

Balanced use of fertilizers:

A key for sustaining crop productivity and soil quality

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Long term fertilizer experiments (LTFEs) conducted across the country illustrated that it is difficult to maintain the pace of productivity to satisfy the food demand of the population without using chemical fertilizers. Results indicated that balanced and integrated nutrient management (INM) improved soil quality which resulted in enhancement of nutrient-use efficiency, grain quality and sustainable crop productivity irrespective of cropping system and soil type. Application of 100% NPK supplemented with Zn and S as per need in major cropping systems sustained the yield. Production was further enhanced by using farmyard manure (FYM) along with recommended dose of fertilizer. Nutrient application either through balanced fertilizer use or INM (100% NPK + FYM) improved soil organic carbon (SOC), physical condition and biological status of soil. Sustainable yield index obtained with balanced and INM was higher over imbalanced fertilizer nutrition. Thus, balanced use of fertilizers is most suitable nutrient application option to sustain crop productivity and soil quality in our country.

Keywords: Balanced fertilizer use, Crop productivity, Long-term fertilizer experiments, Soil quality

SOIL is one of the key components of ecosystem and its quality is the outcome of integrated management of most of the properties of soil that determine crop productivity and sustainability. Continuous application of inadequate and imbalanced use of fertilizers leads to decline in soil organic matter hence, adversely affect the soil quality. Thus, one of the major concerns in Indian agriculture is the imbalanced nutrient use that has resulted in poor crop yields and deterioration in soil fertility and health. There is a gap of around 10 million tonnes of nutrients (NPK) between nutrient removal by crops and subsequent addition through fertilizers. The N:P:K ratio of 4:2:1 is considered ideal and accepted for macro-level monitoring. The NPK use ratio for the whole world is 3.4:1.3:1. However, in India, the current NPK use ratio (employing K as a base) is reported to be 6.5:2.8:1 for 2020–21. For sustainable production

system with minimum damage to the environment, there is need of balanced and integrated nutrient management (INM) practices to maintain organic matter under intensive production system. Our country witnessed Green Revolution, but at the same time it also led to observe nutrient imbalances in terms of emergence of multi-nutrient deficiencies, decrease in nutrient use efficiencies, partial and total factor productivity etc. Based on the United Kingdom's "Rothamsted Classical Experiments" model and also considering the importance of manuring and fertilization on soil and crop quality and the environment, the Indian Council of Agricultural Research (ICAR) launched the All India Coordinated Research Project (AICRP) on Long Term Fertilizer Experiments (LTFEs) in September 1970. The LTFEs were identified in all irrigated and intensively cropped areas representing different agro-climatic

zones. It is well documented that the crop productivity and soil quality are governed by several factors such as soil organic carbon status, balanced nutrient supply, nutrient-use efficiency, soil biological health, etc of the agricultural ecosystem. Keeping this in view, the findings emanated from AICRP on LTFE are briefed hereunder:

Soil organic carbon

Soil organic carbon (SOC) is the key indicator of soil quality and affects majority of the soil properties. Thus, maintaining and enhancing it through better management practices, viz. Balanced and INM is highly needed. Results from the LTFEs conducted in different soil types and major cropping systems in the country clearly demonstrated that SOC improved with an application of balanced (100% NPK) and INM (100% NPK+FYM) practices over imbalanced nutrient application.

Table 1 Effect of nutrient management on crop productivity (kg/ha) at long term fertilizer experimental sites of AICRP LTFE

Treatment	Pantnagar		Ranchi		Akola		Raipur		Palampur	
	Rice	Wheat	Soybean	Wheat	Sorghum	Wheat	Rice	Wheat	Maize	Wheat
	(kg/ha)									
Control	1274	1184	552	715	427	390	1993	1132	600	400
100% N	3296	3182	438	855	1702	721	3308	1713	0	0
100% NP	4103	3447	673	3419	2652	1951	4473	2846	1456	863
100% NPK	3674	3363	1426	3259	3229	2391	4617	2860	3175	1904
150% NPK	3520	3306	1653	3403	3937	3060	5173	3179	2732	1542
100% NPK+Zn/Lime	4432	4071	2081	4218	3420	2560	4517	2873	2903	1658
100% NPK+FYM	5131	4748	2053	4302	4260	3186	5050	3103	4559	2879



100% N (Maize)



100% NPK+FYM (Maize)



100% N (Wheat)



100% NPK+FYM (Wheat)

Effect of application of only nitrogenous fertilizers (100% N) *vis-a-vis* INM (100% NPK+ FYM) on crop growth and productivity in Alfisols of Palampur

Crop productivity

Balanced use of fertilizers as well as INM improved crop productivity across the LTFE sites. The balanced fertilizer uses, i.e. 100% NPK with inclusion of lime and zinc resulted in yield enhancement compared to imbalanced nutrient application over the years. The application of 100% N alone in the form of urea found to reduce the yield drastically

and led to deleterious effect on soil quality and overall soil health (Table 1). The acid soils (Alfisols) of Ranchi, Palampur and Bengaluru are experiencing too much fatigue in recent years. Thus, yield of maize and wheat reached to almost zero due to 100% N that was even inferior to unfertilized control during recent years at Palampur.

Soil biological health

Soil biological health reflects the microbial activity in soil. The dehydrogenase enzyme is one of the most critical indicators of soil respiratory activity as it affects the decomposition of organic matter in soil. The study indicated that dehydrogenase activities (DHA) are adversely influenced with imbalanced fertilizer use. Thus,



N deficiency in finger millet (Bengaluru)



K-deficiency in finger millet (Bengaluru)

balanced and INM is the option to revive the biological health of soil. It has been very well illustrated that 100% NPK and 100% NPK + FYM significantly improved the DHA in major cropping systems in LTFEs.

Nutrient-use efficiency

Nutrient use efficiencies (NUE) of applied N, P and K in majority of crops indicated that the efficiency gradually improved with addition of each nutrient. The efficiency further improved with INM, i.e. NPK+FYM in major crops and soils across LTFE sites. However, NUE had drastically reduced due to imbalanced use of fertilizers.

Nutrient deficiency

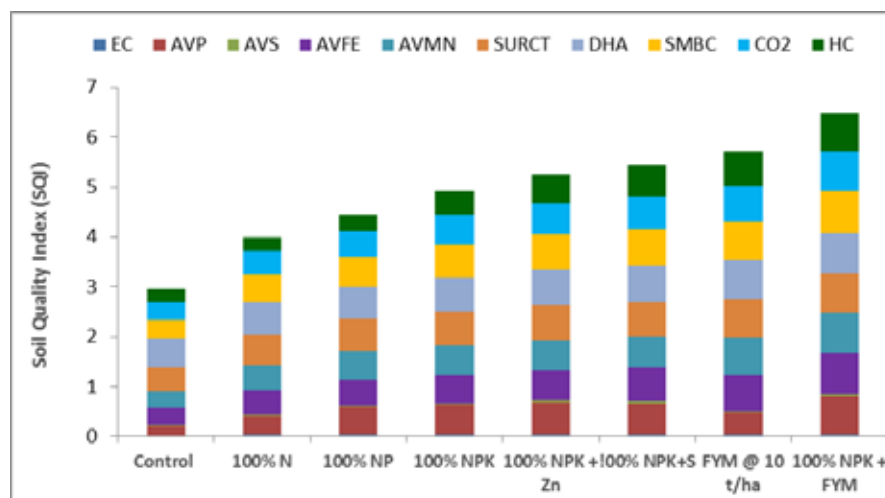
Imbalanced nutrient application resulted in an emergence of nutrient deficiency in some crops and soils over the years. Potassium (K) is a yield limiting nutrient in Alfisols of Bengaluru, Ranchi and Palampur. Similarly, N and S found to be deficient in maize at Bengaluru. Zinc found as a controlling factor in rice, cultivated in Mollisols of Pantnagar (Uttarakhand) and which led to Zn

deficiency in rice that is popularly known as *Khaira* disease. However, integrated nutrient management, i.e. 100% NPK+FYM could met out the deficiency of most of these macro and micronutrients in crops and soils across almost all the LTFEs.

Grain quality and nutritional composition

The study conducted at GKVK Bengaluru under AICRP LTFE indicated that nutrient application at optimal dose (100% NPK, 150%

NPK) and integrated nutrient management (100% NPK + FYM/ Lime) resulted in better grain quality of maize as well as nutritional quality in terms of Ca, Mg and crude proteins of finger millet grain. On the contrary, imbalanced nutrient application (Control, N and NP alone) resulted in poor nutritional quality of grain. As a result grains appeared to be dark in colour and recorded less test weight due to imbalanced nutrient application.



Effect of nutrient management on soil quality at long term fertilizer experiment



S-deficiency in maize (Bengaluru)



K deficiency in soybean (Ranchi)

Table 2. Effect of nutrient management on sustainable yield index at long term fertilizer experimental sites of AICRP LTFE

Soil type	LTFE site	Crop	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+ FYM	100% NPK+ Lime
Alfisols	Bengaluru	Finger millet	-0.26	-0.23	-0.19	0.45	0.61	0.56	0.43
		Maize	-0.20	-0.18	-0.11	0.49	0.60	0.63	0.52
	Palampur	Maize	0.01	0.07	0.15	0.35	0.36	0.53	0.47
		Wheat	0.04	0.05	0.15	0.28	0.28	0.42	0.40
	Ranchi	Soybean	0.10	0.03	0.21	0.49	0.47	0.62	0.60
		Wheat	0.02	0.03	0.40	0.47	0.51	0.61	0.56
Inceptisols	Barrackpore	Rice	0.15	0.29	0.34	0.35	0.41	0.40	
		Wheat	0.11	0.30	0.36	0.38	0.47	0.41	
	Coimbatore	Finger millet	0.08	0.12	0.36	0.37	0.41	0.46	
		Maize	0.06	0.09	0.36	0.39	0.43	0.47	
Vertisols	Akola	Sorghum	-0.01	0.22	0.25	0.34	0.40	0.47	
		Wheat	0.02	0.32	0.33	0.50	0.55	0.59	
	Jabalpur	Soybean	0.13	0.15	0.26	0.31	0.33	0.35	
		Wheat	0.14	0.15	0.5	0.54	0.57	0.59	
Mollisols	Pantnagar	Rice	0.13	0.39	0.43	0.41	0.38	0.50	
		Wheat	0.15	0.46	0.51	0.51	0.50	0.62	

Soil quality

Soil quality index (SQI) is a measurable soil parameter that affects the capacity of a soil to perform a specific function. Soil quality is an effective tool for monitoring soil function by measuring physical, chemical, and biological soil properties. The SQI is computed by selecting a set of soil quality parameters which are referred to as indicators. Results from LTFEs clearly depict the betterment of soil quality on inclusion of FYM with 100% NPK (INM) and also in balanced treatment (100% NPK) compared to imbalanced treatments at LTFE locations.

Yield sustainability

The sustainable yield index (SYI) is a quantitative measure of sustainability and implies minimum guaranteed yield that is obtained relative to maximum yield. The SYI improved with balanced and INM over imbalanced and unfertilized control. The negative values of SYI were observed in Alfisols, i.e. finger millet and maize at Bengaluru. Similarly, SYI values

are approaching towards zero in maize and wheat grown in LTFE at Palampur and soybean and wheat at Ranchi (Table 2). Thus, nutrient management options having negative SYI are not sustainable any more in Alfisols. On the contrary, the SYI were positive with higher values when crop was nourished with balance nutrition or INM.

Revival of crop productivity and soil quality

Based on the studies from LTFEs, the effect of ameliorants and organic manures plays key role in sustaining crop productivity especially in Alfisols. An increase in yield was many fold higher with an application of lime and FYM in soybean and wheat at Ranchi. It has clearly shown that in treatments with imbalanced fertilizers use, application of lime or FYM along with 100% NPK is crucial in Alfisols.

SUMMARY

Results emanated from long-term fertilizer experiments (LTFEs) clearly brought out that there is an increase in crop productivity

on balanced nutrient application through fertilizers. It resulted an increase in soil carbon and microbial population, and thus ruled out the notion that chemical fertilizer deteriorates soil carbon and adversely affects the growth of the soil microorganisms. At Pantnagar, balanced fertilizer use with inclusion of S and Zn had additive effect on yield. In Alfisols, results indicated that application of urea alone (100% N) had deleterious effect on crop productivity as well as grain quality. However, the FYM application was found to be superior to lime amendment as far as soil productivity in Alfisols is concerned. Thus, the soils deteriorated with imbalanced fertilizer use could be revived with either organic manure addition or lime amendment as in case of Alfisols. The soil quality index (SQI) got improved with balanced and integrated nutrient management (100% NPK+FYM).

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Know Krishi Unnati Yojana

The *Krishi Unnati Yojana*, a central sector scheme, is envisaged as umbrella programme for focusing on food security, by merging schemes on Soil-health Card, Integrated Scheme on Agricultural Co-operation and Agricultural Marketing, National Mission on Agriculture Extension, Horticulture Development, Price Stabilization Fund, National Mission on Sustainable Agriculture and other programmes.