pradesh, and Bihar.

Soil nutrient depletion may not be as critical in the short term, but in the medium to long term it has grave implications...(i) more acute and multiple plant nutrient deficiencies, (ii) reduced fertilizer use efficiency and returns from fertilizer application, (iii) weakened foundation for high-yielding sustainable farming, and (iv) very high remedial costs for rebuilding depleted soils.

Opportunities and Strategies

While the projection for large increases in fertilizer use offers equally large opportunities, the "hidden" challenge lies in changing the ratio in which plant nutrients must be used. Scientific knowledge tells us that crop output from an unbalanced 45 M t of nutrient use (2011/12 projection) can be obtained with smaller tonnage, but with better balance among $N:P_2O_5:K_2O$. Serious initiatives must be implemented to break the psychological barrier of 4:1 as the ideal $N:K_2O$ ratio in the Indian mindset, particularly among central and state government personnel. This will not be easy as consumption has not even reached the 4:1 ratio and further fertilizer projections are not aimed at narrowing this ratio. At 30 M t $N+P_2O_5+K_2O$ in 2006/07 and 45 M t in 2011/12, three different patterns of N, P, and K use are based on: (i) the current consumption pattern of 6.8:2.8:1, (ii) the traditional 4:2:1 ratio, and (iii) a more progressive 2:1:1 ratio (**Table 7**).

Using 2006/07 as an example, the distribution of 30 M t nutrient in a 4:2:1 ratio will save the farmers and the country US$300 million annually when compared to continuing with the currently prevalent wide ratio of 6.8:2.8:1, simply by substituting a part of the costlier N with less expensive K_2O while narrowing the nutrient ratio. The benefits of narrowing the plant nutrient ratios are thus agronomic, economic, and ecologically sound because of higher N-use efficiency. Appropriate initiatives are needed quickly and on a large-scale if the goal of balanced plant nutrient application is to be achieved for India. **BCI**

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Dr. Sam Portch Honored with Friendship Award in China

Dr. Sam Portch, PPIC Vice President (retired), PPI/PPIC China and India Programs, recently received the prestigious "Friendship Award" which recognizes foreign experts who have made outstanding contributions to economic construction and social development in the People's Republic of China (PRC). The State Administration of Foreign Experts Affairs (SAFEA), authorized by the State Council of the PRC, first established the Award in 1991. The annual presentation ceremony in Beijing took place before China's National Day, October 1. Dr. Portch was one of only 51 individuals receiving the Award in 2002, representing 17 countries. An estimated 440,000 foreigners are working in China.

Dr. Sam Portch, at left, accepts the Friendship Award from Mr. Qian Qichen, Vice Premier of the State Council, PRC, during the ceremony in Beijing.

The Award was presented by Mr. Qian Qichen, Vice Premier of the State Council, on the occasion of the 53rd anniversary of the founding of the PRC. Mr. Zhu Rongji, Premier, also congratulated the recipients. The leaders commended the foreign experts for their contributions to China's social development and economic, scientific, technological, educational, and cultural construction. Mr. Qian stated that with a population of 1.3 billion, China's stability and prosperity is of great significance to the civilization, peace, and development of the whole world.

Dr. Portch is a well-respected leader, working in international agriculture for more than 35 years with government agencies and the private sector. He joined PPI/PPIC in 1988 and directed the agronomic research and education programs of the Institute in China since 1989. Based in Hong Kong, he traveled to all regions of China.

In accepting the award, Dr. Portch acknowledged the PPI/PPIC China Program staff, PPI/PPIC offices in North America, companies and government agencies who support the Institute's programs, the Chinese Academy of Agricultural Sciences, the Ministry of Agriculture, and cooperation of provincial institutions, extension personnel, farmers, and others who have helped achieve more balanced fertilization programs.

"I accept this honor on behalf of all who have cooperated for the progress of agriculture in China. It is this group of many that won the award," Dr. Portch said. **BCI**