Fertilizers and manures

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Fertilizer has been the key input in augmenting food-production in India. However, fertilizer use in India is skewed, high in a few states having adequate irrigation and dismally low in the NE states. There is also imbalanced use of N, P and K. Deficiency of secondary nutrient sulphur and micronutrient zinc is widespread in the country and boron deficiency is reported from the eastern states. While attempts are being made to increase the fertilizer use in states where levels of application are low, the focus is on developing and promoting secondary and micronutrient fortified/customized fertilizers. A serious thought needs to be given for increasing the use efficiency of nitrogen, which is very low, specially in rice. Therefore, more efficient nitrogen fertilizers using low-cost nitrification inhibitors and coating materials need to be developed and produced. Production and promotion of organic manures also needs due attention.

Keywords: Crop response ratio, fertilizers, manures, nitrification inhibitors.

Introduction

OUT of the total cultivated area of 142 million hectares (M ha) in India during 2007–08, 100.4 M ha was under cereals and 23.6 M ha under pulses, the staple food grains in the country. There is very little scope of bringing additional area under food grains; on the contrary this may decline in future due to the land needed for civil amenities (housing, schools, hospitals, roads, railways, etc.) and industrial purposes. Further, a lot of good agricultural land around villages and towns is being lost to urban development. At the 1950–51 level of productivity, when very little fertilizer was used, 100.4 M ha under cereals would have produced only 54.4 million tonnes (Mt) of cereals, and 23.6 M ha under pulses would have produced 10.4 Mt of pulses. As against this during 2007–08, 216 Mt of cereals and 14.8 Mt of pulses were produced. This was possible due to improved agricultural technology that included high-yielding crop varieties, use of fertilizer, an increase in irrigated area and introducing plant protection. As regards fertilizers, 22.57 Mt of fertilizer ($N + P_2O_5 + K_2O$) was used in 2007–08 as compared to a mere 69.8 thousand tonnes in 1950–51. This brings out the fact that the earth can supply only limited amount of plant nutrients, as can be approximately judged from the productivity level of 1950–51, and for each additional tonne of food grain produced, adequate amounts of additional plant nutrients must be externally applied as fertilizer. Some estimates[1] of N, P and K removed per tonne of food grain produced are given in Table 1. Thus the fertilizer has been the key input for realizing yield potential of responsive, high-yielding crop varieties. Role of fertilizer in food grain production became more evident after the green revolution and NPK consumption increased from 1.1 Mt in 1966–67 to 23 Mt in 2007–08, and the food grain production increased from 74 Mt in 1966–67 to 231 Mt in 2007–08 (Figure 1)[2]; about 72% of the total NPK was consumed in food grains production (Figure 2)[3].

Present fertilizer production and consumption scenario

At present, India is the second largest producer of fertilizer-nitrogen and the third largest producer of phosphate fertilizers in the world (Table 2). Potash is totally imported. As regards consumption, India is second only to China in nitrogen and phosphorus. However, the fertilizer consumption in India is quite skewed. The average fertilizer consumption of 120 kg/ha (in 2007–08) masks more than it reveals. During 2007–08, fertilizer NPK

Table 1. Removal of NPK (kg/t grain) of major food grain crops

Crop	N	P (P_2O_5)	K (K_2O)
Rice	20.4	3.6 (8.2)	20.4 (24.5)
Wheat	22.4	3.8 (8.7)	28.2 (33.8)
Maize	24.3	6.4 (14.6)	18.3 (22.0)
Sorghum	26.1	4.5 (10.3)	21.5 (25.8)
Pearl millet	27.1	8.2 (18.8)	39.7 (47.6)
Chickpea	50.6	8.6 (19.7)	29.7 (35.8)
Pigeonpea	92.1	8.2 (18.8)	30.7 (36.8)

Table 2. Production and consumption of nitrogen and phosphate fertilizers (2007–08)[2]

	Production (Mt)		Consumption (Mt)	
Country	N	P_2O_5	N	P_2O_5
China	35.3	12.6	31.3	11.5
India	10.9	3.7	14.4	5.5
USA	8.5	8.9	11.6	4.1

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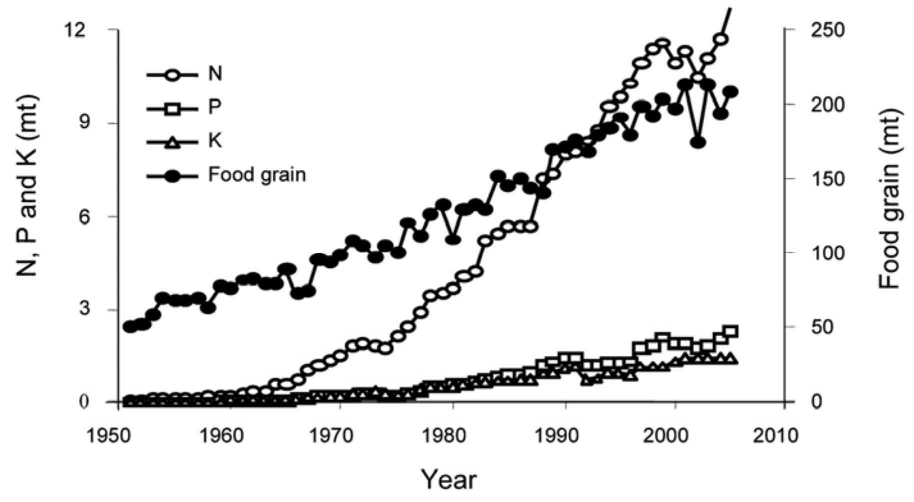

Figure 1. Food grains production and consumption of N, P and K.

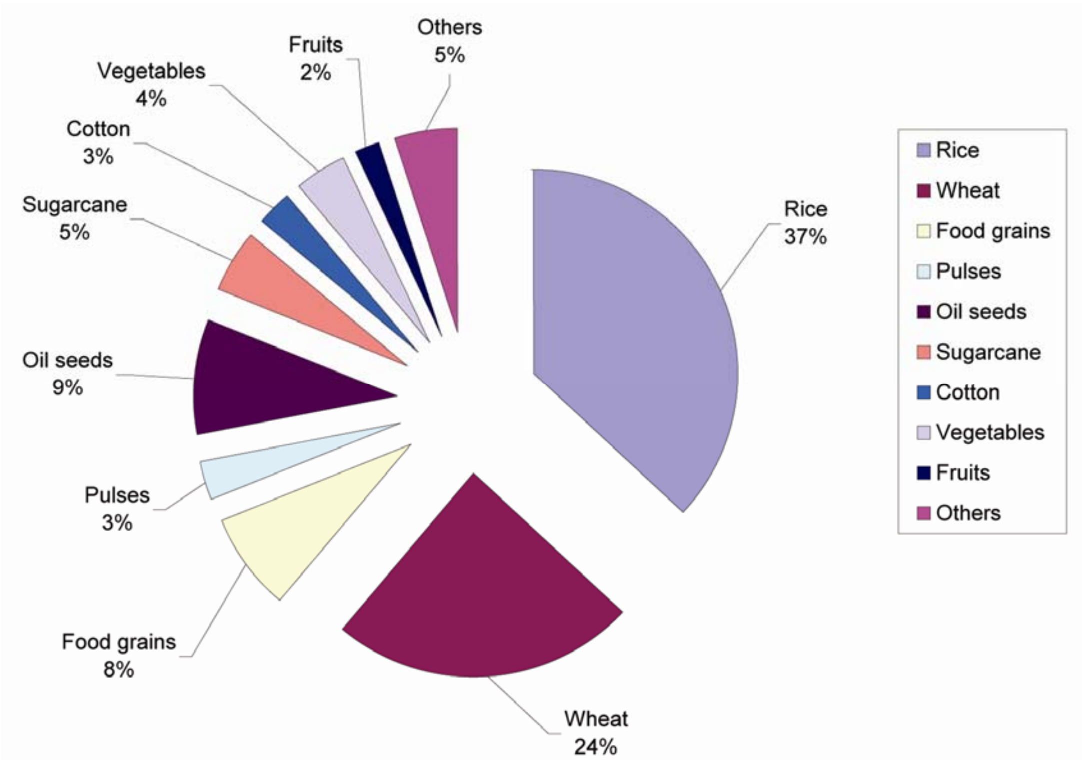

Figure 2. Crop-wise consumption of fertilizers in India.

consumption (kg/ha) was maximum in Andhra Pradesh (205) followed by Punjab (196), Tamil Nadu (184), Haryana (182) and Uttar Pradesh (154), but was less than 2 kg/ha in Arunachal Pradesh and Nagaland.

Crop response to fertilizers

Crop response ratio or agronomic efficiency of fertilizers is defined as follows:

$$\text{Crop response ratio} = Y_f - Y_c/F_a,$$

where Y_f refers to yield in kilograms in fertilized plot, Y_c refers to control plot yield and F_a is fertilizer applied (kg). The average response ratio of 8.6 for cereals (Table 3) is close to the value of 8 used by the Planning Commission for determining fertilizer needs of the country for the Seventh Five-Year Plan (1985–1990). However, the National Commission on Agriculture in its report[4] had used a response ratio of 10. These responses are quite low

Table 3. Average response ratio (kg of grains/kg N, P_2O_5, K_2O) of cereals to fertilizers

Crop	Field	Control plot yield (kg/ha)	Over control				P over		K over	
			N	NP	NK	NPK	N	NK	P	PK
Rice (paddy)	1498	2392	11.4	11.7	11.3	10.6	12.9	14.7	11.6	13.8
Wheat	967	1595	6.2	6.6	6.2	6.8	7.4	8.3	6.5	7.9
Sorghum	42	829	3.4	4.1	4.4	5.1	5.4	7.2	6.4	8.2
Pearl millet	229	998	4.5	4.5	4.4	4.6	5.0	5.1	4.2	4.8
Maize	261	1302	12.5	13.3	12.8	13.4	15.1	14.8	14.3	14.6
All cereals	2997	1803	8.6	9.0	8.7	8.6	10.0	11.3	9.2	10.8

Source: Indian Agricultural Statistics Research Institute, New Delhi.

Table 4. Growth rate in fertilizer use and crop output

Period	Trend in growth rate (percentage)		
	Fertilizer (kg NPK/ha)	Crop output	Range
1966–67 to 1991–92	9.2	2.8	7–70
1991–92 to 2006–07	3.4	1.3	70–113
1998–99 to 2006–07	2.6	1.1 NS	87–113

All growth rates except NS were significant at 0.1–5% level.
NS, Not significant up to 20% level.
Growth rate in fertilizer refers to quantity of NPK and growth rate in crop output refers to index number of production of all crops.

and need to be increased by identifying and removing the factors limiting them.

A recent study at the National Centre for Agricultural Economics and Policy Research, New Delhi[5] has also shown that the growth rate in crop output has not kept pace with that in fertilizer consumption and both have declined over the years. This is a matter of great concern and the causes for this need to be found.

Not only is the crop response ratio (agronomic efficiency) low, the recovery efficiency (% of N recovered by crop) is only 30–50%, and it is as low as 20% in rice[6]. This calls for the use of efficient nitrogen fertilizers such as nitrification inhibitor-treated fertilizers or slow-release fertilizers[7]. At present only neem-coated urea (NCU) developed at the Indian Agricultural Research Institute, New Delhi, is being manufactured at some fertilizer plants, but its demand is increasing. In field trials at New Delhi villages, it gave 6–11% increase in agronomic efficiency over prilled urea[8].

Imbalanced use of NPK

Due to the imbalanced use of plant nutrients, mining of nutrients is considered as the main cause for decline in crop yield and crop response ratio. About 8–10 Mt of NPK is mined annually in India[9] (Table 5). Soils are also being depleted of secondary and micronutrients. About 42% of the soils are deficient in sulphur[10], 48.5% deficient in zinc and 33% deficient in boron[11]. Thus from single-plant nutrient deficiencies in the past, Indian soils are currently witnessing multi-nutrient deficiencies. This calls for 'site-specific nutrient management' (SSNM) and development of customized and value-added fertilizers, especially micronutrient fortified fertilizers.

According to Chand and Pandey[5], imbalanced use of NPK can be represented by following expression:

$$I = \sqrt{\{(\mathrm{N}_a - \mathrm{N}_n)^2 + (\mathrm{P}_a - \mathrm{P}_n)^2 + (\mathrm{K}_a - \mathrm{K}_n)^2\}/3},$$

where I is the measure of deviation in the actual use of NPK from the normal ratio of 4 : 2 : 1 ($N : P_2O_5 : K_2O$), and subscripts a and n refer to actual use and norm. When NPK is used in the recommended normal ratio I is 0, while the maximum value of I is 0.49. Thus I would lie between 0 (perfect balance) and 49% (extreme imbalance). This study showed that after 1966–67, barring a few years, imbalance in NPK use was only 4–8%. However, the norm of 4 : 2 : 1 ($N : P_2O_5 : K_2O$) needs to be debated and defined for different crops and soils. Interestingly, in 2005–06 paddy yield was 3.8 t/ha in Punjab, which had the widest $N : P_2O_5 : K_2O$ ratio (23.1 : 9.4 : 1), and it was only 2.9 t/ha in Andhra Pradesh, which had a near normal $N : P_2O_5 : K_2O$ ratio of 3.9 : 1.7 : 1.

Future nutrient demands

To meet food grains requirement of 300 Mt by 2025, 45 Mt of N + P_2O_5 + K_2O is estimated to be required per annum. Out of this, 35 Mt is proposed to be met from the

Table 5. Balance sheets for NPK in India

Nutrient	Gross balance sheet (Mt)			Net balance sheet (Mt)*		
	Addition	Removal	Balance	Addition	Removal	Balance
N	10.9	9.6	1.3	5.5	7.7	–2.2
P_2O_5	4.2	3.7	0.5	1.5	3.0	–1.5
K_2O	1.4	11.6	–10.2	1.0	7.0	–6.0
Total	16.5	24.9	–8.4	8.0	17.7	–9.7

*The net values were arrived at by adjusting nutrient-use efficiency (50% for N, 35% for P_2O_5 and 70% for K); this also included residual effects. On the removal side, this was taken as 80% of crop uptake for N and P, and 60% for K.

Table 6. Available nutrients from organic manure

Component	Potential availability (Mt)	Actual availability (Mt)	Nutrient value (Mt)
Crop residue	603	201	5
Animal dung	791	287	4
Green manure	4.5*	NA	0.2
Rural compost	184	184	2.6
City compost	12.2	12.2	0.4
Biofertilizer	0.01	Negligible	0.4
Others	96.6	NA	0.9
Total			12.8

*In million hectares. Net available after 30% deduction: 9 Mt. NA, Not available.

chemical fertilizers and the rest from organic manures. A similar estimate of one-and-half times the present (2007–08) consumption of 23 Mt of NPK was made by Tiwari[12]. The present installed capacity of fertilizers is only 12.3 Mt of N and 5.7 Mt of P_2O_5. All potash is imported. During 2007–08, 6.9 Mt of urea, 3.0 Mt of DAP/MAP and 4.4 Mt of muriate of potash (KCl) were imported. Obviously, imports will increase in the coming years to sustain increased food production unless adequate incentives are provided to the fertilizer industry to increase the installed fertilizer production capacity.

Fertilizer subsidy

Fertilizer subsidy started from the middle of the seventies to attain a reasonable degree of self-reliance in fertilizer production for improving food security. This was later replaced by group pricing scheme[13] from 1 April 2003. In addition, subsidy/concession on decontrolled (since 1992) phosphate and potash fertilizers has been announced from time to time. The subsidy increased from a mere Rs 600 million in 1976–77 to Rs 403,880 million in 2007–08. The main cause of increase is that prices of fertilizers have remained stagnant since 2002, whereas the prices of the feedstock, raw materials and intermediates have increased substantially.

The year 2010–11 was a landmark in the history of the Indian fertilizer sector, since the Nutrient Based Subsidy (NBS) was introduced with effect from 1 April 2010 for phosphate [other than single super phosphare (SSP)][14]. SSP was brought under the NBS scheme with effect from 1 May 2010. NBS has brought a major breakthrough in policy since the 1970s for the following reasons:

1. It made a shift from product-based subsidy regime to nutrient-based subsidy.
2. The subsidy per unit remains fixed under NBS.
3. NBS will promote the development of customized fertilizers.

Organic manures

Plant nutrient ($N + P_2O_5 + K_2O$) availability from organic sources such as farmyard manure, compost, vermicompost and green manure is estimated at 13 Mt (9 Mt net) (Table 6)[15]. These estimates exclude secondary and micronutrients added, which are sizeable. Organic manures and crop residues can play a major role in recycling K. Concomitant use of organic manure and fertilizer-N can reduce leaching losses of N. Thus Integrated Nutrient Management is vital for increasing food production.

Policy perspectives

The recent decisions by the Central Government on fertilizer policy are historical. These include: (i) nutrient-based pricing and subsidy; (ii) allowing additional cost of fortification and coating on approved subsidized fertilizers to manufacturers (5–10% above the MRP); (iii) paying freight subsidy for all subsidized fertilizers on actual basis instead of uniform basis and (iv) allowing higher rate of concession to SSP fertilizer to revive the SSP industry.

- Policy for SSNM encouraging the development and promotion of secondary and micronutrient fortified customized fertilizers must be developed and implemented.

- Proper support and popularization is required for promotion of fertigation; production and supply of water-soluble nutrients.
- Encouraging the development of low-cost indigenous nitrification inhibitors and coating materials for developing more efficient nitrogen fertilizers.
- Logistic support, including provision of adequate number of covered wagons and warehouses for transport and storage of fertilizers.
- Improved quality of fertilizer materials to be enforced through establishment of reliable referral laboratories.
- Promotion of organic manures, including biofertilizers, farmyard manure, compost/vermi-compost, green manure, and mechanized composting, and reclamation of nutrients from urban refuse and market-yard refuse needs to be done through incentives.

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