The Changing Face of Balanced Fertilizer Use in India

By K.N. Tiwari

For India, there is an urgent need to narrow the wide ratio between nitrogen (N) and phosphorus (P) and potassium (K) consumption by stepping up P and K usage, which suffered markedly during much of the 1990s. By doing so, food security will be safeguarded and agricultural practices will be more sustainable. India would need about 25 million tonnes (M t) of NPK in addition to 10 M t of organic and bio-fertilizer sources to produce about 246 M t of foodgrain required by 2010.

India's introduction to fertilizer-responsive, high-yielding varieties (HYV) of rice and wheat during the 1960s made it possible to produce 15 to 20 tonnes of plant biomass (dry matter) per hectare per year. This productivity could be initially maintained with N fertilizer alone as the soil could provide much of the other nutrients needed by the crop. However, within a few years, the soil reserves of many nutrients were gradually exhausted, and high yields were no longer possible by applying N alone. Therefore, a growing emergence of plant nutrient deficiencies occurred in areas of increasing crop intensity.

During 1998-99, consumption of N, P_2O_5 and K_2O in India was 11.3, 4.1 and 1.33 M t, respectively at 90 kg/ha. A sustained, imbalanced use of nutrients is reflected by the $N:P_2O_5:K_2O$ ratio which widened from 5.9:2.4:1 in 1991-92 to 8.5:3.1:1 in 1998-99 (**Table 1**).

If the nutrient consumption pattern in 1998-99 equaled the desired 4:2:1 ratio, the 11.32 M t of N would be matched with 5.66 million P_2O_5 tonnes (38 percent more than actual) and 2.83 million K_2O tonnes (over twice actual K_2O consumption). The challenge for government and industry alike is to meet or exceed this consumption level.

Table 1. Trends in nutrient consumption and use ratio, India.

Year	$N-P_2O_5-K_2O$ consumption, kg/ha	Consumption ratio $N:P_2O_5:K_2O$	$N:P_2O_5$
1991-92	69.8	5.9: 2.4: 1	2.4: 1
1992-93	65.5	9.5: 3.2: 1	3.0: 1
1993-94	66.3	9.7: 2.9: 1	3.3: 1
1994-95	72.1	8.5: 2.6: 1	3.3: 1
1995-96	74.4	8.5: 2.5: 1	3.4: 1
1996-97	76.7	10.0: 2.9: 1	3.4: 1
1997-98	86.8	7.9: 2.9: 1	2.7: 1
1998-99	90.0	8.5: 3.1: 1	2.7: 1
Overall desired norm		4: 2: 1	2: 1

Long-term Experiments Emphasize Balanced Fertilizer Use

Findings from long-term fertilizer experiments have clearly shown how the high productivity of an N-driven system is short-lived and counter-productive. Continuous use of N alone can never produce sustained, high yields without addition of adequate

P, K and other deficient plant nutrients. This can be verified by the relatively higher P and K fertilizer use efficiencies and relatively lower N use efficiency in India during the 1980s and 1990s as compared to the 1970s (**Tables 2** and **3**).

Table 2. Response to N, P and K over years in a rice-wheat cropping sequence on alluvial soils at Faizabad, Uttar Pradesh, India.

Crop	Period	Control yield, kg/ha	Response, kg/ha[1] N (120)	P_2O_5 (80)	K_2O (40)
Rice	1977-78	1,010	2,905	500	50
	1989-90	820	2,640	925	231
	Change	-190	-265	+425	+181
Wheat	1977-78	833	2,625	617	25
	1989-90	602	2,140	1,170	398
	Change	-231	-485	+553	+373

Source: Project Directorate of Cropping Systems Research, ICAR, Modipuram, Uttar Pradesh.

[1] Numbers in parentheses represent nutrient rates per hectare.

The Dynamic Nature of Balanced Fertilization

A wealth of information on the dynamic nature of balanced fertilization in intensive cropping systems has become available from several long-term fertilizer experiments in which HYVs are grown. Results consistently show: 1) intensive cropping with only N input is a short-lived phenomenon; 2) omission of a plant nutrient (be it macro or micro) leads to its progressive deficiency as a result of heavy removals; 3) sites initially well supplied with natural soil P, K or sulfur (S) become deficient when continuously cropped using N alone or S-free fertilizers; 4) fertilizer rates considered as optimum still resulted in nutrient depletion at high productivity levels and, if continued, become sub-optimal rates.

More than anything else, these experiments solidly demonstrated that a field producing 1,300 kg grain/ha from two crops grown without fertilizer could produce 7,420 kg grain (5.7 times more) under optimum plant nutrient application (data not shown). Responses to fertilizers in these experiments were always in the order of NPK>NP>N. Continuous use of N alone produced the greatest yield decline at a majority of sites. Responses to N declined with the passage of time, while responses to P and K improved due to increased soil P and K deficiency (**Table 3**).

Data such as those in **Table 3** are not just pieces of academic

Table 3. Nutrient response ratio (kg grain/kg nutrient) in long-term fertilizer experiments: 1973-77 vs. 1992-96, India.

Location, soil and crops	Nitrogen 1973-77	Nitrogen 1992-96	Phosphorus 1973-77	Phosphorus 1992-96	Potassium 1973-77	Potassium 1992-96
Palampur (Alfisol)						
Maize	14.6	-1.6	13.9	20.6	2.4	20.0
Wheat	4.3	-3.1	13.4	21.2	3.6	13.2
Ranchi (Alfisol)						
Soybean	-10.4	-8.1	6.1	10.6	4.1	20.6
Wheat	-7.8	-1.4	29.9	38.2	1.0	15.9
Coimbatore (Inceptisol)						
Finger millet	3.1	5.4	35.3	43.9	-11.4	13.4
Maize	1.7	-1.3	32.7	28.6	-1.3	14.5
Bhubaneshwar (Inceptisol)						
Rice (kharif)	6.7	2.6	-1.05	5.5	6.9	8.2
Rice (rabi)	11.2	3.2	1.8	14.1	2.7	5.5
Jabalpur (Vertisol)						
Soybean	26.0	8.4	7.9	7.7	2.9	13.7
Wheat	7.0	0.5	20.2	41.1	8.4	6.0

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

information because they clearly point out the disastrous consequences of practicing intensive farming without due attention to balanced fertilization. Taking the case of maize at Palampur, during 1973-77 each unit of N applied produced 14.6 kg grain while each unit of K produced 2.4 kg grain. About two decades later (1992-96) in the same field, the maize response rate to N dropped from 14.6 to -1.6 while that to K increased from 2.4 to 20 kg grain/kg K_2O. The response to N dropped because other plant nutrients (i.e., P, K) became deficient, preventing the full benefit of N. The response to P and K increased over time because of the depletion of soil P and K reserves, which made fertilizer application essential for high yields. As a result, use of N alone became a losing proposition while that of P and K became more attractive and profitable. At Ranchi, use of N alone always resulted in negative responses and monetary losses because the experimental soils were highly P deficient.

These are some eye-opening examples of the disastrous agro-economic consequences of unbalanced (N-dominated) fertilization. Adoption of a balanced approach right from the beginning will safeguard higher returns from money spent not only on plant nutrients, but also other input costs and farming enterprise as a whole.

Optimum Rates Change with Yield Goals

Results of long-term experiments also reveal that the conventionally considered optimum application rates can in reality be sub-optimal and not capable of producing the highest yield potential (**Table 4**).

Evidently, normally recommended rates of NPK fertilizers are sub-optimal in intensive cropping systems in several cases. Maximum yield research data initiated by the PPIC–India Programme revealed that it is possible to surpass the national demonstration yield level by a considerable margin both in a rice-rice system (Tamil Nadu) and rice-wheat system (Punjab, Uttar Pradesh) by applying higher NPK rates and adopting improved production technology. This implies that higher nutrient depletion demands a higher rate of nutrient replenishment to safeguard the soil fertility balance.

Table 4. The sub-optimal status of optimum NPK application rates in wheat, India.

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

Source: Nambiar, K.K.M. (1994) ICAR-AICRP long-term fertilizer experiments.

Balanced Fertilization Includes Nutrients Other than NPK

Balanced fertilizer use today in India implies much more than NPK application. Almost 50 percent of over 200,000 soil samples analyzed have tested low (deficient) in zinc (Zn). Soil S deficiencies once considered to be

Table 5. Balanced nutrient application for a number of soil/crop combinations in India.		
No.	Situation	Component of Balance
1.	Many alluvial soils, wheat belt	N, P, K, Zn, and S
2.	Red and lateritic soils	N, P, K, with lime
3.	Many areas under oilseeds	N, P, K, S, and B
4.	Malnad area of Karnataka	N, P, K, S, and Mg
5.	High yielding tea in South	N, P, K, Mg, S, and Zn

confined to coarse-textured soils under oilseeds are now estimated to occur in a wide variety of soils in nearly 130 districts, and yield increases from application of S under field conditions have been recorded in over 40 crops. Likewise, in specific areas, the application of magnesium (Mg) and boron (B) has become necessary for high yields, greater plant nutrient use efficiency, and enhanced profits. These nutrient combinations represent the many facets of balanced fertilizer use (**Table 5**).

Therefore, feeding crops for high yields in India is no longer a simple NPK story. This in no way minimizes the importance of NPK (fertilizer pillars), but emphasizes that the efficiency of NPK and returns from their application can be maximized only when due attention is paid to other plant nutrient deficiencies.

In conclusion, Indian agriculture is now in an era of multiple plant nutrient deficiencies. At least five nutrients (N, P, K, S, and Zn) are now of widespread practical importance from an application point of view. It would not be surprising if progressive farmers in several areas must apply four to six nutrients to sustain high yields of premium crops. Policies and strategies need to be developed to fully recognize the changing needs and dynamics of balanced fertilization. Towards this end, policy-makers, researchers, extension personnel, fertilizer industry, dealers, and farmers all have to contribute. **BCI**

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Dr. Tiwari is shown inspecting a bean crop grown with balanced fertilization in India.