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Soil nutrient status and yield of wheat as influenced by INM under continuous sorghum-wheat cropping sequence in vertisol

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Abstract
The present study was conducted during 2016-17 to study the impact of manuring and fertilization on soil nutrient status under sorghum-wheat sequence in Vertisol was studied after 29 years in 2016-17. The treatments comprised of 50% NPK, 100% NPK, 150% NPK,100% NPK (-S), 100% NPK + Zn @ 2.5 kg ha^{-1}, 100% NP, 100% N,100% NPK + FYM @ 5 t ha^{-1}, 100% NPK + S, FYM, 75% RDF + 25% N through FYM and Control laid out in randomized block design (RBD). The results of the present study revealed that, organic carbon content of soil was significantly increased under different treatments in sorghum-wheat cropping system with maximum value (7.87 g kg^{-1}) was recorded under 100% NPK + FYM @ 5 t ha^{-1} (to kharif only) treatment in surface soil and minimum (3.79 g kg^{-1}) under control. Calcium carbonate content in surface soils was significantly affected by long-term application of fertilizer. The calcium carbonate after harvest of wheat was higher (6.47) with the application of 100 % NPK + FYM @ 5 t ha^{-1} (to kharif only). Available N, P and K content in surface soil was significantly increased with various fertilizer treatments with maximum value i.e. 324, 20.30, and 488 kg ha^{-1} was recorded under 100% NPK + FYM @ 5 t ha^{-1}(to kharif only). The grain and straw yield of wheat were increased with successive increase in fertilizer level. Significantly higher grain and straw yield was recorded with the application of 100 % NPK + FYM @ 5 t ha^{-1} (to kharif only) followed by 150 % NPK.

Keywords: INM**,** soil nutrient status, vertisol, sorghum-wheat sequence

Introduction

Agriculture is the backbone of Indian economy and it provides employment to about 70% population. Significance of improving and maintaining soil fertility for enhancing and sustaining crop productivity was realised long back worldwide. The most logical way to manage long term fertility and productivity of soil is the integrated use of both organic and inorganic sources of plant nutrients. Long term fertilizer experiments usually provides the best test of sustainability of crop management system (Nambiar, 1994) [7].

Adequate plant nutrient supply holds the key for improving the food grain production and sustaining soil health. Integrated use of inorganic and organic sources of plant nutrients has a tremendous potential not only sustaining agricultural productivity and soil health but also substituting part of fertilizer requirement by organics for different cropping systems. Continuous application of chemical fertilizers poses problems like toxicity due to high amounts of salts as a residues of fertilizer and deterioration of physico-chemical properties. Organic manure ameliorates this problem as organic matter helps in increasing adsorptive power of soil for cations and anions particularly phosphate and nitrate.

The concept of balanced fertilization can not be confined to nitrogen, phosphorous, potassium only. Balanced fertilization includes application of all plant nutrients required for high agricultural productivity and soil health. Inadequate replenishment of plant nutrients in a imbalanced way has resulted in the emergence of multinutrient deficiencies like P, K, S, Zn, Fe, Cu, Mn and B in soils and plants on large scale. Managing organic source of plant nutrients with mineral fertilizer and their incorporation into the soil in a cropping system has certain favourable and augmenting effects on soil physical properties for sustainability and high productivity of crop.

The present investigation was carried out to study the impact of manuring and fertilization on soil nutrient status under sorghum-wheat sequence in Vertisol was studied after 29 years in 2016-17.

Materials and Methods

A long-term field experiment on sorghum-wheat cropping sequence was initiated during 1988-89 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola (MS). The experiment comprised various manurial and fertilizer treatments (Table 1).

Table 1: Treatment details under long term fertilizer experiment

Trt.	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 + 2.5 kg Zn ha^{-1}
T_6	100 % NP	100 % NP
T_7	100 % N	100 % N
T_8	100 % NPK + FYM @ 5 tha^{-1}	100 % NPK
T_9	100 % NPK + 37.5 kg S ha^{-1}	100 % NPK + 37.5 kg S 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)

The 29th cycle of the experiment during 2016-17 was studied in the present investigation. The recommended dose of fertilizer was (100:50:40 kg N, P_2O_5, K_2O ha^{-1}) applied to sorghum while 120:60:60 kg N, P_2O_5, K_2O ha^{-1} was followed for wheat. Farmyard manure (0.54 % N, 0.21 % P, and 0.58 % K) was added on oven dry basis before sowing of sorghum whereas, half dose of N and full dose of P and K was applied at the time of sowing to sorghum and remaining half dose of N was applied 30 days after sowing. The half dose of N and full dose of P and K was applied at the time of sowing to wheat and remaining half dose of N was applied 21 days after sowing. The soil of experimental site was deep, clayey black soil taxonomically classified as fine, smectitic, calcareous, hyperthermic family of Typic Haplusterts. The soil is having low hydraulic conductivity and high water holding capacity. The initial analysis indicated that soils are low in organic carbon (4.60 g kg^{-1}) and available N (120 kg ha^{-1}), very low in available P (8.40 kg ha^{-1}) and high in available K (358 kg ha^{-1}). The soils are marginal in S (11.8 mg kg^{-1}) and Zn (0.62 mg kg^{-1}) status.

The plot wise surface (0-20 cm) soil samples were collected after harvest of wheat crop. For the determination of organic carbon, Walkley and Black's method was followed (Nelson and Sommers, 1982) [8]. Calcium carbonate was determined by rapid titration method (Jackson, 1973) [4]. Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) [13]. Available phosphorus was determined by Olsen's method using 0.5 M sodium bi-carbonate as an extractant using UV based double beam spectrophotometer (Watanabe and Olsen, 1965) [15]. Available potassium was determined by neutral normal ammonium acetate method using flame photometer (Hanway and heidel, 1952) [3].

Results and Discussion

Soil Organic Carbon

The soil organic carbon status after harvest of wheat (2016-17) ranged between 3.79 to 7.87 g kg^{-1}. The higher value of soil organic carbon was recorded with the application of 100% NPK + FYM@ 5 t ha^{-1} (7.87 g kg^{-1}). The initial organic carbon content at the start of experiment was 4.6 g kg^{-1} which is maintained under almost all the treatments except that control. Significant improvement in the status of soil organic carbon was observed under NPK + FYM, FYM alone and 150% NPK treatment. The improvement in the status of soil organic may be due to FYM, which provide substrate to the microorganism as well as root biomass as a result of enhanced crop growth, similarly the application of 150% NPK resulted better crop growth ultimately reflects in root biomass.

Table 2: Effect of different treatments on chemical properties of soil (after harvest of wheat)

Treatment	pH	EC (dSm^{-1})	Organic carbon (gkg^{-1})	Calcium carbonate (%)
T_1 - 50 % NPK	8.03	0.27	5.41	6.12
T_2 - 100 % NPK	7.92	0.31	6.24	6.25
T_3 - 150 % NPK	7.95	0.35	6.64	6.51
T_4 - 100 % NPK S free	8.03	0.32	5.94	6.23
T_5 - 100 % NPK + 2.5 kg Zn ha^{-1}	8.01	0.34	6.53	6.31
T_6 - 100 % NP	7.86	0.31	5.93	6.21
T_7 - 100 % N	7.80	0.30	5.36	6.01
T_8 -100 % NPK+ FYM @ 5 t ha^{-1} (to sorghum only)	8.10	0.36	7.87	6.47
T_9 - 100 % NPK + 37.5 kg S ha^{-1}	8.13	0.34	6.63	6.31
T_{10} - FYM @ 10 t ha^{-1}	8.04	0.30	7.35	6.11
T_{11} - 75 % NPK + 25 % N through FYM	7.98	0.33	6.72	6.07
T_{12} - Control (No manures and fertilizer)	8.08	0.23	3.79	5.88
SE (m)	0.008	0.007	0.378	0.009
CDat 5%	0.025	0.021	1.114	0.026

The results are in close agreement with finding of Thakur *et al.*(2011) reported that application of 100% NPK along with FYM @ 15 t ha^{-1}significantly increased the organic carbon content in soil.

Soil nutrient status

The available N ranged between 129 to 324 kg ha^{-1}. The increasing levels of NPK from 50% NPK to 150% NPK significantly increased the status of available N. The improvement in the status of available N with increasing levels of NPK may be due to application nitrogen in incremental doses which helps in the increased available N status. The application of NPK + FYM @ 5 t ha also resulted in improvement in available N content after harvest of wheat. The increased available N with combined application of NPK + FYM.

The available P status ranged between 4.80 to 20.30 kg ha^{-1}. The p status was increased significantly with the increasing levels of NPK fertilizers as well as combined application of NPK + FYM. However, the higher available P was recorded with the application of 100% NPK + FYM @ 5 t ha^{-1} (20.30 kg ha^{-1}). The highest available P under such treatment may be due to externally applied P as well as application of FYM.

Table 3: Effect of different treatments on available nutrients status of soil

Treatment	Available nutrients (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T_1 - 50 % NPK	174	9.08	246
T_2 - 100 % NPK	262	15.11	386
T_3 - 150 % NPK	314	18.52	477
T_4 - 100 % NPK S free	253	14.76	378
T_5 - 100 % NPK + 2.5 kg Zn ha^{-1}	265	15.04	379
T_6 - 100 % NP	249	14.80	232
T_7 - 100 % N	230	7.84	201
T_8 -100 % NPK+ FYM @ 5 t ha^{-1} (To sorghum only)	324	20.30	488
T_9 - 100 % NPK + 37.5 kg S ha^{-1}	273	15.34	388
T_{10} - FYM @ 10 t ha^{-1}	229	11.91	267
T_{11} - 75 % NPK + 25 % N through FYM	267	15.60	318
T_{12} - Control (No manures and fertilizer)	129	4.80	167
SE (m)	2.61	0.51	3.57
CDat 5%	7.70	1.50	10.53

The K status ranged between 167 to 488 kg ha^{-1}. The higher value of K was recorded with the combined application of NPK + FYM. The balanced application of fertilizers i.e. 100% NPK maintained available K at fairly high level indicating need of balanced fertilization under sorghum-wheat sequence.

However, imbalanced application of i.e. 100% N fertilizer caused decline in the K status as compared to balanced fertilization indicating leaching of K. The higher K status under 100% NPK + FYM treated plot may be due to application rate of K and use of FYM, which ultimately helps in improving the status of soil K. The results are in close confirmedly with the earlier finding by Sonune *et al.* (2003) they studied the long-term effect of manures and fertilizers on fertility and crop productivity of Vertisol under sorghum-wheat sequence in semi-arid climatic conditions of Vidarbha region of Maharashtra. Similar findings were reported by Kumar *et al*. (2008) [5] on integrated management of FYM, green manure and crop residues with inorganic fertilizers in rice-wheat system at Ludhiana, since 1993. They reported that the incorporation of crop residues along with 50 per cent NPK and FYM or GM contributed towards meeting 50 per cent NPK requirement of rice. Long-term application of crop residues and organic manures increased the soil organic carbon content of the soil and available N, P and K.

Yield of wheat

The application of 100 % NPK + FYM @ 5 t ha^{-1} recorded significantly higher grain yield (34.73 q ha^{-1}) of wheat followed by 150 % NPK (31.53 q ha^{-1}) . However, these treatments were found at par with each other. The application of 100 % NPK along with sulphur @ 37.5 kg ha^{-1}(29.03 q ha^{-1}) and zinc @ 2.5 kg ha^{-1} (27.30 q ha^{-1}) also found effective for obtaining maximum yield. However, its omission resulted reduction in the grain yield of wheat.

The reduction in the grain yield of wheat was substantial with the application of 100 % NPK (devoid of sulphur). The omission of K fertilizer (100 % NP or 100 % N) resulted decrease in the grain yield of wheat respectively to the extent of 96 % and 214 % compared 100 % NPK. This necessitates the role of potassium in the sequence.

The highest straw yield of wheat i.e. 51.27 q ha-1, were obtained with the application of 100 % NPK in combination with FYM @ 5 t ha-1 followed by 150 % NPK as compared to all other treatments and was superior in treatment. Application of recommended NPK dose without sulphur decreased straw yield of wheat significantly over recommended NPK along with sulphur. Sulphur application enhanced the wheat yield significantly. Lowest straw yield was recorded in control i.e. 10.27 q ha-1.These finding are in consonance with the results of Ravankar *et.al.* (1998) [9] who observed significant increase in straw yield of wheat and sorghum with the application of 100 % recommended NPK in combination with FYM @ 10 t ha-1.

Table 4: Effect of different treatment on grain and straw yield of wheat.

Treatment	Yield (q ha^{-1})	
	Grain	Straw
T_1 - 50 % NPK	17.73	32.35
T_2 - 100 % NPK	26.57	38.98
T_3 - 150 % NPK	31.53	44.82
T_4 - 100 % NPK S free	25.17	38.04
T_5 - 100 % NPK + 2.5 kg Zn ha^{-1}	27.30	42.92
T_6 - 100 % NP	20.53	32.89
T_7 - 100 % N	7.77	12.83
T_8 -100 % NPK + FYM @ 5 t ha^{-1} (to sorghum only)	34.73	51.27
T_9 - 100 % NPK + 37.5 kg S ha^{-1}	29.03	42.75
T_{10} - FYM @ 10 t ha^{-1}	11.73	19.32
T_{11} - 75 % NPK + 25 % N through FYM	28.33	44.64
T_{12} - Control (No manures and fertilizer)	5.33	10.27
SE (m)	1.95	2.60
CD at 5%	5.77	7.68

Conclusion

From the study it can be concluded that, the application of 100% NPK + FYM @ 5 t ha^{-1}significantly increased the soil nutrient status (available N, P and K) and organic carbon. The highest grain and straw yield of wheat was observed with the application of 100% NPK + FYM @ 5 t ha^{-1}.

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