Nitrogen use scenario in India

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Abstract Nitrogen is one of the major plant nutrients without which the agricultural production is not possible. Nitrogen use in Indian agriculture was nearly 55000 tons in 1950—1951 that increased to 11.31 million tons in 2001—2002. The total food production of the country has also experienced the similar increase from 50.83 to 222 million tons in the respective years. Interestingly the N fertilizer consumption of India remained almost constant during the last six years indicating the possibility of reducing N consumption. The highest N consumption is in North zone owing to the introduction of rice-wheat cropping system followed by West, South and East.

The N use efficiency has been reported to be varying between 30% to 50% depending on the crops and the management. But in most of the cases, N use efficiency has been calculated based on the total N removed by the crops (above ground part only) ignoring the N content left in the roots. It has been observed in controlled experiments that the total N uptake by roots varied from 18% to 44% of the total N removed by the above ground parts, i.e. grain and straw. If the root N is also accounted, the N use efficiency will be higher than reported. The management of other organic sources has to be improved so as to increase the fertilizer use efficiency as well as to check the direct release of N in the atmosphere. In this review all these issues will be dealt.

Keywords: nitrogen use scenario, India.

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Nitrogen is one of the important plant nutrients without which the plant growth is not possible. Application of nitrogenous fertilizers increased tremendously with the introduction of high yielding crop cultivars and exploitation of irrigation facilities. Nitrogen is highly mobile in soil and plant system. It has been observed by various workers that about half of the applied fertilizer N is either leached down the soil profile as NO_3 to join the ground waters[1−3] or lost to the atmosphere as NH_3 and NO_x[4−8]. Under both the conditions, N is polluting either ground waters or the environment. Keeping in view the importance of N for crop production as well as environmental pollution, lots of research activities have been intensified to increase N use efficiency for various cropping sequences and maintain healthy environment.

According to Roy et al.[9], the world food demand will be around 2800 Mt a^{-1} and it would require 96 Mt N a^{-1}. Global level mineral N losses to the environment from fertilizers are currently 36 Mt a^{-1} worth USD 11700 million and its adverse environmental impacts are unaccountable. However, innovative fertilizer use efficiency technologies enable increased production with less than a proportionate increase in

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mineral N use. The anthropogenic reactive N of Asia increased dramatically from 14.4 Tg a^{-1} in 1961 to approximately 67.7 Tg a^{-1} in 2000 and is likely to be 105.3 Tg a^{-1} by 2030[10].

To increase the efficiency of applied fertilizer N and decrease its release in both ground waters and the environment, different sources of fertilizer N have been tried[11−18]. The transformation of urea is quick and immediately it changes to various pools of N in soils. Organic matter is another important soil component controlling the N dynamics in soils[19−21]. Similarly the time and rate of application of N fertilizers can also play an important role in manipulating the increased N use and decreased losses. This paper will deal with N use scenario in Indian agriculture, and various future researches need to decrease the N emission in environment.

1 N use scenario in India

N consumption in India has been increasing tremendously since the introduction of high yielding cultivars of cereal crops (Fig. 1). During the past six years N use in Indian agriculture is either stable or slightly decreasing. There can be various reasons for such kind of trends. With the increasing communication of technology their adoption might have advocated the limited use of nitrogenous fertilizer or unfavorable weather conditions. Thorough analysis is necessary to correlate this change in fertilizer use with the agricultural productivity. With the introduction of WTO the cost of production has to be decreased so that the commodities can compete in the international market. Nitrogen use in various zones of India also changed with time (Table 1, Fig. 2).

The highest N consumption was in north zone followed by south, west and east zones. This increase has been because of the increased response of cereal crop to N application. This is a matter of great concern to environmentalists that more the N use per unit area more are the chances of its losses to either ground wa-

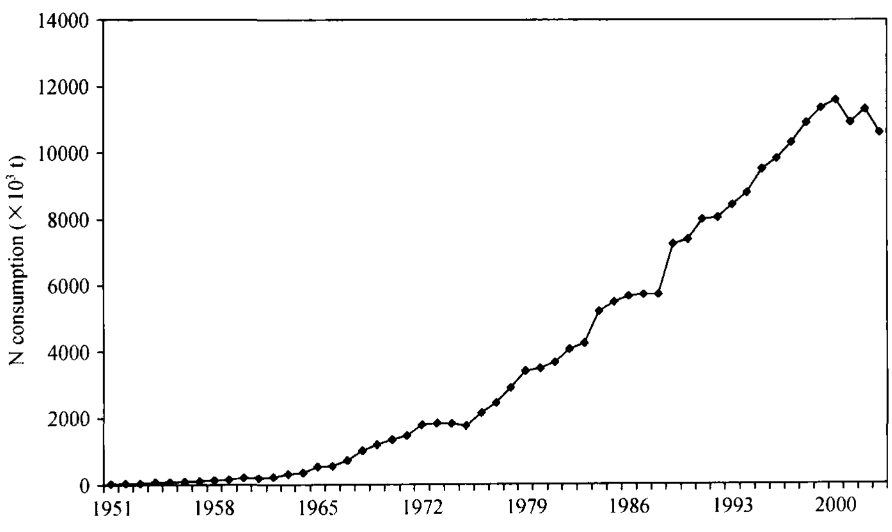

Fig. 1. Nitrogen use scenario in India.

Table 1 Periodical changes in nitrogen consumption in various zones of India

Zone	Year						
	1971	1976	1981	1986	1991	1996	2001
	N consumption ($\times10^3$ t)						
South	494.0	701.2	933.8	1311.3	1968.0	2241.8	2727.4
West	309.4	412.2	699.1	1114.6	1911.1	2455.1	2495.7
North	534.3	740.8	1600.4	2616.7	3101.2	3812.1	4079.0
East	147.3	241.3	391.9	714.7	1041.0	1313.6	1618.1
All India	1487.1	2148.6	3678.1	5815.4	8021.3	9822.8	10920.2

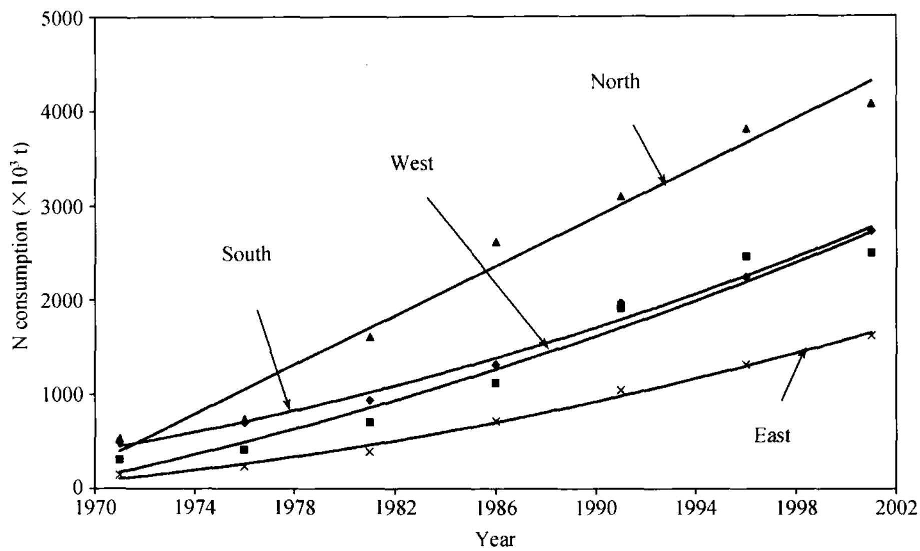

Fig. 2. Nitrogen use scenario in various zones of India.

ter or the environment. The N consumption in other three zones is also increasing but is still far less as compared to the north zone. The low consumption of N in other three zones is also related to the crops grown in these zones and their productivity levels.

2 N consumption and food production

N consumption is closely related to the food production. The N consumption and food production pattern of India have been presented in Fig. 3. The lines of N consumption and the food production are closely related to each other. Surprisingly the N consumption in the last three years is decreasing but not at the cost of production. Thus it is possible to reduce the N consumption in Indian agriculture without affecting the productivity.

Nitrogen consumption of a country can also be increased with bringing more area under food crops. But the area under food crops is almost constant for the past few years (Fig. 4). However the change of crops is another important factor in changing the fertilizer consumption. To cater for the need of growing population, the area and productivity of the cereal crops have to be increased. As in most productive states, i.e. Punjab and Haryana, there had been shifted in various cropping systems to rice-wheat that is more fertilizer-responsive. Moreover, with time the crops started responding to various nutrients because of the mining of the native nutrient reserves. Thus proper management practices are important to maintain the soil productivity and food demand, and save the damage to the environment.

3 Alternative N sources

There are many chemical fertilizers either containing N alone or in combination with other nutrient elements. Urea is one of the major sources of N in Asian agriculture. Apart from the chemical fertilizers, there are so many organic products which could be used as organic sources to supply N for growing crops. Majority of the crop residues are burnt and the N contained in them is lost in the environment and simultaneously releasing oxides of carbon. Production of some crop residues and the total recyclable N in Indian agriculture has been enumerated in Table 2. All the crop residues are not burnt and used for other important purposes like animal feed, shelter for men and animals etc. About 309 Mt of crop residues produced in India by major crops contain about 1.61 Mt of N. If half of this straw is burnt, about 0.8 Mt of N is released in the environment. At the same time the C:N ratio of these crop residues is quite wide to cause immobilization of plant nutrients and result in decrease in crop produc-

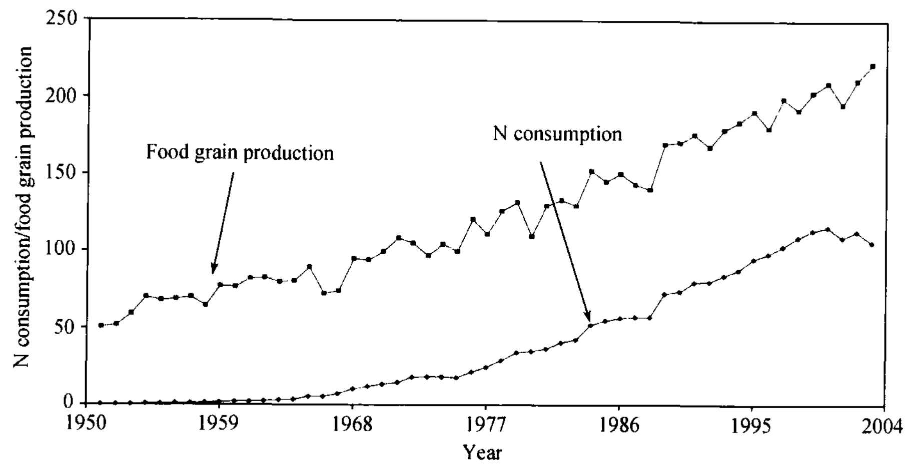

Fig. 3. Nitrogen consumption ($\times 10^5$ t) and food grain production (Mt) scenario in India.

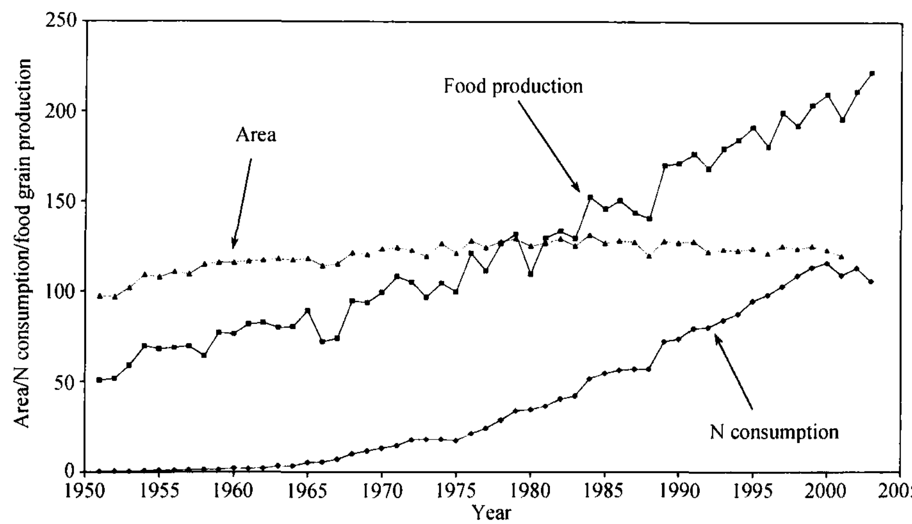

Fig. 4. Periodical changes in area under food grains (Mha), fertilizer N consumption ($\times 10^6$ t) and food grain production (Mt) in India.

Table 2 Production of residue and total recyclable N from some important crops in India

Crop	Total production (Mt)	N content (%)	Total N ($\times 10^3$ t)
Rice	127.31	0.61	776.57
Wheat	103.14	0.48	495.10
Sorghum	11.57	0.52	60.18
Maize	18.10	0.52	94.13
Pearl millet	10.59	0.45	47.65
Barley	2.15	0.52	11.17
Small millet	6.68	1.00	6.68
Sugarcane	29.92	0.40	119.68
Total	309.46		1611.16

Source: Fertilizer Statistics of India, 2002.

tivity. Thus the turnover time has to be more to decompose them *in situ* or composted out of the field to reduce the C:N ratio before applying to the field.

In case of oil seed crops, the residues left after the oil extraction are called cake. These cakes are rich in plant nutrients (Table 3). The N content of these cakes ranges from 3.11% to 7.88% with low C:N ratio. The cakes from edible oil are good as feed for animals but the cake from non-edible oil crops cannot be used as animal feed. The cake from non-edible oil crops is being used as a source of energy in most of the cases. It can be used as good organic manure rather than wasting the nutrients like N and S while burning. There are reports of harmful effects of the toxicants present in these cakes or the intermediate degradation products on the crop growth. These harmful effects can be mitigated by applying these cakes 3 to 4 weeks prior to crop sowing[22,23].

Table 3 Average N content of oil cakes

Crop	N content (%)	Crop	N content (%)
Edible		Non-edible	
Groundnut	7.29	Castor	4.37
Mustard	4.52	Neem	5.22
Rapeseed	5.21	Mahua	3.11
Linseed	5.56	Karanj	3.97
Sesame	6.22	Kusum	5.23
Cotton seed	6.41	Khakan	4.32
Safflower	7.88		

Source: Bhardwaj (1995).

Nitrogen use is also influenced by many factors such as the cost of various nutrients, cropping systems, agronomic practices and use of bio-fertilizers and organic manures. The ratio between N and P use has been changing with change in the cost of nitrogenous fertilizer. Higher N application has been observed at the cost of P because of the higher price of the later fertilizer. The N:P ratios for various zones have been presented in Table 4.

Table 4 Periodical changes of N : P ratio in various zones of India

Zone	Year			
	1970−1971	1980−1981	1990−1991	2000−2001
South	2.97	2.91	2.27	2.20
West	1.54	2.39	1.90	2.10
North	2.09	3.53	3.34	3.40
East	3.90	3.28	2.78	2.73

There is increasing interest in the environmentalists to grow organic produce to avoid the contamination of natural resources, i.e. soil, water and environment. Several workers have shown that the productivity of cereal crops reduces with organic farming. Application of N becomes necessary when organic manures have been used for crop production. Application of all other fertilizers can be reduced/avoided under manured conditions[24,25].

The nutrient use efficiency of N is quite low and hence needs to be increased. Generally the N use efficiency has been calculated by dividing the total N removed by the biomass from the total N added in the soil. But the N absorbed by the roots of the crops is always ignored. The amount of N absorbed by various parts of wheat plant as a function of the application of various inputs has been presented in Table 5. Variable quantities have been retained in the root portion of wheat crop and increased by increasing the N application. The proportion of N retained in the roots in relation to the N removed by the above ground parts, i.e. grain and straw, has been calculated (Table 6).

The proportion N retained in the roots is almost 25% to that of the above ground portion. It also increased with increasing application of N in the soil. Thus if the N retained in the root is also considered, then the N use efficiency would be increased by about 25%. In many experiments this much quantity has been left as unaccounted or accounted as losses whereas this part of N would be available to subsequent crops upon mineralization.

Table 5 Total nitrogen uptake by wheat roots and above ground parts

Treatment	N dose (mg N kg^{-1} soil)					Mean
	0	30	60	90	120	
Above ground parts (grain+straw), (g pot^{-1})						
Control	0.22	0.29	0.38	0.49	0.62	0.40
Pearl millet roots	0.16	0.27	0.40	0.55	0.65	0.41
FYM	0.24	0.37	0.51	0.59	0.68	0.49
Roots+FYM	0.23	0.32	0.42	0.51	0.67	0.43
Mean	0.22	0.32	0.43	0.54	0.66	
Roots						
Control	0.06	0.07	0.11	0.11	0.13	0.10
Pearl millet roots	0.07	0.10	0.13	0.12	0.16	0.12
FYM	0.07	0.11	0.13	0.13	0.15	0.12
Roots+FYM	0.06	0.08	0.11	0.12	0.12	0.10
Mean	0.06	0.09	0.12	0.12	0.14	

Source: Mukherjee (1998).

Table 6 Percentage of nitrogen absorbed by roots compared to above ground parts of wheat crop

Treatment	N dose (mg N kg^{-1} soil)					Mean
	0	30	60	90	120	
Control	27.27	24.14	28.95	22.45	20.97	25.00
Pearl millet roots	43.75	37.03	32.50	21.82	24.62	29.27
FYM	29.16	29.73	25.49	22.03	22.06	24.49
Roots+FYM	26.09	25.00	26.19	23.53	17.91	23.26
Mean	27.27	28.13	27.91	22.22	21.21	

4 Future research needs

Based on the N consumption scenario, the availability of alternative sources of N, N use efficiency of crops and cropping systems, and entire N use strategies need to be reoriented in a way to reduce the losses of N to the environment. It would not only save the environmental degradation but also decrease the cost of inputs in agriculture. The following research needs should get due importance in respective places:

1) The organic waste resources need to be updated with respect to quantity, quality and use pattern.

2) The fertilizer requirements of various crops and cropping systems have to be worked out under manured conditions.

3) Nitrogen losses should be quantified and the agronomic practices have to be developed to reduce these losses.

4) The Leaf Colour Charts (LCC) need to be developed for various crops and propagated among the farming communities.

5) The technologies must be developed for *in*- and *ex-situ* decomposition of crop straw and avoid the burning of these resources.

6) Native nutrient exploiting genotypes need to be developed.

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