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Crop production and nutrient use efficiency: A review

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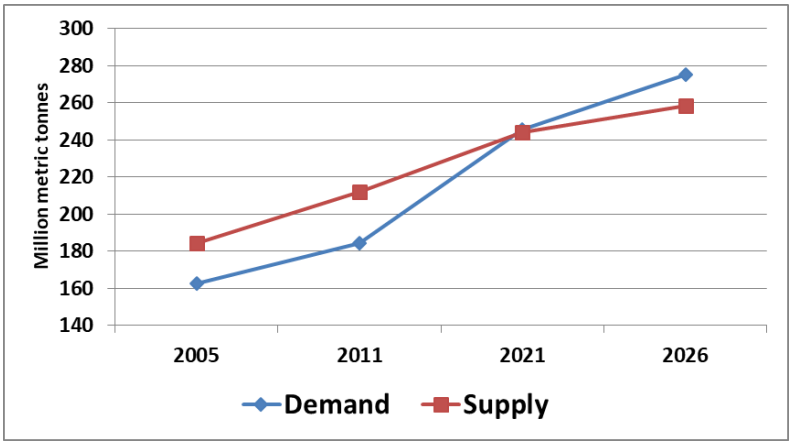
Abstract
Soil resource are under greater pressure because of ever increasing population Indian soils are under continuous threat to various types of degradation particularly nutrient mining which is resulting in the deterioration of soil health and weakening of foundation of sustainable agriculture. The country has become self-sufficient in food production, and the main contributing factor considered is fertilizers in addition to improved/high yielding variety of seed, enhanced irrigation facilities and effective plant protection measures. Fertilizers alone contribute over 50% in increased crop/food production. Growing of high yielding varieties use of high analysis NPK fertilizers, increase in irrigated areas and increase in cropping intensity catalysed the depletion of the finite reserves of micronutrients. As a consequence, deficiencies of micronutrients have been on the rise one by one in the country over last four decades. Application of nutrients at the right rate, right time and in the right place is the best management practice for achieving optimum nutrient efficiency. Use efficiency of micronutrients is very low. Nitrogen use efficiency has also shown declining trend over a period of time while in various other countries the use efficiency is improving.

Keywords: Food production, micronutrient deficiency, nutrient use efficiency, soil health

Introduction
India is the second most populous country in the world. A large percentage of Indian population depends on agriculture for its subsistence. India has 17.31% of the world's populations and it occupies only 2.4% of the worlds land area. Fast growing population causes stress on the available natural resources to meet the food requirement (Singh, 2012) [13]. The continuous increase in population in the country demands for additional food grain. For example in the year 2021 the projected food grain demand would rise to 245 million tonnes, while the net sown area in the country has shown an insignificant increase during past five decades. Under such a precarious situation the gap between demand and supply is obvious as depleted in fig. 1.



Source: Surabhi (2008)

Fig 1: Future supply and demand balance for total cereals in India

Importance of fertilizers

Fertilizers may be regarded as a valuable and concentrated food for plants, their raw material, by and large, being natural. The proof of this is that during the last 35 years when the chemical fertilizers were used in considerable quantities though at much lesser rate but in an imbalanced form, as compared to several developed and developing countries of the world, the average life expectancy in India has increased from 45-62 years therefore, in the real sense the problem lies more with the wrong and indiscriminate use of chemicals be the pesticides or fertilizers or any other chemical, rather than with their use per se.

Soil health is extremely valuable but highly vulnerable. Soil resource are under greater pressure because of ever increasing population Indian soils are under continuous threat to various types of degradation particularly nutrient mining which is resulting in the deterioration of soil health and weakening of foundation of sustainable agriculture. Intensively cultivated areas are manifested with the depletion of soil fertility particularly in respect of secondary and micronutrients.

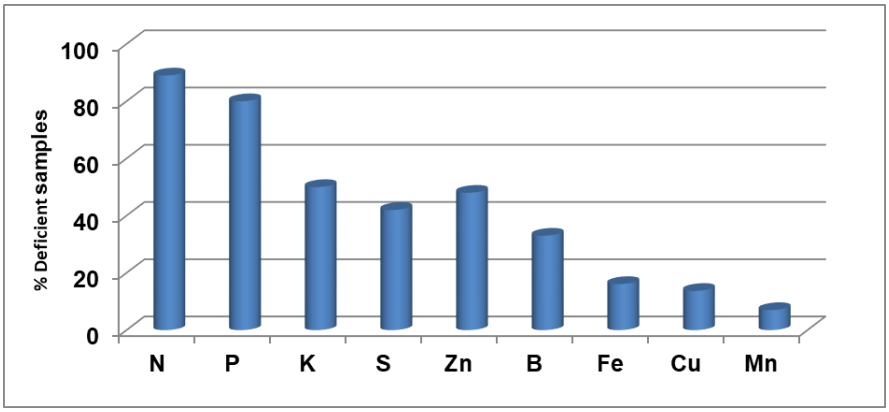


Fig. 2: Nutrient status in Indian soils

Table 1: Food grain production (Mt) and fertilizers consumption (Mt) in India

Year	Production (Mt)	N	P	K	Total
1999-00	209.8	11.59	4.80	1.68	18.07
2000-01	196.81	10.92	4.22	1.57	16.71
2001-02	212.85	11.31	4.38	1.67	17.36
2002-03	174.77	10.47	4.02	1.60	16.09
2003-04	213.19	11.08	4.12	1.60	16.8
2004-05	198.36	11.71	4.62	2.06	18.39
2005-06	208.6	12.72	5.20	2.41	20.33
2006-07	217.28	13.77	5.54	2.34	21.65
2007-08	230.78	14.42	5.52	2.64	22.58
2008-09	234.47	15.09	6.51	3.31	24.91
2009-10	218.11	15.58	7.27	3.63	26.48
2010-11	244.78	16.56	8.05	3.51	28.12
2011-12	259.8	17.30	7.91	2.58	27.79
2012-13	257.1	16.82	6.66	2.61	26.09
2013-14	264.8	17.02	5.65	2.06	24.73
2014-15	252.0	16.94			
2015-16	252.2	17.60			

Source: Ministry of Agriculture, GOI (2014-15)

Fertilizers use and food security

While there is no doubt that nutrient constraints can be alleviated by organic manure additions and by strengthening of soil biological practices but the problem of soil fertility decline is so serious (Kanwar and Katyal, 1997) [21]. That it may not be possible to cover all of it with the use of organic manure alone.

Fertilizers consumption in India has grown from 69000 tonnes of NPK during 1950-51 to 24.72 million tonnes during 2013-14 which is an increase from 0.52 kg to 146 kg ha^{-1} corresponding by the food production has increased from 50 Mt to 264.8 Mt (Table –7). The country has become self-sufficient in food production, and the main contributing factor considered is fertilizers in addition to improved/high yielding variety of seed, enhanced irrigation facilities and effective plant protection measures. Fertilizers alone contribute over 50% in increased crop/food production (fig. 3). Fertilizers consumption has, however, not grown uniformly throughout the country because of the fact that agro-ecological and soil conditions are also not uniform.

Table 2: Food grain production and fertilizer consumption on time scale

Year	Food grain production		Fertilizers consumption	
	Mt	Kg ha^{-1}	Mt	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	2.18	13.13
1980-81	129.59	1023	5.52	31.87
1990-91	176.39	1380	12.54	67.49
1999-2000	208.87	1697	18.06	94.72
2001-02	212.85	1734	17.36	72.90
2004-05	198.36	1652	18.40	75.62
2005-06	208.6	1715	20.34	105.5
2007-08	230.78	1850	22.57	115.27
2009-10	218.20	1798	26.48	137.81
2010-11	244.78	1967	28.12	146.32
2011-12	257.44	-	27.79	144.59
2012-13	257.1	-	25.54	130.8
2013-14	264.8	-	24.72	126.6

Source: Fertilizer statistics (2014-15**)**

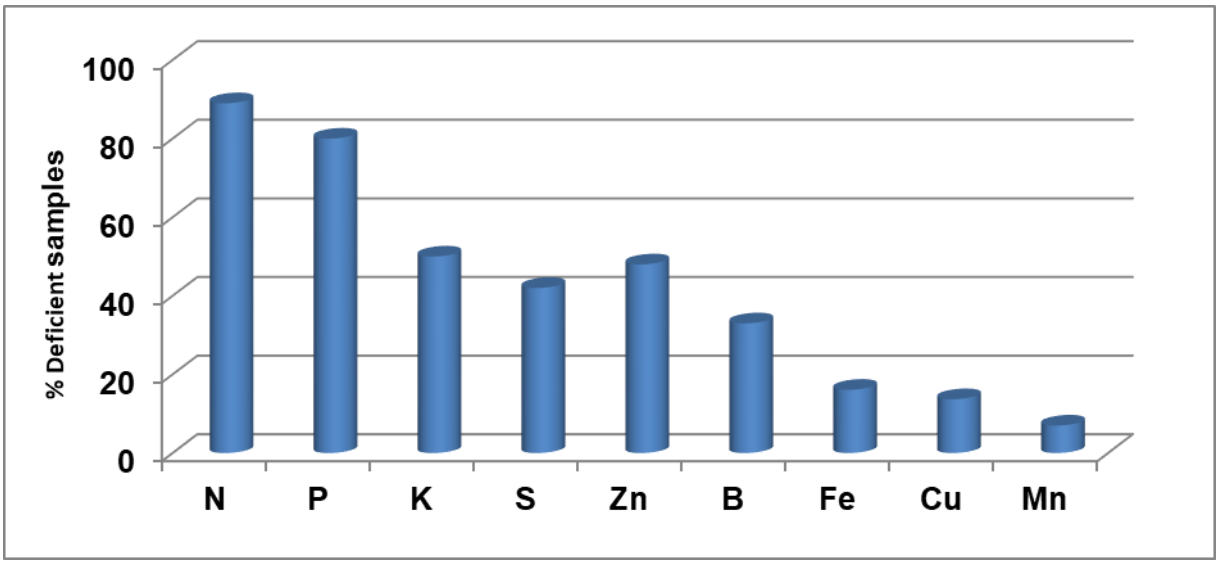


Fig 3: Food production and fertilizers consumption (Mt) trend

Imbalance Use of NPK: Imbalanced use of plant nutrients as well as wide NPK ratio has led to the mining of nutrients and it is the main cause for decline in crop yield and crop response ratio (Table 3).

Table 3: All India consumption trend of fertilizers nutrients

Year	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	N+P_2O_5+K_2O (Kg/ha)	N:P:K
	'000 tonnes				
1960-61	212	53	29	1.9	7.3:1.8:1.0
1970-71	1479	514	2366	13.9	6.3:2.2:1.0
1980-81	3678	1214	624	31.8	5.9:1.9:1.0
1990-91	7997	3221	1328	67.6	6.0:2.4:1.0
2000-01	11310	4372	1667	90.2	6.8:2.6:1.0
2007-08	14419	5514	2636	115.7	5.5:2.1:1.0
2008-09	15090	6506	3312	127.7	4.6:2.0:1.0
2009-10	15580	7274	3632	135.8	4.3:2.0:1.0
2010-11	16890	8001	3391	145.0	5.0:2.4:1.0
2011-12	17300	7914	2575	142.3	6.7:3.1:1.0
2012-13	16820	6653	2062	130.8	8.2: 3.2:1.0
2013-14	16750	5633	2098	126.6	8.3: 2.7: 1.0
2014-15	16945	6099	2533	131.6	6.7: 2.4: 1
2015-16	17599	7069	2333.5	138.9	7.5: 3.0: 1

Source: Indian journal of fertilizers (2016)

Data on balance sheet of nutrients (Table-4) clearly indicates that about 8-10 Mt of N, P and K is mined annually in India (Tandon, 2004) [18].

Table 4: Balance sheet of NPK in India

Gross balance sheet (Mt)						
Nutrient	Addition	Removal	Balance	Net balance sheet (Mt)*		
				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 (52% for N, 35% for P_2O_5 and 70% for K_2O). This also included residual effects on the removal side, this was taken as 80% of crops uptake for N, P and 60% for K.
Source: Prasad (2012) [8].

Soils are also being depleted of secondary and micronutrient. Thus, from single plant nutrient deficiencies in the past, Indian soils are currently witnessing multi-nutrient deficiencies. 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 chemical fertilizers and the rest from organic manures (Prasad, 2012) [8].

Nutrient use efficiency

Soil tests, environmental and climatic data, and production goals determine the uses of the nutrients in a system (Singh, 2012) [13]. Hence application of nutrients at the right rate, right time and in the right place is the best management practice for achieving optimum nutrient efficiency (Robert, 2008). An effective nutrient management involves development of site specific nutrient recommendations including balanced NPK doses, timely application of fertilizers using appropriate methods, development and production of slow-release nitrogen fertilizers and nitrification inhibitors and developing and practicing an integrated plant nutrient supply system.

Table 5: Nutrient use efficiency in India

S. No.	Nutrient	Efficiency (%)
1	Nitrogen	30-50
2	Phosphorus	15-20
3	Potassium	70-80
4	Sulphur	8-12
5	Zinc	2-5
6	Iron	1-2
7	Copper	1-2

Source: Tiwari, (2002)

Response ratio, measured as kg grain produced per kg NPK use declined from 15.0 during 5th plan (1974-79) through 7.5 in 8th plan, 7.0 in 9th plan and 6.5 in 10th plan to 6.0 during 11th plan (2007-12) as demonstrated in fig. 4.

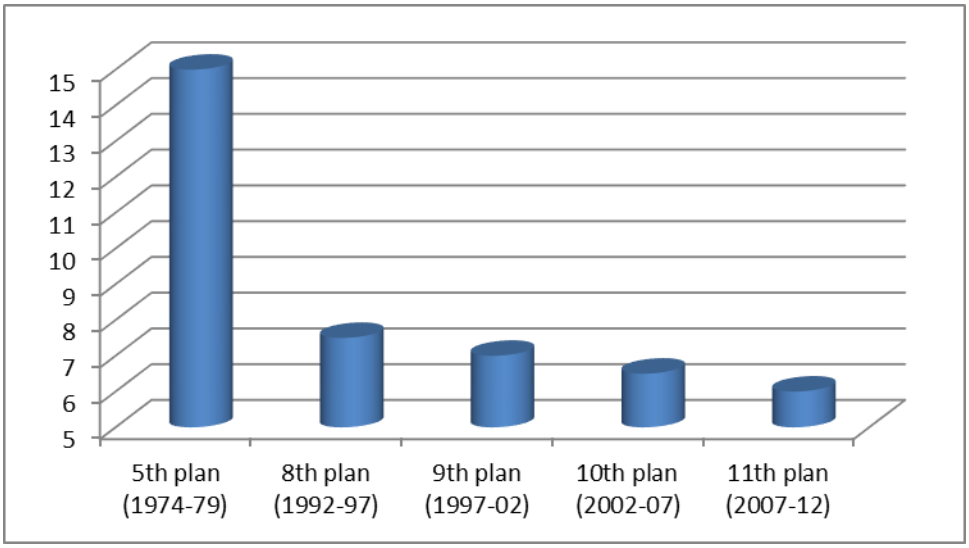


Fig 4: Trend in response ratio in plan periods

Nutrient use efficiency given in table -5 clearly indicates that use efficiency of micronutrients is very low. Nitrogen use efficiency has also shown declining trend over a period of time while in various other countries the use efficiency is improving (Table 6).

Table 6: Change in nitrogen use efficiency in different countries in relation to time

Country	Year	Nitrogen use efficiency	Change (%)	Rate of change (% per year)
India	1970	60	-	-
	2004	20	- 60	-1.7
USA	1980	42	-	-
	2000	57	+ 36	+1.6
U K	1981-85	36	-	-
	2001-02	44	+ 23	+1.1
Japan	1985	57	-	-
	2001	75	+ 32	+1.8

*Indian Journal of Agronomy, June, 2009.

Nutrient deficiency in Indian soil

As a resulted of green Revolution, deficiencies of micronutrients from different parts of country have been reported at time to time (Nene, 1965; Takkar and Nayyar 1981, and Takkar and Randhawa, 1978) [6, 15, 16]. Growing of high yielding varieties use of high analysis NPK fertilizers, increase in irrigated areas and increase in cropping intensity catalysed the depletion of the finite reserves of micronutrients (Rattan *et al.*, 2009) [10]. As a consequence, deficiencies of micronutrients have been on the rise one by one in the country over last four decades (Fig. 5).

Table 7: Progressive expansion in the occurrence of nutrient deficiency in India

							?
						Mo	Mo
					B	B	B
				Mn	Mn	Mn	Mn
				S	S	S	S
			K	K	K	K	K
			Zn	Zn	Zn	Zn	Zn
			P	P	P	P	P
		Fe	Fe	Fe	Fe	Fe	Fe
	N	N	N	N	N	N	N
Year	1950	1960	1970	1980	1985	1990	2005

(**Source:** Rattan *et al.*, 2009) [10]

Conclusion

It is thus important that to achieve desired yield of different crops, their nutrient requirement including major and micronutrients may be met out through different sources such as inorganic fertilizers and organic sources. It is thus apparent that to achieve production levels, there is a need of use of nutrients in integrated manner through different sources.

References

1. Bhattacharyya P. Prospect of organic nutrient resources utilization in India. Indian Journal of fertilizers. 2007; 3(1):93-110.
2. Kanwar JS, Katyal JC. Plant nutrient needs supply efficiency and policy issue 2000-2025 NAAS, New Delhi.

3. Katyal JC. withering soil science education –revival and resurgence boosters. Journal of the Indian society of soil science. 2015; 63(1):1-13.
4. Marwaha BC. Food security in India-Challenges and opportunities. Indian Journal of fertilizers. 2011; 7(12):80-91.
5. Nambiyar KKM. Major cropping systems in India in agricultural sustainability-economic-environment and statistical considerations (Barnett, V., Pyne, R. and Steiner (R eds), 1995, 133-168, John Wiley and sons New York U.S.A.
6. Nene YL. Bulletin of Indian phytopathological society, 1965; 3:97-101.
7. Prasad R. Efficient fertilizers use. The key to food security and better environment. Journal of Tropical Agriculture. 2009; 47(1-2):1-17.
8. Prasad R. Fertilizers and manure, Current science. 2012; 102(6):25-32.
9. Prasad Rajendra. Integrated plant nutrient supply systems (IPNS) for sustainable agricultural. Indian Journal of fertilizers. 2008; 4(12):71-90.
10. Rattan RK, Patel KP, Manjaian KM, Datta SP. Micronutrient in soil, plant, animal and human health. Journal of the Indian society of soil science**.** 2009; 57(4):546-558.
11. Robert LT. Improving nutrient use efficiency. Turkish journal of Agriculture. 2008; 32:177-182.
12. Singh Munishwar, Wanjari RH. Balanced nutrient managements A key to sustain productivity and soil health on long term basis. Indian Journal of fertilizers. 2013; 9(12):72-85.
13. Singh Ravendra. Need to optimize resource use efficiency for sustainable agriculture. Journal of the Indian society of soil science. 2012; 60(S):100-108.
14. Surabhi M. Demand-supply trends and projections of food in India. Working paper No. 20, Indian council for research on international economics relations, New Delhi, 2008.
15. Takkar PN, Nayyar VK. Preliminary field observations of manganese deficiency in wheat and berseem. Fertilizers news. 1981; 26(2):22-23.
16. Takkar PN, Randhawa NS. Micronutrient in Indian agriculture. Fertilizers news. 1978; 23(8):3-26.
17. Tandon HLS. In plant nutrient needs, supply efficiency and policy issue NAAS New Delhi, 1997, 15-28.
18. Tandon, HLS. Fertilizers in Indian agriculture from 20th century to 21st century. FDCO, New Delhi, 2004.
19. Tiwari KN. Nutrient management for sustainable agriculture Journal of the Journal of the Indian society of soil science. 2002; 50(4):374-397.
20. Tomar VS, Gupta GP, Kaushal GS. Soil resources and agro climatic zones of Madhya Pradesh. Department of soil science and agricultural chemistry, J.N.K.V.V. Jabalpur, 1995.
21. Kanwar JS, Katyal JC. Plant nutrient needs supply efficiency and policy issue 2000-2025 NAAS, New Delhi, 1997.
22. Nene YL. Bulletin of Indian phytopathological society. 1965; 3:97-101.
23. Prasad R. Fertilizers and manure, Current science. 2012; 102(6):25:32
24. Rattan RK, Patel KP, Manjaian KM, Datta SP. Micronutrient in soil, plant, animal and human health. Journal of the Indian society of soil science. 2009; 57(4):546-558.
25. Singh Ravendra. Need to optimize resource use efficiency for sustainable agriculture. Journal of the Indian society of soil science. 2012; 60(S):100-108.
26. Takkar PN, Nayyar VK. Preliminary field observations of manganese deficiency in wheat and berseem. Fertilizers news. 1981; 26(2):22-23
27. Takkar PN, Randhawa NS. Micronutrient in Indian agriculture. Fertilizers news. 1978; 23(8):3-26.
28. Tandon HLS. Fertilizers in Indian agriculture from 20th century to 21st century. FDCO, New Delhi, 2004.