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Effect of long term manuring and fertilization on yield and micronutrient status under wheat grown in vertisol

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Abstract
Field experiments were conducted during *rabi* season of 2016-17 (29^{th} cycle) at Akola. The experimental design was randomized block design. There were 12 treatments replicated three times. The treatments comprised of different levels of recommended dose of fertilizers (RDF) viz; 50, 75, 100 and 150% and RDF in combination with farm yard manure (FYM), FYM alone (5 t ha^{-1}), RDF devoid of S, RDF along with S @ 37.5 kg ha^{-1} and Zn @ 2.5 kg ha^{-1}, NP, N alone and control. The results of the present experiment indicated that, application of 100% NPK+ FYM was found beneficial in improving the status of DTPA-Zn (0.93 mg kg^{-1}) followed by 100% NPK+ Zn (0.78 mg kg^{-1}). The DTPA-Fe was slightly increased with the application of 100% NPK+ FYM followed by FYM @ 10 t ha^{-1} (8.68 mg kg^{-1}) and 150% NPK (8.58 mg kg^{-1}) at harvest of wheat. The application of 100% NPK +FYM @ 5 t ha^{-1} (4.18 mg kg^{-1}) was found beneficial in improving the status of DTPA-Cu. The application of 100% NPK + FYM recorded highest DTPA-Mn (8.99 mg ka^{-1}) followed by 150% NPK (8.23 mg kg^{-1}) and FYM @ 10 t ha^{-1} (8.22 mg kg^{-1}). The highest use efficiency of Nitrogen, Phosphorus and Potassium was registered under integrated use of chemical fertilizer and organic manures. The application of 50% NPK also found beneficial in improving N, P, and K use efficiency.

Keywords: Wheat, vertisol, use efficiency, DTPA micronutrients, FYM

Introduction
Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed in several long term experiments all over India (Nambiar, 1994) [5]. Therefore, emphasis should be to optimize the use of chemical fertilizer and to improve their use efficiency. Organic sources constitute an important component of the integrated nutrient management. Addition of nutrients through organic manures and the release of these nutrients from the organics depend on their C: N ratio and lignin content. Integrated use of organics and fertilizers for improving the long term productivity of rice-wheat system was reported by Bhandari *et al.* (2002) [2] and the profitability of organic sources such as straw and FYM when used as a complementary dose to inorganic NPK in intensive rice-rice systems was reported by Dawe *et al.* (2003) [3].
The interactive advantage of combining organic and inorganic sources of the nutrients in integrated nutrient management system has proved superior to the use of its each component separately besides, restoring soil fertility and crop productivity. This approach may also help to check the emerging deficiency of nutrients other than N, P and K and favourably affects physical, chemical and biological environment of the soil.
Nutrient use efficiency in rainfed ecosystem may be improved through integrated nutrient supply system. Loss of organic matter either by high temperature or erosion aggravates nutrient deficiency. Judicious use of organic manures such as FYM, farm residues, bio fertilizer along with chemical fertilizer improves soil physical, chemical and biological properties and improves crop productivity. It is essential to adopt beneficial practice under available resources which bring more sustainability to the production under cropping system besides improving the crop productivity. Long term fertilizer experiment provide valuable information about impact of continuous use of fertilizer with varying combination of organic or inorganic on soil fertility and crop productivity and become good platform for monitoring the changes in soil fertility and productivity of cropping system.
Soil degradation is a major concern in agriculture because of non-judicious use of agricultural inputs and over exploitation of natural resources which has emerged as great threat to sustain crop productivity and soil quality. The most important soil degradation processes in agricultural systems are decline in nutrient supplying capacity, fertility depletion and loss of

soil organic carbon. Soil organic carbon and associated major and micronutrients are the critical components of soil quality, which determine the yield sustainability of cropping systems. In view of this, the present experiment was conducted to study the effect of long term manuring and fertilization on yield and micronutrient status under wheat grown in Vertisol.

Material and Methods

A permanent field trial was laid out in 1988-89 at the research farm of the Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola (MS) ($22^0$42'N latitude and $77^0$02' E longitude at an altitude of about 307.42 m above mean sea level), Maharashtra, India with a sorghum-wheat cropping system under the All-India Coordinated Research Project on long-term fertilizer experiments. The treatments comprised 12 different combinations of manures and fertilizers (Table 1). The experiment was replicated four times in Randomized Block Design. The recommended dose of sorghum was 100: 50: 40 kg N, P_2O_5 and K_2O ha^{-1}. Whereas, the recommended dose of wheat was 120: 60: 60 kg N, P_2O_5 and K_2O ha^{-1}. The treatment details under Long Term Fertilizer Experiments are given below.

Table 1: Treatment details under Long Term Fertilizer Experiment

Tr.	Treatment Details	
	Kharif (Sorghum)	**Rabi (Wheat)**
T_1	50% NPK	50% NPK
T_2	100% NPK	100% NPK
T_3	150% NPK	150% NPK
T_4	100% NPK S free	100% NPK S free
T_5	100% NPK	100% NPK + Zn @ 2.5 kg ha $^{-1}$
T_6	100% NP	100% NP
T_7	100% N	100% N
T_8	100% NPK + FYM @ 5 t ha $^{-1}$	100% NPK
T_9	100% NPK + S @ 37.5 kg ha^1	100% NPK + S @ 37.5 kg ha $^{-1}$
T_{10}	FYM @ 10 t ha $^{-1}$	FYM @10 t ha $^{-1}$
T_{11}	75% NPK + 25% N through FYM	75% NPK + 25% N through FYM
T_{12}	Control (No manures and fertilizer)	Control (No manures and fertilizer)

DTPA-Zn, Fe, Mn and Cu were determined from the soil extracted with DTPA solution by using atomic absorption spectrophotometer as described by (Lindsay and Norvell, 1978) [4]. The grain and straw yield of wheat was recorded and expressed as quintal per hectare. The nutrient use efficiency was determined by the following expression.

$$NUE = \frac{\text{Nutrient uptake in fertilizer plot (kg ha}^{-1}) - \text{nutrient uptake in control plot (kg ha}^{-1})}{\text{Nutrient applied (kg ha}^{-1})} \times 100$$

Results and Discussion

DTPA-Zn

The Zn was maintained in most of the treatments (150% NPK, 100% NPK+ FYM, 100% NPK + Zn and FYM @ 10 t ha^{-1}) except that control, 50% and 100% N, 100% NP, 100% NPK (S free) and 100% NPK + S treatments, where, Zn level has gone down near to critical limits or below the critical limits (Table 2). However, the application of 100% NPK+ FYM (0.93 mg kg^{-1}) was found beneficial in improving the status of DTPA-Zn followed by 100% NPK+ Zn (0.78 mg kg^{-1}). This suggests that, in order to maintain soil Zn status over and above critical limit under exhaustive sorghum-wheat cropping sequence, application of 100% NPK along with FYM or relatively higher dose of balanced fertilizer is necessary. The significant increase in DTPA-Zn under integrated nutrient management due to addition of organics may be due to the organic materials which form chelates and increase the availability of Zn. The similar results reported by Suresh *et al.*, 1999 [8].

Table 2: Effect of various treatments on DTPA-Zn at various growth stages of wheat

Sr. No	Treatment	DTPA-Zn (mg kg^{-1})		
		30 DAS	**60 DAS**	**At harvest**
T_1	50% NPK	0.52	0.47	0.48
T_2	100% NPK	0.64	0.62	0.59
T_3	150% NPK	0.68	0.64	0.63
T_4	100% NPK S free	0.61	0.60	0.58
T_5	100% NPK + Zn @ 2.5 kg ha $^{-1}$	0.82	0.81	0.78
T_6	100% NP	0.48	0.48	0.46
T_7	100% N	0.46	0.45	0.43
T_8	100% NPK + FYM @ 5 t ha $^{-1}$ (to sorghum only)	1.02	0.97	0.93
T_9	100% NPK + S @ 37.5 kg ha $^{-1}$	0.62	0.61	0.58
T_{10}	FYM only 10 t ha $^{-1}$ (to sorghum and wheat)	0.81	0.78	0.78
T_{11}	75% NPK + 25% N through FYM	0.68	0.66	0.63
T_{12}	Control	0.40	0.38	0.37
	SE(m) (±)	0.007	0.006	0.01
	CD at 5%	0.021	0.018	0.03

DTPA-Fe

The DTPA-Fe was decreased at different growth stages of wheat (Table 3). The DTPA-Fe was slightly increased with the application of 100% NPK+ FYM followed by FYM @ 10 t ha^{-1} (8.68 mg kg^{-1}) and 150% NPK (8.58 mg kg^{-1}) at harvest of wheat. The increasing levels of NPK significantly increased DTPA-Fe. However, the higher Fe was noted with the application of 150% NPK. The increasing levels of NPK fertilizer resulted to produce higher root biomass and growth of the crop, which subsequently reflected in higher DTPA-Fe after harvest of wheat. The increase in DTPA-Fe with the application of 100% NPK along with FYM was obvious, as FYM contain appreciable quantity of micronutrients which might be reflected in higher content of DTPA-Fe under these treatments. The reduction in DTPA-Fe was noted under no manures and fertilizer treatments. The higher DTPA-Fe under integrated nutrient management for a long period might be due to the addition of organics.

Table 3: Effect of various treatments on DTPA-Fe at various growth stages of wheat

Sr. No	Treatment	DTPA-Fe (mg kg^{-1})		
		30 DAS	**60 DAS**	**At harvest**
T_1	50% NPK	6.10	6.01	5.97
T_2	100% NPK	6.91	6.70	6.59
T_3	150% NPK	9.21	8.90	8.58
T_4	100% NPK S free	7.00	6.75	6.59
T_5	100% NPK + Zn @ 2.5 kg ha $^{-1}$	7.21	7.03	6.90
T_6	100% NP	6.21	6.01	5.92
T_7	100% N	6.10	6.01	5.85
T_8	100% NPK + FYM @ 5 t ha $^{-1}$ (to sorghum only)	10.00	9.69	9.42
T_9	100% NPK + S @ 37.5 kg ha $^{-1}$	8.02	7.90	7.73
T_{10}	FYM only 10 t ha $^{-1}$ (to sorghum and wheat)	8.92	8.82	8.68
T_{11}	75% NPK + 25% N through FYM	6.34	6.30	6.27
T_{12}	Control	4.90	4.61	4.11
	SE(m) (±)	0.015	0.023	0.06
	CD at 5%	0.044	0.067	0.177

DTPA-Cu

The data presented in Table 4 indicate that, the DTPA-Cu significantly influenced with various treatments at various growth stages of wheat. DTPA-Cu was decreased as growth stages of wheat advanced. However, the DTPA-Cu was highest at 30 DAS followed by 60 DAS and least value of DTPA-Cu was noted at harvest of wheat. Among various treatments, the application of 100% NPK +FYM @ 5 t ha^{-1} (4.18 mg kg^{-1}) was found beneficial in improving the status of DTPA-Cu. The application of 150% NPK (4.00 mg kg^{-1}) and FYM @ (3.95 mg kg^{-1}) was found equally beneficial in improving the DTPA-Cu at harvest of wheat. The decrease in DTPA-Cu was noted with advancement of growth stages of wheat with least DTPA-Cu was recorded at harvest of wheat. The results are in close agreement with the earlier finding of Behera and Shukla (2013) [1].

Table 4: Effect of various treatments on DTPA-Cu at various growth stages of wheat

Sr. No	Treatment	DTPA-Cu (mg kg^{-1})		
		30 DAS	**60 DAS**	**At harvest**
T_1	50% NPK	3.22	3.15	3.07
T_2	100% NPK	3.89	3.75	3.64
T_3	150% NPK	4.37	4.26	4.00
T_4	100% NPK S free	3.66	3.52	3.58
T_5	100% NPK + Zn @ 2.5 kg ha $^{-1}$	3.72	3.63	3.52
T_6	100% NP	3.72	3.62	3.49
T_7	100% N	3.51	3.47	3.21
T_8	100% NPK + FYM @ 5 t ha $^{-1}$ (to sorghum only)	4.41	4.35	4.18
T_9	100% NPK + S @ 37.5 kg ha $^{-1}$	3.91	3.86	3.74
T_{10}	FYM only 10 t ha $^{-1}$ (to sorghum and wheat)	4.15	4.02	3.95
T_{11}	75% NPK + 25% N through FYM	3.55	3.32	3.19
T_{12}	Control	2.41	2.39	2.29
	SE(m) (±)	0.015	0.015	0.014
	CD at 5%	0.044	0.046	0.042

DTPA-Mn

The DTPA-Mn as influenced by various fertilizer treatments at various growth stages of wheat is given in Table 5. The data revealed that, the higher value of DTPA-Mn was observed at 30 DAS followed by 60 DAS and least value of DTPA-Mn was noted at harvest of wheat in all the treatments. Among various treatments, the application of 100% NPK + FYM recorded highest DTPA-Mn (8.99 mg ka^{-1}) followed by 150% NPK (8.23 mg kg^{-1}) and FYM @ 10 t ha^{-1} (8.22 mg kg^{-1}). Similarly, the increasing levels of NPK caused significant improvement in the status of DTPA-Mn. The higher DTPA-Mn under 100% NPK + FYM and FYM alone treatments may be due to FYM which ultimalty reflected in improving the status of DTPA-Mn.

Table 5: Effect of various treatments on DTPA-Mn at various growth stages of wheat

Sr. No	Treatment	DTPA-Mn (mg kg^{-1})		
		30 DAS	60 DAS	At harvest
T_1	50% NPK	5.93	5.48	5.41
T_2	100% NPK	6.89	6.75	6.53
T_3	150% NPK	8.83	8.55	8.23
T_4	100% NPK S free	6.84	6.57	6.40
T_5	100% NPK + Zn @ 2.5 kg ha $^{-1}$	6.85	6.76	6.63
T_6	100% NP	6.52	6.46	6.33
T_7	100% N	5.55	5.43	5.35
T_8	100% NPK + FYM @ 5 t ha $^{-1}$ (to sorghum only)	9.36	9.19	8.99
T_9	100% NPK + S @ 37.5 kg ha $^{-1}$	6.94	7.87	6.73
T_{10}	FYM only 10 t ha $^{-1}$ (to sorghum and wheat)	8.65	8.47	8.22
T_{11}	75% NPK + 25% N through FYM	6.26	6.18	5.91
T_{12}	Control	3.94	3.77	3.60
	SE(m) (±)	0.025	0.278	0.017
	CD at 5%	0.075	0.822	0.049

Grain and Straw Yield of Wheat

The grain and straw yield of wheat was significantly increased with the application of 100% NPK + FYM @ 5 t ha^{-1} followed by 150% NPK. The crop productivity was sustained under INM indicating that the favourable conditions caused due to improvement in physical and biological properties of soil due to conjoint use of manures and fertilizers, which helped in sustaining crop productivity (Swarup, 2010) [9]. The application 100% NPK along with S @ 37.5 kg ha^{-1} as well as 100% NPK along with Zn @ 2.5 kg ha^{-1}found beneficial to increase the grain and straw yield of wheat. The application FYM alone @ 10 t ha^{-1} to the sequence resulted drastic decline in the grain and straw yield of wheat. The increase in grain and straw yield of wheat was observed with the increase in the level of NPK. These results are in conformity with the findings of Ravankar *et al*. (2005) [6]. The yield obtained from 100% N, 100% NP and 100% NPK showed significant increasing trend from N to NPK. This suggests the importance of balance fertilization for achieving productivity of crop. Similarly, Rupa *et al.* 2003 [7] reported that better sustainability of the system could be achieved through inclusion of K in the fertilizer schedule.

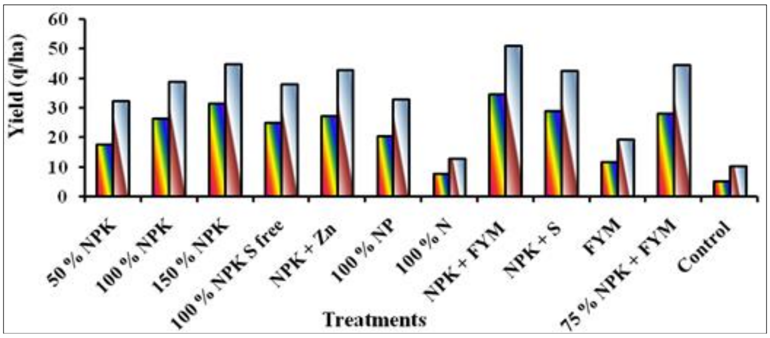

Fig 1: Effect of various treatments on grain and straw yield of wheat

Nutrient use efficiency

The nutrient use efficiency as influenced by various treatments is depicted in Figure 2, 3 and 4. The N, P and K use efficiency was ranged between 26.3 to 37.9%, 14.53 to 28.96% and 74 to 126%, respectively. The increasing levels of NPK fertilizers decreased the N, P and K use efficiency. However, the highest use efficiency was registered under integrated use of chemical fertilizer and organic manures. The application of 50% NPK also found beneficial in improving N, P, and K use efficiency. The balanced use of chemical fertilizer also found equally beneficial in higher N, P and K use efficiency viz: 31, 19.56 and 99%, respectively. Whereas, application of N alone and NP application severely affected the nutrient use efficiency demonstrating the importance of P and K in improving NUE. Such improvements in NUE due to balanced treatments were reported Duan *et al.*, 2014 for wheat.

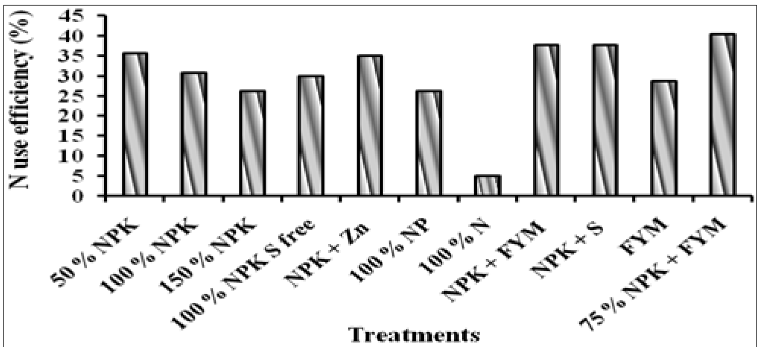

Fig 2: Effect of various treatments on Nitrogen Use Efficiency

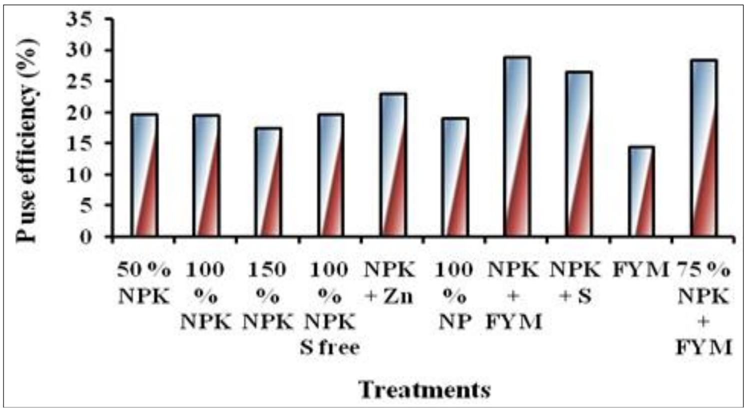

Fig 3: Effect of various treatments on Phosphorus Use Efficiency

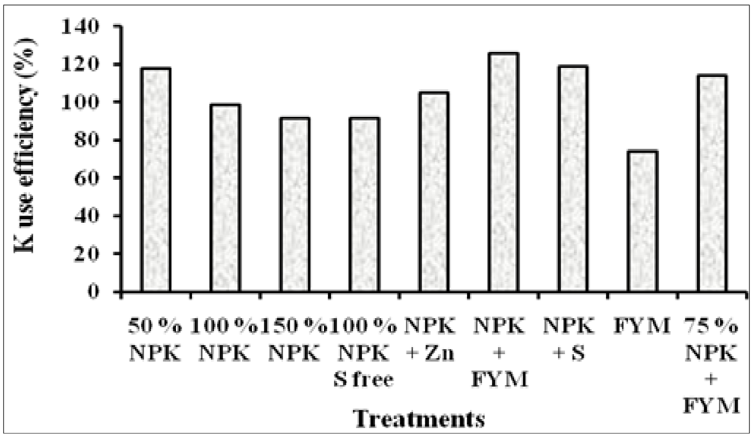

Fig 4: Effect of various treatments on Potassium Use Efficiency

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