Promoting Balanced Fertilization in India – Policies and Economic Issues

M.R. Motsara

Ministry of Agriculture, Govt. of India, Krishi Bhawan, New Delhi-110 001

Abstract

The fertilizer consumption in India has grown during last fifty years from a mere 69000 tonnes of NPK to 18 million tonnes. In the process, food grain production has increased over four times starting from 50 million tonnes during 1950-51 to 208 million tonnes during 1999-2000. Correspondingly, fertilizer consumption per hectare has increased from merely 0.52 kg to 94.72 kg/ha. This represents a consumption of 60.77 kg N, 25.15 kg P_2O_5 and 8.8 kg K_2O and a NPK consumption ratio of 6.9:2.7:1. The NPK consumption ratio during 1991-92 was 5.9:2.4:1 which got widened to 9.5:3.2:1 during 1992-93 due to increase in prices of phosphatic and potassic fertilizers due to their de-control resulting into their reduced consumption. This clearly brings out the major effect of prices on the consumption of fertilizers. The ratio has gradually narrowed down to 6.9:2.7:1 during 1999-2000 due to a number of measures taken by the Government like ad hoc price support to de-controlled fertilizers and increase in the support prices of food grains etc. The increase in the support price of food grains from 1992-93 to 1999-2000 has been of the order of 58% to 92% for different crops. The increase in fertilizer prices during the corresponding period was 50% in case of nitrogen (urea), 90% for phosphorus (DAP) and 150% for potash(MOP). Aggregate crop response to the fertilizer application was 1:7.5 during 8th plan period (1992-97) which declined to 1:7 during 1997-1999. The response during 1999-2000 is estimated to be 1:6.5. The declining response to fertilizer application is clearly emerging. The average fertilizer application by the farmers for food grain + oil seeds is about 75 kg nutrients ha^{-1} as against the recommended level of 162 kg. This as well as non-application of micronutrients in the deficient areas show that the balance in the fertilizer use needs to be improved. The nutrient interaction and mining of excessive nutrients from the soil has been brought out in the paper. The use of integrated nutrient has been highlighted. It has been suggested that a parity be maintained in prices of all the fertilizers according to their response and their price may be directly related to prices of agriculture produce. Through regular experimentation, the fertilizer use crop response and evaluation of the cost benefit relationship may be continuously updated keeping in view the prevalent prices of fertilizers and agriculture produce. A special programme may be launched for promoting the use of micronutrients in general and for promotion of fertilizer use in rainfed areas specifically. The fertigation system may be popularized for achieving higher fertilizer and water use efficiency. Continuous monitoring of the quality of the soils and underground waters and the micronutrient status of the soils and efficiency of the fertilizer use in 77 priority districts in the country, where fertilizer consumption is more than 150 kg ha^{-1}, has been suggested. A need for strong extension programme involving State agencies and fertilizer industry has been advocated for promoting balanced and integrated use of fertilizers which will also be efficient and profitable fertilizer use. The soil testing programme needs to be further strengthened and modernised. Based on the country wide analysis of 3.65 million samples during 1999-2000 it has been brought out that about 89% of the soils are low to medium in nitrogen status, 80% in phosphorus and 50% in potash content. fertilizer use may be promoted on these lines and based on specific soil test results.

Introduction

Fertilizer consumption in India began with the start of the planning era. In the year 1950-51 when the food grain production was just about 50 million tonnes, the fertilizer consumption was equivalent to 69,000 tonnes of NPK. It was almost the lowest among the agriculturally important countries. The role of fertilizer for increasing food production was adequately recognised in the country and fertilizer was declared as an Essential Commodity in the year 1957. This helped the Government to exercise its authority to regulate manufacture, import, supply, distribution, price and quality of fertilizers. Today, India has a successful experience of using fertilizers to the best benefit of farmers and stands 3rd in the world in terms of quantity of fertilizers being used. Due to successful use of fertilizers and other inputs, India has achieved self-sufficiency in food grain production. The country has also started exporting food grain which is a pleasant experience as against that of early sixties when food import and its distribution used to be termed as ‘from ship to mouth’. Now availability of suitable storage facilitates particularly for perishable agriculture produce is area requiring attention. The quality of nutrition and improving the purchasing powers of people identified below poverty line is yet another area engaging Government attention.

Plant nutrient consumption of 18.07 million tonnes(NPK) followed by production of 208.87 million tonnes of foodgrain has been achieved during 1999-2000. It represents consumption of 94.72 kg of NPK and productivity of 1697 kg of foodgrain ha^{-1}. The consumption of as high as 300-500 kg plant nutrients ha^{-1} in many countries and production of 6.0, 7.6, 8.4 ton ha^{-1} of important food crops like paddy (China), wheat (France) and maize (USA) etc. has been attained. As against this, production of 2.8 ton, 2.75 ton and 1.6 ton ha^{-1} of paddy, wheat and maize respectively in India shows the possibilities of further enhancement of crop production. The fertilizers contribute about 50% in the increased production (FAO,1984) hence, other factors of crop production have also to be appreciated and managed for increasing crop production.

A long period has elapsed since the start of the fertilizer use in the country and attainment of self-sufficiency in food production. Numerous measures were taken, effective strategies were adopted which involved creation of facilities for assessment of fertility status of soils, evolving high yielding and high input responsive varieties of crops, carrying out fertilizer response trials under different agro-climatic & soil types, establishment of correlation between nutrients applied in suitable proportions, appropriate forms and profitable crop production. Researches have been undertaken to study and establish nutrient interactions among themselves and their transformation into the soil before crop uptake.

Testing methods to assess the available forms of nutrients have been standardized. Each nutrient has a specific role to perform in influencing plant growth, development, yield and crop quality. When the concentration of a nutrient in the plant tissues drops below the physiologically minimum required levels, deficiency symptoms start appearing on plant parts. Application of such deficient nutrient, therefore, becomes necessary otherwise the crop growth and consequently yields get limited according to Liebig's law of minimum. Liebig's law has practical implications for balanced crop nutrition and becomes progressively more and more relevant as the farming becomes more intensive and a number of essential nutrients start becoming limiting factor at a given site. Application of all such deficient nutrients in required amounts ensures balanced use of fertilizers which in term will result in an efficient nutrient use and profitable crop production.

Fertility status of the soils:

The nutrient availability to the crops is dependent on the inherent fertility status of the soils, the level of soil management and amendments of problem soils like acid and saline/alkali soils which are considered unfavourable soil situations which put constraints in native nutrient availability and also from applied fertilizers. The application of required nutrient has to take into account its possible per cent utilization by crops. Thus, the formulation of recommendation about the quantity of required plant nutrient has to be based on extensive trials to establish sound correlation between fertilizer application and crop response. A number of factors influence the utilization of nutrients and hence all such factors need to be identified and taken note of.

Among the soil nutrient deficiencies in India, the most extensive and important ones are those of nitrogen, phosphorus, potassium, zinc and sulphur. Deficiencies of iron, manganese, boron and molybdenum have also been reported from intensively cultivated areas. Motsara *et al.* (1982) worked out district wise fertility index based on 5.0 million soil sample analysis during 1973-77. It was reported that there was no correlation of the fertility index and fertilizer consumption with regard to all the nutrients i.e. N P K. This may be possibly due to the fact that fertilizer application may not be according to soil test results. In 96 districts identified as potentially important districts, an additional fertilizer consumption of 8.16 lakh tons was assessed over and above 7.27 lakh tones of NPK being consumed during 1982-83. That shows the under fertilization of our soils by nearly half. Again the author (2001) has worked out the nutrient index and available NPK status based on the analysis of 3.65 million soil samples from different States during 1998-99. The concept of 'Soil Nutrient Index' (Parkar *et al.*, 1951) was deployed in comparing fertility level of different areas. Nutrient index was calculated as shown below:-

$$\text{Nutrient Index} = \frac{(N_l X1) + (N_m x2) + (N_h x3)}{N_t}$$

N_t = Total number of samples analysed for a nutrient in any given area.

N_l = Number of samples falling in low category of nutrient status.

N_m = Number of samples falling in medium category of nutrient status.

N_h = Number of samples falling in high category of nutrient status.

Separate indices are calculated for nitrogen, phosphorus and potassium.

According to this formula, if nutrient index value is less than 1.5, the fertility status is considered low in a given area. A value between 1.5 and 2.5 indicates medium and more than 2.5 high fertility status of the area. Earlier workers used these limits for classifying areas into low, medium and high fertility status. Later on, it was felt that these limits give undue weightage to medium class. As a result a new limit of less than 1.67, and between 1.67-2.32 and more than 2.33 indicating low, medium and high fertility status respectively have been adopted. National level fertility status based on 3.65 million soil sample analysis is as under:

% of the samples falling in different categories				
	Low	*Medium*	*High*	*National index*
N	63.1	25.6	11.3	1.48
P	42.3	37.7	20.0	1.78
K	12.9	36.7	50.4	2.37

To assess the micronutrient deficiency in Indian soils, 2,52,000 soil samples and 25,600 plant samples from 20 States were analysed under the All India Coordinated Research Project for micronutrients (AICRP). State wise micronutrient deficiencies extracted from the Annual reports (1998,99) of AICRP and Micro and Secondary nutrients are given in the **Table 1**. As per these reports, 48% samples were found deficient in zinc, 33% in boron, 13% in molybdenum, 12% in iron and 5% in manganese.

Table 1: Extent of micro nutrient deficiency in India

Name of State Union	*Percent samples deficient (PSD)*					
Territory	*Zn*	*Cu*	*Fe*	*Mn*	*B*	*Mo*
Andhra pradesh	49	< 1	3 1	–	–	
Assam	34	< 1	2	20	–	–
Bihar	54	3	6	2	38	–
Delhi	20	–	–	–	–	–
Gujarat	24	4	8	4	2	10
Haryana	60	2	20	4	0	28
Himachal Pradesh	42	0	27	5	–	–
Jammu & Kashmir	12	–	–	–	–	–
Karnataka	73	5	35	17	32	–
Kerala	34	3	> 1	0	–	–
Madhya Pradesh	44	<1	7	1	22	18
Maharashtra	86	0	24	0	–	–
Meghalaya	57	2	–	23	–	–
Orissa	54	–	0	0	–	–
Pondicherry	8	4	2	3	–	–
Punjab	48	1	14	2	13	–
Rajasthan	21	–	–	–	–	–
Tamil Nadu	58	6	17	6	21	–
Uttar Pradesh	46	1	6	3	24	–
West Bengal	36	0	0	3	68	–
All India	48	3	12	5	33	13

Source: Annual Reports (1998, 1999) of AICRP, Micro and Secondary Nutrients.

The nitrogenous fertilizers are being used by larger number of farmers because about 90% of Indian soils give assured response to nitrogen application. Secondly, the nitrogen responses can be visually appreciated by the farmers in terms of the crop growth. The phosphate and potash application is equally critical in view of the fact that about 80% of the soils are low to medium in P status and give significant response to the application of phosphatic fertilizers. Potassic fertilizers are expected to give similar response in 50% of the soils. In other areas, type of crop becomes important factor about response.

The use of major nutrients i.e N P K have been well regulated and monitored in India. The data on food grain production and fertilizer consumption for a period of 50 years is given in the **Table 2** below :

Table 2: Foodgrain production and fertilizer consumption in India over time

Year	*Foodgrain Production*		*Fertilizer consumption*	
	(M.Ton)	*kg* ha^{-1}	*(M.Ton)*	*kg* ha^{-1}
1950-51	50.82	522	0.069	0.52
1960-61	82.02	710	0.306	2.00
1970-71	108.42	872	0.218	13.13
1980-81	129.59	1023	5.52	31.87
1990-91	176.39	1380	12.54	67.49
1991-92	168.38	1382	12.70	69.84
1992-93	179.49	1457	12.15	65.53
1993-94	184.26	1501	12.37	66.67
1994-95	191.50	1546	13.56	73.12
1998-99	203.61	1627	16.79	88.05
1999-2000	208.87	1697	18.06	94.72

The increasing fertilizer consumption has been followed by the increase in food grain production. There may not, however, be direct correlation between fertilizer consumption and food grain production in each year since there are a large number of other factors like rain fall, drought situation and crop management etc. which may affect the crop yields on year to year basis.

Fertilizer & foodgrain prices

The prices of fertilizers and that of food grain are very intimately related which affect the fertilizer consumption by influencing input:output relation. The Government efforts have been to regulate the fertilizer and food grain prices in such a way that the fertilizer use increases for increasing crop production.

Fertilizer Prices

The prices of nitrogenous, phosphatic and potassic used to be statutorily controlled till 24.8.1992. The phosphatic and potassic fertilizers were de-controlled and urea prices were reduced by 10% w.e.f 25.8.1992. Owing to de-control of phosphatic and potassic fertilizers, their prices were increased significantly. The following were the prevailing prices on 24.8.1992 and subsequently.

Date	Price Rs./Ton			% increase in Feb, 2000 over 25.8.92
	Urea	DAP	MOP	
24.8.1992	3060	4680	1700	N = 50%
25.8.1992	2760	app. 6800	app. 5000	P = 90% (as DAP)
1.4.1997	3660	8300	3700	K = 150% (as MOP)
29.1.1999	4000	8300	3700	
29.2.2000	4600	8900	4255	

The fertilizer consumption scenario along with NPK consumption ratio after decontrol is reflected in the **Table 3** in relation to the years preceding decontrol:

Table 3: Consumption of N P K in India

Year	*Consumption of N P K kg* ha^{-1}*				*NPK ratio*
	N	*P*	*K*	*Total*	
1990-91	43.02	17.33	7.14	67.49	6.2:2.4:1
1991-92	44.03	18.18	7.45	69.66	5.9:2.4:1.0
1992-93	45.40	15.32	4.76	65.48	9.5:3.2:1.0
1993-94	47.35	14.38	4.90	66.62	9.6:2.9:1.0
1994-95	51.0	15.73	6.03	72.76	8.4:2.6:1.0
1995-96	52.69	15.54	6.20	74.43	8.5:2.5:1.0
1996-97	55.26	15.97	5.53	76.75	10.0.2.9:1.0
1997-98	57.15	20.52	7.19	84.86	8.1:2.9:1.0
% increase over 1991-92	**(29.79)**	**(12.87)**	**(3.49)**	**(21.82)**	
1998-99	59.52	21.56	6.98	88.05	8.5:3.1:1.0
1999-00	60.77	25.15	8.80	94.72	6.9:2.7:1.0
% increase over 1991-92	**(38.01)**	**(38.33)**	**(18.12)**	**(35.97)**	

**Source:* Deptt. of Agriculture & Cooperation

Due to significant increase in the prices of phosphatic and potassic fertilizers during 1992-93, the consumption of these fertilizers was reduced and NPK consumption ratio which was 5.9:2.4:1 during 1991-92 got widened to 9.5:3.2:1 during 1992-93. However, there was no (immediate) decline in food grain production in the year, which may have been due to the availability of residual nutrients in the form of P &K which might have met the crop needs. Government took steps to lower the market prices of phosphatic and potassic fertilizers by way of giving ad hoc subsidy support. There was a gradual increase in the price of urea which is a major nitrogenous fertilizer accounting for more than 80% nitrogen use in the country. Consequently, the consumption ratio of fertilizers has improved during last two-three years (**Table 3**).

Foodgrain (support) price:

The significance of balanced use of fertilizers has never lost the sight of government. To make sure that fertilizers are consumed in optimum amounts, Government provides price support for important food and other crops of national importance. Minimum support prices for the period between 1992-93 to 2001-02 for various crops is given in **Table 4**. The following data showing the support price during 1992-93 and 2000-01 reveal that over the period, the increase in support price has been between 58% to 92%. Increase in N,P prices has been of nearly the same order (50% to 90%) but in case of potash it is much higher being 150%.

Table 4: Minimum Support Price* of different commodities (Rs./100 kg)

S.No.	*Commodity*	*1992-93*	*2000-01*	*% increase over 92-93*
1.	Paddy (common)	270	490	81.48
	(Fine)	280	520	85.71
2.	Coarse cereals	240	445	85.41
3.	Wheat	330	610	84.84
4.	Gram	600	1100	83.33
5.	Sugarcane	31.0	59.50	91.93
6.	Cotton – H-4	950	1825	92.10
7.	Groundnut	750	1220	62.66
8.	Rapeseed/Mustard	760	1200	57.89
9.	Soyabean (yellow)	525	865	64.76

**Source:* Economics & Statistical Directorate, Min. of Agri.

The increase in support prices of crop produce and that of fertilizer do not relate quantitatively but they bear a trend which shows the good efforts are on to relate the two. Purchasing capacity of the 'food grain' is expressed in terms of the quantity of foodgrain required to buy 1 kg of fertilizers as given in the **Table 5**:

Table 5: Quantity of Food grain required to buy 1 kg of Fertilizers*

	1981-82	*25.8.92*	*1993-94*	*1995-96*	*1998-99*	*99-2000*	*2000-01*
Paddy							
N	4.44	2.22	1.94	2.01	1.81	2.04	1.96
P_2O_5 (DAP)	5.07	4.48	3.62	4.90	3.39	3.15	3.03
K_2O	1.89	2.78	2.05	2.08	1.40	1.45	1.49
Wheat							
N	3.93	2.18	1.82	2.01	1.56	1.82	1.72
P_2O_5 (DAP)	4.48	4.40	3.65	4.90	2.93	2.81	2.66
K_2O	1.67	2.73	1.90	2.08	1.21	1.29	1.22

**Source:* FAI Statistics, 1999-2000.

The above data indicate that kilograms of paddy and wheat required to buy 1 kg of NPK each is gradually reducing. Farmers should, therefore, be able to use fertilizers as required and thus ensure their better balance.

Balanced Fertilization

Balanced fertilization means the application of all the deficient plant nutrients in sufficient amounts, appropriate forms and ratios.

Fertilizer use has been promoted in the country based upon the research support from State agriculture universities, ICAR system as well as the experience of State Departments of Agriculture about the fertilizer use induced crop production. A net work of 530 soil testing laboratories with a capacity to analyze 8 million soil samples annually have been created in the country by the Government and Fertility industry. Over one hundred of these laboratories have been provided with micronutrient testing facilities also. The test data arising out of these laboratories help in formulating recommendation for balanced fertilization. The fact that these laboratories need to be improved, modernised by providing micronutrient testing facilities and computerization for data processing and formulating recommendations for their fast communication to the farmers and more of them to be set up with greater participation of non-governmental organizations is another important aspect needing urgent attention in the country.

Balanced fertilization can be aimed:

- To ensure increased crop yields.
- To improve cost:benefit relationship.
- To improve quality of crops.
- To correct soil nutrient deficiency.
- To maintain or improve soil fertility.
- To avoid or check environmental/soil/underground water pollution.
- To restore soil fertility impaired through imbalanced fertilizer use.

Growth of fertilizer use in different States

The present level of nutrient (NPK) consumption is about 95 kg ha^{-1}. The State to State variation in consumption is an important phenomenon. Consumption of fertilizer nutrients during 1999-2000 was 184.5 kg ha^{-1} in Punjab, 162.9 kg in Tamil Nadu, 158 kg ha^{-1} in Andhra Pradesh, 148.5 kg in Haryana, 136 kg in West Bengal and 103 kg in Karnataka. The nutrient consumption in Orissa was 44 kg ha^{-1}, it was 39.5 kg in Rajasthan, 27.5 kg in Assam and only 3.5 kg in Nagaland. The district wise analysis of fertilizer consumption reveals that out of 464 districts studied during 1998-99, 33 districts consumed more than 200 kg of NPK per hectare annually. The consumption in 44 districts was between 150-200 kg, 98 districts consumed 100-150 kg and 53 districts consumed between 75-100 kg nutrients per hectare. The consumption in 72 districts ranged between 50-75 kg, in 82 districts it was 25-50 kg, in 40 districts it was 10 to 25 kg, 8 districts consumed between 5-10 kg NPK ha^{-1} while the consumption in 34 districts was only upto 5 kg ha^{-1}. The high NPK consuming districts practiced highly intensive agriculture. In such areas, the deficiencies of secondary and micro nutrients have also started appearing which is causing greater imbalance in the available nutrients in the soils. This is evidenced by stagnating yields in these areas and showing the response to micronutrient application. The deficient areas are being delineated with regard to micro and secondary nutrients. The growth, regulation and promotion of micronutrient fertilizers in the country need special attention. State wise nutrient consumption ratio (NPK) as given in **Table 6** shows a great variation from State to State. It is 57.6:14.7:1 in Punjab, 2.2:0.8:1 in Tamil Nadu, 3.0:1.5:1 in West Bengal, 1.6:0.8:1 in Kerala and 7.8:3.4:1 in Andhra Pradesh.

Table 6: State-wise fertilizer nutrients ratio during 1998-99

S.No.	*State*	*N*	*P*	*K*
1.	Andhra Pradesh	7.8	3.4	1.0
2.	Karnataka	3.6	1.9	1.0
3.	Kerala	1.6	.8	1.0
4.	Tamil Nadu	2.2	.8	1.0
5.	A&N Islands	3.1	1.9	1.0
6.	Pondicherry	2.7	1.1	1.0
7.	Gujarat	11.2	4.3	1.0
8.	Madhya Pradesh	18.8	11.4	1.0
9.	Maharashtra	5.7	2.5	1.0
10.	Rajasthan	86.9	30.7	1.0
11.	Dadra & Nagar Haveli	37.3	21.0	1.0
12.	Goa	1.7	.8	1.0
13.	Haryana	167.7	43.4	1.0
14.	Himachal Pradesh	6.9	1.2	1.0
15.	Jammu & Kashmir	23.9	8.1	1.0
16.	Punjab	57.6	14.7	1.0
17.	Uttar Pradesh	28.4	6.4	1.0
18.	Delhi	37.8	3.7	1.0
19.	Assam	4.8	2.0	1.0
20.	Manipur	76.5	7.4	1.0
21.	Meghalaya	18.1	8.8	1.0
22.	Nagaland	7.0	6.4	1.0
23.	Sikkim	10.7	5.6	1.0
24.	Tripura	7.0	1.8	1.0
25.	Arunachal Pradesh	3.3	1.4	1.0
26.	Mizoram	.6	1.4	1.0
27.	Bihar	11.6	3.0	1.0
28.	Orissa	4.4	1.3	1.0
29.	West Bengal	3.0	1.5	1.0
	ALL INDIA	8.5	3.1	1.0

A good crop response depends upon the balanced application of nutrients including micronutrients, adequate water supply, required plant protection measures and sound farm management practices. A national level aggregate response of food crops to the fertilizer consumption was considered as 1:7.5 during 8th plan and 1:7 in the beginning of 9th plan. Based upon a study conducted by Indian Agricultural Statistical Research Institute during 1999-2000, the aggregate fertilizer use crop response from 15 Agro-climatic regions of the country, works out to be 6.5 (**Table 7**).

The data in **Table 8** show that farmers use fertilizers at a much lower level than recommended which is another cause for imbalanced use and lower response.

Table 7: Response ratios for various proportions of acreage under situation-I and II

Acreage (%) Under		*Response – Fertilizer ratio*	
Situation-I	*Situation-II*	*Foodgrains*	*Foodgrains + Oilseeds*
80	20	5.77	5.62
70	30	6.01	5.88
60	40	6.25	6.14
50	50	6.50	6.40
40	60	6.74	6.66
30	70	6.98	6.92
20	80	7.22	7.18

Situation I – *When farmers use their own cultural and management practice.*
Situation II – *When farmers adopt the improved cultural and management crops.*

Table 8: Response-fertilizer ratios for different crop groups (All India)*

Crop	*Area 000'ha*	*Farmers' average fert. level (kg ha^{-1})*				*Recommended Average fert. level (kg ha^{-1})*				*Fertilizer response ratio*		
		N	*P*	*K*	*Total*	*N*	*P*	*K*	*Total*	*Sit-I*	*Sit-II*	*Av.*
Cereals	101108	55	22	8	**85**	97	49	34	**182**	5.33	7.88	6.61
Pulse	10407	9	17	0	**26**	21	50	4	**75**	4.87	5.98	5.43
Foodgrains	111515	50	21	7	**78**	19	48	31	**98**	5.29	7.70	6.50
Oilseeds	17328	21	29	2	**52**	43	15	20	**78**	3.96	7.70	5.83
Foodgrains + Oilseeds	128843	46	22	7	**75**	84	48	30	**162**	5.11	7.70	6.41
Cotton	7293	70	24	8	**102**	113	14	45	**172**	6.51	7.20	6.86

**Source:* Fertilizer Response Ratios for Different Crops in India (IASRI), 2000

Fertilizer Consumption in Rainfed areas:

Rainfed agriculture is important in India covering about 67% of the net cultivated area. It accounts for 91% each of the coarse cereals and pulses, 80% of oil seed crops and 65% of the cotton produced in the country. Dryland soils are generally coarse textured, low in organic matter and deficient in nutrients especially N, P, K, zinc and sulphur. Mostly one crop is taken in rainfed areas. (Singh *et al.*, 2001). Fertilizer consumption in these areas ranges between 10-30 kg NPK ha^{-1} The soils are considered not only thirsty but hungry too. Integrated nutrient management and moisture conservation is important for these areas. Fertilizer management in general and balanced fertilization in specific terms is important for rainfed agriculture. The practice of P & K application is not very popular except P use in leguminous pulse crops.

NPK Consumption Ratio:

The declining response can be attributed, among other factors, to the lack of nutrient supply in the soils and inadequacy of their application in many cases. Fertilization of such areas with NPK alone will be imbalanced fertilization. In the numerous studies, it has been clearly brought out that fertilizer use by farmers in most crops is not as per recommendations

The inherent fertility status of the soil is one of the most important factors which determines the need about types and amounts of plant nutrients to be used through fertilizers. The physical, chemical and biological reactions in the soil-plant system affect the fate of the applied nutrients in terms of their use by the crops or loss through various phenomena. The fertilizer use needs to be promoted accordingly to the soil nutrient status, crop requirement and the balanced to be applied through fertilizers and most ideally in the integrated form containing chemical sources, biological materials like biofertilizers, compost and green manures etc. At the national level, it has been generally recognised that NPK consumption ratio of 4:2:1 may be attained. In fact this ratio corresponds to the standard recommended dose of 120:60:40 of NPK for the crops of paddy and wheat. These crops also consume substantial amounts of fertilizers both per unit area and in absolute amounts due to the coverage of large areas by these crops being 44.8 million ha under paddy and 25 million ha under wheat out of the total 120 million ha under food grains. There may not, however, be pre-determined NPK consumption ratio which may be aimed at but Government efforts have been to promote the use of phosphorus and potash also according to the soil deficiencies and crop needs so as to bring a better ratio in their use. For this purpose a NPK ratio of 4:2:1 was targeted to be considered as desirable which is in consonation with the NPK requirement of wheat/paddy crops. With the spread of fertilizer use in other crops & diversification of crops, the targeted ratio also changes. The efforts in the past have helped in improving the consumption of P & K and thus bringing a greater balance in NPK use. Eventually, each fertilizer application in a piece of land is advocated on the basis of soil test reports. Such application of fertilizer can only ensure balanced fertilization. The widely advocated guidelines for balanced fertilizer use may consist of the following practices (FADINAP, 1993):-

- Fertilizer application on soil test basis.
- Cultivation of high yielding varieties of crops.
- Correlation of all nutrient deficiencies.
- Integrated fertilizer – water management.
- Adoption of best management practices.
- Split application of N to match the soil type and duration of the crops.
- Treatment of urea with neem seed cake or its extract or using coating agent like sulphur, gypsum etc.
- Drilling / placement of soluble P fertilizers.
- Split application of K in coarse textured soils under high rainfall.
- Dipping of rice seedling roots / potato seed tubes in slurries of P and / or zinc fertilizer before planting.

Results of some field trials conducted under the Project Directorate for Cropping Systems Research (PDCSR), Modipuram (1998-99, 1999-2000) have been cited to see the effects of balanced fertilization and nutrient interaction on maintenance of soil fertility and improvement of crop productivity (**Table 9**).

Table 9: Crop yields under Permanent Plot experiments and Effect of Fertilizer x organic manures

S.No	*Treatment*	Crop Yield (kg ha^{-1})			
		Rice-Rice		*Rice-wheat*	
		Rajendra Nagar	*Ludhiana*	*Raipur*	*Varanasi*
1.	Control	7087	3094	3149	2335
2.	50% NPK dose	9603	6289	6336	3152
3.	75% NPK dose	10285	6864	7727	4003
4.	100%NPK dose	10645	8675	8669	4693
5.	50% fertilizers + 50% org. manures	10979	8400	7981	3922
6.	75% fertilizers + 25% or. Manures	10492	7872	8098	4037
	CD at 5%	477	236	170	208

The application of recommended doses of nutrient shows a much higher yield than the sub-normal dose. The combination of chemical fertilizers and organic manures shows their beneficial effects.

The interaction of N & P, N & K and PK is clearly demonstrated in **Tables 10 -12** suggesting the need for application of nutrients in balanced form.

Table 10: Yield (kg ha^{-1}) as affected by N & P interaction

	P_2O_5	*N kgha*			*CD 5%*
		40	80	120	
Rice (Bhubneshwar)	0	1789	2222	2463	108
	40	1885	2324	2469	
	80	1943	2580	2721	
Wheat (Rewa)	0	3401	3757	4359	227
	40	3414	4000	4605	
	80	3580	4438	4782	
Maize (Ranchi)	0	220	413	447	66
	40	223	499	643	
	80	264	488	750	

Table 11: Yield (kg ha^{-1}) as affected by N & K interaction

	K	*N kgha*			*CD 5%*
		40	*80*	*120*	
Maize (Siruguppa)	0	2906	3918	4371	350
	40	3170	3515	5247	

Table 12: Yield (kg ha^{-1}) as affected by P & K interaction

	K	P_2O_5 kgha			CD 5%
		0	40	80	
Rice (Bhubaneshwar)	0	3196	3488	3619	162
	40	3429	3904	4225	
Wheat (Ranchi)	0	1236	3799	4219	357
	40	1566	4642	3990	

The response to zinc and sulphur, other important deficient nutrients is depicted in the **Tables 13** and **14**. Response of various crops to the

Table 13: Response of Zinc & Sulphur in Rice-wheat cropping system (Kalyani, West Bengal)

Rice (irrigated)		*Wheat (irrigated)*	
Var. IET-4094 Dose 80:60:40		Var. UP –262 Dose 100:60:40	
S.No.	*Treatment*	*Average yield (kg ha^{-1})*	
		Rice	*Wheat*
1.	Control	4570	3420
2.	S-25 kg ha^{-1}	4890	3670
3.	Zinc 10 kg ha^{-1} (Zinc Sulphate)	5110	3400
	CD at 5%	227	155

Table 14: Soyabean-wheat at Sehore

Soybean (Rainfed)		*Wheat (irrigated)*	
Var. JS. 335 Dose 20:80:20		Lok-I 100:60:40	
S.No.	*Treatment*	*Average yield (kg ha^{-1})*	
		Soybean	*Wheat*
1.	Control	1369	3167
2.	S-25 kg ha^{-1}	1667	3952
3.	Zinc – 10 kg ha^{-1}	1643	3571
	CD at 5%	163	156

application of different micronutrients has been summarized by Singh, 1998, 99 (**Tables 15** and **16**). It shows the need for regular application of micronutrients and to build the same in fertilizer use recommendations.

Improvement of fertilizer use efficiency

The improvement in fertilizer use efficiency is directly related to the improvement in balanced use and resultant improved cost:benefit relationship. The nutrient use efficiency is briefly described below:

Nitrogen: The efficiency of nitrogen use ranges between 30 to 50% which is rather low. In India, paddy being a major crop using fertilizer and urea

Table 15: Response of crops to zinc in few states of India

Crop	*No. of Expt.*	*Range of response t ha^{-1}*		*Average response t ha^{-1}*
		Individual expt.	*Main expt.*	
Wheat	2447	0.00-4.70	0.01-1.47	0.42
Rice	1652	0.00-5.47	0.14-1.27	0.54
Maize	280	0.01-3.09	0.11-1.37	0.47
Barley	17	0.11-1.18	0.49-0.73	0.55
Oat	2	0.05-0.82	–	0.42
Sorghum	83	0.07-1.35	0.21-0.65	0.36
Pearl Millet	236	0.00-1.17	0.17-.046	0.19
Finger Millet	47	0.00-1.25	0.08-0.42	0.36
Lentil	16	0.03-0.58	0.08-0.39	0.22
Chickpea	15	0.10-1.01	0.23-0.56	0.36
Peas	3	0.18-0.71	0.45-0.48	0.46
Pigeon Pea	1	0.08-0.38	–	0.16
Black gram	10	0.07-1.12	0.11-1.12	0.24
Green gram	9	0.05-0.45	0.06-0.30	0.17
Cow Pea	1	0.31-0.49	–	0.21
Groundnut	83	0.04-0.60	0.21-0.47	0.32
Soybean	12	0.08-0.69	0.16-0.39	0.36
Mustard	11	0.02-0.34	0.14-0.26	0.27
Linseed	5	0.12-0.21	0.15-0.20	0.16
Sunflower	8	0.01-0.67	0.15-0.20	0.24
Sesamum	2	1.32-6.01	–	3.62
Jowar fodder	3	0.90-2.71	–	3.62
Oats fodder	1	0.40-1.20	–	0.90
Sunflower fodder	1	0.80-1.77	–	1.33
Guar fodder	4	0.14-0.41	0.21-0.23	0.22
Chillies	1	0.66-1.53	–	1.03
Onion	3	1.36-8.70	1.70-4.91	5.13
Lady Finger	1	0.01-0.09	–	0.04
Potato	45	1.10-7.60	2.40-3.90	2.96
Sugarcane	6	8.00-4.30	1.72-2.40	37.70
Tea	1	–	–	0.02
Turmeric	1	–	–	3.98
Tobacco	1	0.43-1.65	–	0.92
Cotton	27	0.01-0.78	0.06-0.24	0.22

Source : Annual Report (1999) AICRP on Micro and Secondary Nutrients.

being the pre-dominant source of nitrogen supply to crops, its use efficiency is obviously low. It is important to appreciate the mechanism of nitrogen transformation in the soils to regulate the process for improving its use efficiency. The applied nitrogen goes through one or more of the processes of

Table 16: Responses of crops to Fe, Mn and boron application

Crop	*No. Expt.*	*Response t ha^{-1}*	
		Range	*Mean*
Iron			
Wheat	81	0.0-2.50	0.82
Rice	31	0.20-4.40	1.39
Maize	2	–	1.04
Sorghum	23	0.03-2.9	0.60
Pearl millets	2	0.60-0.80	0.70
Finger millets	2	0.21-0.38	0.30
Lentil	7	0.00-1.01	0.43
Chick pea	7	0.05-0.82	0.33
Black gram	1	0.16-0.50	0.34
Ground nut	10	0.05-0.70	0.89
Sunflower	3	0.46-0.80	0.55
Soyabean	3	0.21-1.00	0.34
Potato	37	1.1-6.90	3.40
Tapoica	1	–	0.39
Tobacco	1	0.60-1.7	1.00
Turmeric	1	–	9.68
Sugarcane	10	2.40-12.80	11.00
Manganese			
Wheat	69	0.0-3.78	0.64
Rice	110	0.40-1.78	0.49
Sorghum	5	0.29-0.51	0.83
Ground nut	1	–	0.11
Sunflower	1	0.40-0.70	0.55
Sesame	1	–	0.43
Soyabean	2	0.03-1.03	0.31
Tomato	1	0.30-0.80	0.60
Potato	35	1.00-3.90	1.90
Boron			
Wheat	35	0.03-1.19	0.39
Rice	107	0.00-1.67	0.32
Maize	5	0.17-1.05	0.57
Chickpea	7	0.09-0.90	0.35
Blackgram	2	0.04-0.35	0.17
Lentil	4	0.04-0.49	0.24
Pigeon pea	2	0.03-0.32	0.19
Ground nut	11	0.05-0.42	0.21
Linseed	2	0.11-0.14	0.12
Sunflower	1	–	0.52
Mustard	2	0.21-0.31	0.26
Sesame	1	–	0.67
Onion	4	3.87-7.30	4.47
Sweet potato	2	0.67-7.0	4.42
Cotton	2	0.06-0.35	0.21

Source : Annual Report (1999) – AICRP on Micro and secondary nutrients.

transformation like mineralisation, nitrification and leaching, de-nitrification and gaseous losses, hydrolysis (urea), volatilization (ammonia), chemical fixation by soil minerals and immobilisation by soil micro organisms. The soil physical, chemical and biological properties regulate the processes. The optimum use of the nitrogen is expected under near neutral soil pH and moisture at 75% of the water holding capacity, adequate aeration and proper soil texture and tilth. Thus the management factors and soil amendment practices particularly in acid, saline and alkali soils play a great role in the nitrogen use efficiency. The nutrient interaction is another important factor which affects the nitrogen use efficiency and also the efficiency of other nutrients. Split application synchronising with peak periods of nitrogen requirement of crops, placement below surface, foliar application, use of nitrification inhibitors in rice fields, use of slow release nitrogen materials or coating of urea with materials like sulphur etc. and the use of super granulated urea and urea briquettes may improve the nitrogen use efficiency. The balanced application as such may not serve the purpose. The factors responsible for fertilizer use have to be so manipulated that the losses of the applied nutrient are minimised and its availability remains in the same ratio in which it was added/applied with the intended crop use.

Phosphorus: Phosphatic fertilizer use by the crops is reported to be 20-30%. It depends on the types of the crops, soil mineralogical composition, microbial population, types of fertilizers used, dose and method of application etc. Studies have been carried out on the formation of reaction products from the applied phosphorus. The formation of calcium-aluminum phosphate in alfisols and ammonium tarankites and variscites in low pH soils while brushite in calcarious soils have been reported to suggest the changes which occur in the applied phosphorus and thus influence its use by the crops. The irrigation system and extent and duration of flooding influence the phosphorous transformation in the soils. Phosphate fixation as calcium phosphate, aluminum and iron phosphate is an important phenomenon influencing P availability to the crops. Solubilization of such fixed phosphorus helps in plant availability. The use of phosphate solubilizing microbes (PSM) is becoming popular in the country and need to be encouraged.

Potassium: Most of the potassium in soils occur within the crystal lattice structures of silicate minerals. Important factors which affect K fixation in soils are pH, nature of clay minerals, cation exchange capacity, nature of cations and moisture regime etc. The soluble and exchangeable forms of potassium remain in equilibrium with each other. A reduction of the soluble form by crop removal or leaching is followed instantly by a transfer from the exchangeable forms so as to maintain the equilibrium relationship. When a soluble potassium salt is added to the soil that contains expandable lattice clay minerals like montmorillonite and vermiculite, a substantial part of it may be converted into a form which is not readily available. Potash fixation should not be considered at a total loss but as an addition to the reserve supply form, which helps to reduce leaching and luxury consumption of soluble and exchangeable form. Its availability is generally intermediate between that of exchangeable and non-exchangeable forms. In case of potash Fertilization, a phenomenon of luxury consumption is observed when a high supply of readily available potassium is present and other growth conditions are favourable, the uptake by crops may far exceed average requirements.

Nutrient Interaction: The nutrient interaction is an important phenomenon influencing their use, efficiency and also the balance in nutrient uptake. The nitrogen and phosphorus interactions are generally recorded to be positive and their affects are associated with the nutrient balance in the plant. If the supply of nitrogen and phosphorus is high relative to that of potassium, growth may be rapid at first, but the potassium concentration in the plants may be reduced to a deficiency level. Thus, at high nitrogen and phosphorus levels, addition of potassium to the soils would be necessary to maintain the nutrient balance required for rapid and continued growth. In a situation of high available potassium, and low nitrogen or phosphorus supply, luxury consumption of potassium can be expected. Thus, all nutrients have to be applied in a certain proportion which are determined taking into account the soil available status and requirement of crop / cropping system / crop rotation in question. The NP interaction is of great practical importance because of wide spread deficiencies of N & P in Indian soils. In case of leguminous crops, the interaction may be negative at times. The NK interaction is strongest in crops which require high amount of potassium such as potatoes, sugar beet and maize. At higher rate of nitrogen, higher rate of K are needed to achieve higher crop yields.

In the event of one limiting nutrient, synergism or antagonism between different nutrient is likely to occur. Several studies have shown that the interaction effects of N x S, K x S, Ca x S and S x Zn are synergistic whereas P x S (at high levels only), and S x Mo were antagonistic in influencing the yield, quality (oil, protein, amino acid and fatty acid synthesis) and uptake of nutrients by different crops. To illustrate an example of the differential behaviour of one nutrient in relation to the concentration or rate of application of other nutrient, SxP interaction study of Aulakh *et al.*, 2001 in soybean is cited. At adequate levels of 40 kg S and 80 kg P_2O_5 ha^{-1}, the seed yield and oil content of soybean increased from 6.1 and 1.1 q ha^{-1} in control to 17.4 and 4.1 q ha^{-1}, respectively. But application of 20 kg S and 120 kg P_2O_5 ha^{-1} created an imbalanced and reduced the seed and oil yield to 15.8 and 3.6 q ha^{-1} respectively.

Brassica and legumes grown on the soils having high levels of available Mo often accumulate relatively toxic amounts of Mo. As a result of the antagonistic effect of S on Mo, the Mo toxicity can be alleviated with the application of S as S fertilization suppresses Mo uptake and consequently improves plant growth for a crop grown on a highly Mo-polluted soils. Selenium (Se) is not an essential element for plants but its concentration in forage crops is important for animal health. Selenium poisoning of animals has been reported in the foothill areas of Shivaliks where groundwater containing appreciable amounts of soluble Se is used for irrigation. Sulphur applications alleviate the harmful effect of Se grown on Se-toxic soils. Thus, S fertilization is useful not only in increasing crop production, oil content, and protein, but also in improving soil conditions for crop growth. (Aulakh 2001). Similarly, the interaction among various other essential plant nutrients is important and needs to be taken note of in formulating fertilizer use practices.

Mining of Nutrients from the soil :

As per the present level of crop production, estimated nutrient (NPK) removed is about 28 million tons. Consumption of nutrients through chemical fertilizers being 18.0 million tons, a negative balance of 10.0 million tons nutrients is estimated. Organic manures may be supplying estimated 4.0 million tons of nutrients thus leaving a net negative balance of 6.0 million tons/year. Crop-wise removal of nutrients (NPK, S) as compared by Tandon (1991) is indicated in **Table 17.** It may be seen that the nutrient removed in many crops is much higher than the recommended doses. The farmers do not use nutrients, often, as per recommendations which is a cause of nutrient deficiency and imbalance in the soil-plant system. Erosion is another factor responsible for nutrient loss from the soils.

The lack of supply of required micro and secondary nutrients results into stagnant or reduced crop production which needs to be addressed on priority

Table 5: Crops Uptake of NPK and S

Crop	Yield (kg ha^{-1})	Total Uptake (kg ha^{-1})			
		Nitrogen	Phosphorus	Potassium	Sulphur
Wheat	3900	136.5	25.7	137.2	11.9
Rice(Kharif)	2682	56.5	12.2	59.0	6.5
Rice(Rabi)	3131	63.5	11.4	67.0	10.0
Maize	2132	61.0	9.9	51.0	6.5
Chick pea	1500	91.0	6.0	49.0	13.0
Lentil	2000	114.0	13.0	36.0	6.0
Pigeon pea	1200	85.0	8.0	16.0	9.0
Black gram	890	17.8	5.6	50.1	5.1
Green gram	1000	106.0	21.0	61.0	12.0
Ground nut	2550	75.2	6.0	64.3	8.5
Mustard	2596	130.9	25.3	133.3	44.9
Soyabean	2500	125.0	43.0	101.0	22.0
Sunflower	2380	114.2	26.4	141.3	16.8
Safflower	1909	74.4	6.6	34.9	24.3
Seasame	1200	62.0	24.0	64.0	14.0
Linseed	1600	96.0	13.0	72.0	9.0
Tea	1000	110.0	16.5	37.0	10.0

Source : Data compiled by Tandon (1991).

in most of the areas in the country. While the delineation of the different areas needs to be done on faster speed, the already identified areas may have to be supplied with required nutrients. Chemical fertilizers are the major source. However, compost prepared with farm waste and cow dung, vermi-compost and sugarcane press mud etc. can be a good source of supply of micro & secondary nutrients. Ploughing back the crops residues also helps for building the nutrient status of the soil.

Policies & Economic issues:

The Indian fertilizer use is the third largest in the world at 18.1 million mt. nutrients during 1999-2000. The consumption is steadily increasing. This poses significant challenges on the supply side due to the lack of indigenous resources for fertilizer manufacture particularly phosphatic and potassic fertilizers.

(i) After the severe droughts of the mid-1960s, the Government of India gave top priority to increase agricultural productivity which led to the launching of Green Revolution in the country. The fertilizer sector became a priority sector. Stable prices and costs during the 1960s and 1980s enabled Indian fertilizer industry and agricultural productivity to prosper.

(ii) The first energy crisis increased feedstock costs but fertilizer cost increases were not passed on to farmers. This continued to help the farmers in using fertilizers.

(iii) Faced with rising costs, and increasing subsidy, the government set up the Marathe committee in 1976 that recommended the Retention Pricing Scheme (RPS) for nitrogen producers. The objectives of RPS were to:

(1) stimulate fertilizer use and crop yields by keeping retail fertilizer prices at low levels,

(2) keep domestic producers viable given the sharp increase in raw material costs and cost of production.

(3) The retention prices were plant specific and were calculated based on production costs plus a 12% after-tax return on capital.

(4) The cost of production calculation utilised industry norms for capacity utilisation and raw material use efficiencies.

(iv) The Government used to fix the maximum sales price (MSP). This used to be the retail ceiling price for all the controlled fertilizers which is now valid in case of urea only. Phosphatic and potassic fertilizers stand decontrolled w.e.f. 25.8.1992. Due to Ad hoc subsidy scheme being operated for these fertilizers, indicative sale prices are declared for decontrolled fertilizers also.

(v) The subsidy paid to the producers used to be the difference between the retention price and the company's realization from selling at the MSP. Fixed transportation costs to distribution points were also used to be reimbursed to producers.

(vi) After implementing the RPS for nitrogen products in 1977, RPS was introduced for phosphate fertilizers in coming years, including single super phosphate in 1982.

The RPS system had the following effects:

(a) Stimulating Demand: Total nutrient use increased by 8.7%/year from 5.2 million t in 1980 to 12 million t in 1990.

(b) Stimulating Supply: Urea production increased by 13.8%/year from 3.5 million t in 1980 to 12.8 million t in 1990.

As a result, the subsidy bill also increased from 5 billion rupees in 1980-81 to 44 billion rupees in 1990-91.

(vii) General economic reforms necessitated the fertilizer subsidy issue to be addressed afresh. Govt. increased the retail price of fertilizer by 40% in 1991 and low analysis fertilizers were decontrolled. The price increase was later rolled back to 30% and small farmers were exempted from this increase but this exemption was found to be difficult to administer and monitor.

- With the increasing amounts of subsidy, the Govt. took some special measures, the most important one was to decontrol phosphatic and potassic fertilizers in Aug,1992. However, urea prices were reduced by 10%.

- Low-analysis fertilizers were bought back under price control.

- Ad-hoc subsidies @ Rs.1000/ton was introduced on DAP, MOP and proportionate amounts on complexes during *Rabi* 1992. SSP was not covered.

- Certain other measures were taken to cushion the impact of decontrol. Govt. introduced a scheme with an outlay of Rs. 400 crores to create infrastructural facilities particularly to benefit the small and marginal farmers. This was considered a very useful scheme by the States.

- Convertibility of rupee and unified exchange rate were introduced during 1993. Ad hoc subsidies were introduced for SSP and only indigenous DAP was kept eligible and imported DAP was kept out side the scheme during 1993-94 to 5.7.1996.

- Retail urea price was increased by 20% w.e.f 10.6.1994. Low analysis fertilizers were decontrolled again.

- Subsidy on indigenous DAP was increased to Rs.3,000 and subsidy on imported DAP was made available at Rs.1,500 during 1996-97. Subsidy on SSP was raised from Rs.340/ton to Rs.500/ton.

- Hanumantha Rao Committee (HRC) was set up in 1997 to explore the reforms of the RPS. Empowered Committee was set up to determine the subsidies for decontrolled fertilizers. Industry was represented.

- DAP subsidies were increased by Rs. 750, and Rs. 1,500. Differential between indigenous and imported DAP was maintained. MOP subsidy was increased by Rs. 500 while that of SSP by Rs. 100 per tonne.

- The subsidy on indigenous DAP was raised to Rs. 4,400/tonne, on imported DAP to Rs. 3,400/ton and on MOP to Rs. 3,000/ton in April, 1998.

- Producers are now paid 80% of the initial subsidy. Since 1999 each quarter, a final subsidy is determined based on exchange rates and cost of imported materials during the previous quarter.

- Import duties of 5.5% were levied on all fertilizer imports.

- In March 2000, provisional subsidies were lowered to Rs. 3,900 from Rs. 4,550 for indigenous DAP and Rs. 1,050 for imported DAP. For MOP, it was brought to Rs. 2,800 from Rs. 3,350 and for SSP to Rs. 800 from Rs. 900/tonne.

- It may be seen that the Government has been continuously monitoring the fertilizer situation keeping in view the internal demand supply position and international price fluctuations. Government has been reviewing and accordingly revising price support so that the fertilizer supply is not obstructed due to market fluctuations. The success of these measures can be seen in the growing fertilizer consumption and improving NPK consumption ratio. One can argue that the position could have been even better for which Government continues to make efforts in consultation with the fertilizer industry and others concerned.

- Government has been implementing a scheme on Balanced & Integrated Use of fertilizers with a view to strengthen the soil testing labs for ensuring improved fertilizer use recommendations based on soil test reports so that balanced fertilizer is promoted. The scheme also supports the programmes aimed at increasing the availability of organic plant nutrients as supplementary source.

- The Indian fertilizer subsidy has, however, increased exponentially in recent years. The factors that have caused this increase are:

  (a) Subsidies are paid on more tonnage each year hence subsidy amount increases with increasing consumption of fertilizers.

  (b) Due to non-increase of retail prices, the subsidy bill continues to increase.

  (c) The steady depreciation of the rupee has significantly increased the cost of imported raw materials, intermediates and final products hence more subsidies on price controlled fertilizers.

- In July 2000, the Ministry of Chemicals & Fertilizers issued a draft long-term fertilizer policy based on the HRC report, which aims to adopt a single retention price for the entire industry while providing some cost reimbursements for high cost plants for a limited period.

- The increase in fertilizer prices gradually, which may be commensurate with the support prices for food grain and other agricultural commodities could be one way to check the fertilizer subsidy. However, support prices do not help the farmers who do not have marketable surplus.

- The most effective way could be to improve the fertilizer use efficiency which would result into improved profitability of the farmers by way of saving in fertilizer use for a given land area and getting higher production per unit. The balanced fertilization is the key to improve fertilizer use efficiency. Fertilizer use efficiency stipulates the use of all deficient nutrients in integrated manner involving chemical fertilizers including micronutrients, bio-fertilizes, organic manures, green manures etc.

- The successful and profitable fertilizer use has been achieved due to:-

  (a) Appropriate Government policies and programmes.

  (b) Due to the promotional efforts of State Governments and fertilizer industry.

  (c) Farmers' acceptance of the fertilizer use as one of the important means to increase crop production.

- The experience of fertilizer use in India has been described as successful owing to achieving self sufficiency in food production. The most important factors being the affordable prices of fertilizers to the farmers.

- Without commenting on the merit or demerit of the subsidy, the known fact needs to be highlighted that the subsidy is being lowered gradually. It may result in increased selling price of fertilizers. The fertilizer consumption in such a situation may not continue to grow with the same pace as in the past hence increasing food production and the production of other non-food crops may be affected. It is important that the fertilizer prices are kept affordable and the fertilizer use continues to be economical to farmers.

- The existing balance in fertilizer use and their efficiencies are certainly not ideal and would need to be improved in future.

The following further measures are suggested:

(i) Soil testing labs need to be effectively strengthened including smicronutrients and involvement of private entrepreneurship may be encouraged in this service.

(ii) A system of charging fee on soil analysis may be introduced in all labs and the improved fertilizer use recommendations may be made available to the farmers for their timely adoption.

(iii) Fertilizer products of greater efficiency may be introduced which may include:–

(a) Products having major nutrients fortified with micro/secondary nutrients based on the compatibility of the products and the identified and established deficiency for the micro/secondary micronutrient in question.

(b) Products suitable for drip/sprinkling system of irrigation may be popularised.

(c) Integrated nutrient products having organic manures fortified with chemical fertilizers may be promoted.

(iv) Orientation of the research emphasis may be changed and the studies on the economics of the fertilizer use with changed price situation may be undertaken. Fertilizer recommendation may need to be reviewed taking into account changing cropping pattern, fertilizer response and fertilizer prices.

(v) Special efforts may be made to promote the use of super phosphate in the country which is an important source of supply of P, S and calcium. The Government policy of supplying at least 30% of phosphorus through SSP got dis-continued in the process of SSP getting into dis-use due to frequent problem of manufacture and supply of un-satisfactory quality products by many SSP units. Revival of both the policy and quality of SSP will help farmers, SSP industry and the country.

(vi) Government may consider launching a National Programme on Promotion and use of micronutrients which may include delineation of deficient areas, their mapping, and manufacture of standard quality products and their use based on soil test reports.

(vii) Extension and promotion of fertilizers needs to be done much more now than before due to the likely decontrol in future which has mostly set in the process. Fertilizer Industry may need to recognise that one important way of improving the efficiency of chemical fertilizers is to mix fertilizers with organic manures before use. Improved efficiency will ensure improved profitability and their continued use by the farmers. Integrated use of nutrients may need to be the thrust of fertilizer promotion by the industry and Government in future.

(viii) In Government policies, a price parity on all the major nutrients may be considered. To each nutrient, a value worth its utility and response may be assigned and then building these aspects in pricing/subsidy, may be helpful. No benefit can accrue due to use of a nutrient just because it is cheaper than other required nutrient. No nutrient can replace its requirement by another. They are not interchangeable.

(ix) With the opening up of World Trade globally, the country may have to keep in mind the efficient and competitive fertilizer manufactured elsewhere and take steps to bring in the less efficient fertilizer units to the required level of efficiency. Otherwise, the fertilizer supply may not remain sustainable.

(x) Crop support price scheme has been of immense use and may continue. A price increase in fertilizers may be built into the price increase in food grain to the extent of contribution of fertilizers in the cost of production. It is estimated to be 10-12% in most of the crops.

(xi) In States of North-Eastern region, the private entrepreneurship in fertilizer distribution may be encouraged to have greater availability of funds for fertilizer procurement and distribution as has been done with good success in almost all other major States in the country.

(xii) Special programme may be launched to promote the fertilizer use in rainfed areas which account for about 67% of the net cultivated area in India and contribute about 44% to the country's food grain production while the fertilizer consumption in such areas is quite low.

(xiii) A programme may be launched to monitor the quality of soil including underground waters, micronutrient status, efficiency of nutrient use and crop response at least in 77 districts in the country where the nutrient consumption is more than 150 kg ha^{-1}.

Acknowledgement

The author expresses his appreciation to Potash Research Institute of India and the International Potash Institute for inviting him to give a Plenary lecture on the important subject of Promoting Balanced Fertilization in India on the occasion of International Symposium on Importance of Potassium in the Nutrient Management for Sustainable Crop Production. The author is also grateful to the authorities in the Government of India, Ministry of Agriculture for permitting his participation in the symposium. The views expressed and suggestions given in the paper are, however, in the personal capacity of the author as soil fertility specialist and they may not be the views of the Ministry of Agriculture.

References

Annual Reports 1998-99, 1999-2000. All India Coordinated Research Project on Cropping System (ICAR).

Annual Reports 1998, 1999 & 2000. All India Coordinated Research Project on Micro and Secondary Nutrients.

Aulakh, M.S. 2001. Role of Sulphur in Crop Production. Group discussion on Importance of Sulphur in Balanced Fertilization. October 2001.

Fertilizer Response Ratios for Different Crops in India – A report by IASRI, 2000.

Fertilizer Statistics 1999-2000. The Fertilizer Association of India, New Delhi.

Motsara, *et al.* 1982. *Fertilizer News.* **27:** Sept. 1982.

Parkar, *et al.* 1951. *Agronomy Journal* **43:** 105-112.

Singh, H.P., Srinivas, K. and Sharma, K.L. 2001. Proceedings National Workshop on Phosphorus in Indian Agriculture, pp 169-182, PPIC, Gurgaon.

Tandon, H.L.S. 1992. Management of Nutrient interactions in Agriculture, a Publication of FDCO, New Delhi.

Tandon, H.L.S and Kimo, I.J. 1993. Balanced Fertilizer Use – its practical importance and guidelines for agriculture in the Asia & Pacific Region (FADINAP).