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Influence of Long Term Manure and Fertilizer Application on Available Nutrients Under Sorghum-Wheat System in vertisols.

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ABSTRACT: *A permanent field experiment is continued since 1988 at Research Farm, LTFE, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra with a view to find out influence of long term manure and fertilizer application on available nutrients in a sorghum-wheat systems in a Vertisols. The long term impacts of manure and fertilizer application on available nutrients were studied after 24th and 25th cycle (2011-12 and 2012-13). The treatment comprised different levels of recommended dose of fertilizers (RDF), viz. 50, 75, 100, 150% RDF in combination with farm yard manure. The results indicated that, significantly highest available N (290.12, 306.13 kg ha^{-1}) was recorded by integration of NPK with FYM. Available phosphorous of soil after both the trials was noticed significantly highest (48.99, 43.60 kg ha^{-1}) in treatment receiving 100% NPK + FYM @ 10t ha^{-1}. The results indicated the beneficial effect of organics in combination with NPK over chemical fertilizers in maintaining the available potassium in soil. Available potassium of soil was showing significantly highest value (559.95, 565.40 kg ha^{-1}) in treatment receiving 100% NPK + FYM @ 10 t ha^{-1}. Overall increase in available sulphur was noted in treatment receiving phosphorous through single super phosphate, (Nearly 12% sulphur) and decline in available sulphur was seen in treatment T_4 (100% NPK -S) where phosphorous was applied through DAP. During both the year for sorghum and wheat crop, the highest available sulphur (30.68, 31.92 mg kg^{-1}) was recorded in treatment T_9 comprising 100% NPK + S @ 37.5 kg ha^{-1}.*

Keywords: *long term manure and fertilizer application, FYM, Vertisols, available N, P, K.*

INTRODUCTION

The ever increasing population pressure, the land resources per capita are gradually shrinking and simultaneously the food grain demand is increasing. Thus, vertical increase in crop production along with nutritional security is possible only through higher and better use of both organic and inorganic sources. The supplementary and complementary use of organic manures and chemical fertilizers will increase not only the nutrient use efficiency and crop yields but also help to maintain a higher growth rate of food production. Since the cultivable land is constant rather decreasing due to urbanization, industrialization and other human activities, therefore the only alternative left is to increase the productivity of various crops per unit area and time. These changes can be through steady increase the productivity of various crops. This can be achieved by intensification of cropping system and managing the available resources more efficiently to reduce the unit cost of production. Achieving four per cent growth in agriculture is essential for food security and inclusive growth of large rural sector in India. With shrinking land resources, the desired growth has come from further intensification of agriculture and gains in land productivity. The fertilizers have played vital role in increasing food grain production, contributing about 50% in post green revolution period and should continue to do so in future as well (Sharma, 2008). In view of the ever increasing population in India and the fact that area expansion for agriculture is not feasible, cropping intensity has to be increased, and therefore, there is urgency for developing efficient nutrient management strategies for

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Table 1
Treatment Details

Tr.	*Treatment details*	*N, P_2O_5 and K_2O rate (kg ha^{-1})*		*Fertilizer source*
		Sorghum	*Wheat*	
T_1	50% NPK	50:25:20	60:30:30	Urea, SSP, MOP
T_2	75% NPK	75:37.5:30	90:45:45	Urea, SSP, MOP
T_3	100% NPK	100:50:40	120:60:60	Urea, SSP, MOP
T_4	100% NPK-S Free	100:50:40	120:60:60	Urea, DAP,MOP
T_5	150% NPK	150:75:60	180:90:90	Urea, SSP, MOP
T_6	100% NP	100:50:00	120:60:00	Urea, SSP
T_7	100% N	100:00:00	120:00:00	Urea
T_8	100% NPK + Zn @ 2.5 kg ha^{-1}	100:50:40	120:60:60	Urea, SSP, MOP, $ZnSO_4$
T_9	100% NPK + S @ 37.5 kg ha^{-1}	100:50:40	120:60:60	Urea, DAP MOP, Gypsum
T_{10}	100% NPK + FYM @ 10*t* ha^{-1}	100:50:40	120:60:60	Urea, SSP, MOP
T_{11}	FYM @ 10*t* ha^{-1}	10 t ha^{-1}	No manure, no fertilizer application	Well decomposed FYM
T_{12}	Control	–	–	–

sustaining higher crop productivity and soil health under intensive agriculture system. Long term studies are required to reach a definite conclusion for bringing about changes in fertilizer application practices for a cropping system. An adequate and balanced supply of plant nutrients, maintaining and improving the level of soil organic matter is prerequisite to maximize crop production, ensuring soil quality and sustainability (Singh, 2008). In the initial years of green revolution, with the introduction of high yielding varieties, crop response to nitrogen followed by phosphorus was observed. In the recent years even the application of NPK at optimal levels or super optimal doses do not maintained soil fertility and ultimately crop productivity. This has been attributed to nutrient imbalances caused by fertility depletion through decrease in recycling of crop residues and animal manures. The field experiments are being conducted under AICRP on long term fertilizer experiment with different crops and cropping systems on various soils since last 42 years. These long term fertilizer experiments suggest integrated use of inorganic and organic fertilizer for long term sustenance productivity and fertility. Thus, this is an urgent need emerged for the use of inorganic fertilizer in combination with organic manures to maintain fertility and to sustain the growth in agricultural production to achieve food grain target.

The experience in long term fertilizer experiment in various agro-ecosystems has shown that judicious combination of both organic and inorganic components may be helpful to develop a useful model to maintain soil health at the optimum level, define the indices and provide sustainability in production. Fertilizer use is becoming a key factor for increasing agricultural production and its consumption in agriculture is increasing rapidly. Need was felt for studying the effect of fertilizer not only on the crop productivity and grain quality but also on the soil and the environment under intensive cropping system. This necessities long term studies at fixed site for monitoring the long term changes in nutrient dynamics with the objectives of developing strategies for sustainable productivity by incorporating the interventions. Sorghum-wheat cropping sequence has been popular among the farmers of peninsular India covering Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh. Soil type greatly influences the choice of crop and cropping system. Earlier in Vidarbha region of Maharashtra, sorghum-wheat cropping system has been most widely practiced due to the important place of these food grains in human diet.

MATERIALS AND METHODS

The present investigation was undertaken during the year 2011-12 and 2012-13 on the old long-term fertilizer experiment started since 1988, to study the influence of long term manure and fertilizer application on available nutrients in a sorghum-wheat system in a Vertisols at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The soil at the start of experiment was Vertisol with slightly alkaline in reaction (8.1), low in organic carbon (4.6 g kg^{-1}), available N (120 kg ha^{-1}) and available phosphorus (8.4 kg ha^{-1}) and high in available potassium (358 kg ha^{-1}). There were twelve treatments replicated four times in a randomized block design comprised of varying NPK levels with and without FYM, S and Zn. The details of various treatments in the permanent plot experiment are given in Table 1. FYM containing on an average 0.52, 0.17, 0.56% N, P_2O_5 and K_2O, respectively on dry weight basis was applied in *kharif* season only. The recommended dose of fertilizer was applied @ 100:50:40 and 120:60:60 N, P_2O_5 and K_2O

Table 2
Available Nitrogen of soil as influenced by long term manure and fertilizers application under sorghum-wheat cropping sequence

		Available Nitrogen (kg ha^{-1})					
		Sorghum			Wheat		
Tr.	Treatment details	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
T_1	50% NPK	176.75	175.00	175.87	178.75	175.75	177.25
T_2	75 % NPK	220.25	232.00	226.12	245.25	248.50	246.87
T_3	100 % NPK	242.25	238.00	240.13	245.25	251.00	248.13
T_4	100 % NPK-S Free	229.00	226.00	227.50	244.75	248.25	246.50
T_5	150 % NPK	282.50	279.00	280.75	289.50	311.00	300.25
T_6	100 % N P	229.75	219.00	224.37	233.25	239.00	236.13
T_7	100 % N	223.25	216.25	219.75	216.50	226.50	221.50
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	251.75	247.50	249.62	264.00	269.75	266.88
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	258.00	254.00	256.00	263.75	272.75	268.25
T_{10}	100 % NPK + FYM @10 t ha^{-1}	288.75	291.50	290.12	295.00	317.25	306.13
T_{11}	FYM @ 10 t ha^{-1}	210.75	219.50	215.12	213.75	223.75	218.75
T_{12}	Control	124.00	122.00	123.00	133.00	135.25	134.12
SE (m) ±		8.44	9.05	8.74	8.86	9.39	9.12
CD at 5%		24.29	26.05	25.17	25.49	27.02	26.25
Initial value			120.00				

kg ha^{-1} to sorghum and wheat respectively. Half dose of N and full dose of P and K was applied at the time of sowing to sorghum and wheat crops. Remaining half dose of N was applied at 21 days after sowing.

The sulphur (though gypsum) was applied to each plot as per the treatments. Zinc (through zinc sulphate) was applied once in two years for wheat crop only. Plot-wise surface (0-15 cm) soil samples were collected after the harvest of sorghum and wheat. The crop was harvested at maturity. Soil samples were collected before sowing (at the end of 23th cycle) and after harvest of *kharif* and *rabi* crops (24^{h} and 25th crop) 2011-12 and 2012-13 and analyzed for the soil chemical analysis as available Nitrogen, Phosphorus, Potassium and Sulphur. Available Nitrogen was analyzed by alkaline permanganate method as described by Subbiah and Asija (1956).

Available Phosphorus was determined by Olsen's method as described by Watanabe and Olsen using 0.5 M sodium bicarbonate pH (8.5) as an extractant. Darco-G-60 soluble phosphorus was used to absorb the dispersed organic matter and make the filtrate colorless for further colorimetric analysis (Watanabe and Olsen, 1965). Available Potassium was determined by the flamephotometer using neutral N ammonium acetate (pH 7.0) as an extractant as described by Hanway and Heidel (1952). Available Sulphur was determined by Turbidimetric method as described by Chesnin and Yien (1950).

RESULT AND DISCUSSSION

Effect of various long term treatments showed significant influence on available nitrogen of soil. The data presented in Table 2. showed significantly highest soil available nitrogen due to application of 100% NPK + FYM @ 10*t* ha^{-1} treatment after sorghum (288.75, 291.50 kg ha^{-1}) and wheat crops (295.00, 317.25 kg ha^{-1}) during respective years of experimentation and the lowest value was observed in absolute control. The pooled data revealed that, significantly highest soil available N was recorded in 100% NPK + FYM @ 10 t ha^{-1} treatment (290.12, 306.13 kg ha^{-1}) in sorghum and wheat crop and the lowest value was observed in absolute control (123, 134 kg ha^{-1}). The application of NPK through chemical fertilizers with FYM recorded more available N status, as compared to use of 100 per cent NPK dose through only chemical fertilizers. The favorable soil conditions under FYM addition might have helped in mineralization of soil N leading to build up of higher available N. (Bellakki *et al.* 1998, Ravankar 1998). The addition of mineral nitrogen along with organic source narrowed the C:N ratio of organic manures and this helps in enhancing the rate of mineralization resulting in rapid release of nutrients from the organic sources in swell-shrink soil under sorghum-wheat sequence.

Direct incorporation of nitrogen through FYM to the available pool of soil, may be the reason for increase in the available N in the sequence (Sonune *et al.* 2003). Thus, from the results obtained, it is seen

Table 3
Available Phosphorus of soil as influenced by long term manure and fertilizers application under sorghum-wheat cropping sequence

		Available P (kg ha^{-1})					
		Sorghum			*Wheat*		
Tr.	*Treatment details*	*2011-12*	*2012-13*	*Pooled*	*2011-12*	*2012-13*	*Pooled*
T_1	50 % NPK	23.60	24.11	23.85	21.54	20.01	20.77
T_2	75 % NPK	28.73	31.80	30.26	27.70	30.78	29.24
T_3	100 % NPK	34.88	36.93	35.91	31.80	33.86	32.83
T_4	100 % NPK-S Free	33.86	32.83	33.34	26.67	27.70	27.19
T_5	150 % NPK	45.14	47.71	46.42	36.93	43.09	40.01
T_6	100 % N P	31.80	32.83	32.32	29.75	31.80	30.78
T_7	100 % N	27.70	27.70	27.70	20.52	20.52	20.52
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	35.91	38.98	37.45	34.88	34.88	34.88
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	37.96	41.04	39.50	33.86	35.91	34.88
T_{10}	100 % NPK + FYM @ 10 t ha^{-1}	46.17	51.81	48.99	42.06	45.14	43.60
T_{11}	FYM @ 10 t ha^{-1}	26.67	28.73	27.70	23.08	23.08	23.08
T_{12}	Control	10.75	10.77	10.76	10.26	10.31	10.28
SE (m) ±		2.39	2.18	2.29	2.35	2.18	2.27
CD at 5%		6.90	6.29	6.60	6.78	6.27	6.53
Initial value			18.40				

that the balanced use of NPK fertilizers along with manures is essential for augmenting N status in Vertisol under cereal – cereal cropping system. (Mali 2015). To sustain the productivity over the years, regular supply of P to plant is essential. Effect of various long term treatments showed significant influence on available phosphorus of soil. The data presented in Table 3. showed significantly highest soil available phosphorus due to application of 100% NPK + FYM @ 10*t* ha^{-1} treatment after sorghum (46.12, 51.81 kg ha^{-1}) and wheat crops (42.06, 45.14 kg ha^{-1}) during respective years of experimentation and the lowest value was observed in absolute control. The pooled data revealed that, significantly highest soil available P was recorded in 100% NPK + FYM @ 10 t ha^{-1} treatment (48.99, 43.60 kg ha^{-1}) in sorghum and wheat crop and the lowest value was observed in absolute control (10.76, 10.28 kg ha^{-1}). Integrated use of NPK along with FYM and super optimal or optimal doses of NPK alone resulted in higher build up of available P. Integrated use of NPK along with FYM and super optimal (150% NPK) or optimal doses of NPK (100% NPK) alone resulted in higher build up of available P as compared to initial status. This emphasizes the need for rethinking in recommending the regular application of phosphorus to every crop. Similarly low available phosphorus under control treatment was recorded to the extent of 10.76 and 10.28 respectively of sorghum and wheat (pooled mean). The less available phosphorus under control treatments may be due to long absence of phosphatic fertilizers in swell-shrink soils under sorghum-wheat sequence (Jadhao *et al*. 2014). Although K is not a constituent plant but required in large quantity almost equal to N. Effect of various long term treatments showed significant influence on available K of soil.

The data presented in Table 4. showed significantly highest soil available K due to application of 100% NPK + FYM @ 10*t* ha^{-1} treatment after sorghum (555.78, 563.12 kg ha^{-1}) and wheat crops (561.72, 569.09 kg ha^{-1}) during respective years of experimentation and the lowest value was observed in absolute control. The available K significantly increased with the application of 100% NPK + FYM @ 10 t ha^{-1}. Long term application of chemical fertilizers with organic manures increased the K content of the soil. This could be attributed to the greater capacity of organic colloids to hold K ions on the exchange sites. However, a declining trend form its initial value of available K status was also observed as a result of continuous cropping, this indicates considerable mining of available K from the soil. Similar findings were seen in the previous literature reported by Singh *et al.* (2008). The increase in the status of available K with the combined use of organic and inorganic fertilizers as compared to even optimal or super optimal dose of NPK may be due to addition of organic materials which supply nutrients to the soil. Also higher amount of available K in the FYM treated plots may be due to the fact that FYM addition could increase the CEC of soil,

Table 4
Available Potassium of soil as influenced by long term manure and fertilizers application under sorghum-wheat cropping sequence

		Available K (kg ha^{-1})					
		Sorghum			Wheat		
Tr.	Treatment details	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
T_1	50% NPK	324.38	316.91	320.64	311.40	310.50	310.95
T_2	75 % NPK	343.61	354.72	349.16	344.23	356.19	350.21
T_3	100 % NPK	455.82	454.89	455.35	447.11	449.31	448.21
T_4	100 % NPK-S Free	443.20	439.74	441.47	445.71	448.45	447.08
T_5	150 % NPK	521.65	525.32	523.48	538.04	545.68	541.86
T_6	100 % N P	295.05	289.94	292.50	289.19	287.64	288.42
T_7	100 % N	271.30	266.64	268.97	272.67	268.42	270.54
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	448.96	455.51	452.23	450.23	458.73	454.48
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	468.67	462.60	465.63	453.69	459.18	456.43
T_{10}	100 % NPK + FYM @10 t ha^{-1}	556.78	563.12	559.95	561.72	569.09	565.40
T_{11}	FYM @ 10 t ha^{-1}	319.62	354.17	336.90	302.93	306.70	304.82
T_{12}	Control	237.61	235.52	236.57	214.61	210.67	212.64
SE (m) ±		10.68	10.03	10.36	10.25	9.91	10.08
CD at 5%		30.74	28.88	29.81	29.50	28.54	29.02
Initial value			358.00				

Table 5
Available Sulphur of soil as influenced by long-term effect manure and fertilizers application under sorghum-wheat cropping sequence

		Available S (mg kg^{-1})					
		Sorghum			Wheat		
Tr.	Treatment details	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
T_1	50% NPK	14.87	14.75	14.81	15.34	16.05	15.70
T_2	75 % NPK	18.05	20.06	19.05	19.00	21.00	20.00
T_3	100 % NPK	20.18	21.00	20.59	21.83	22.07	21.95
T_4	100 % NPK-S Free	10.62	10.86	10.74	11.33	11.92	11.62
T_5	150 % NPK	24.54	25.02	24.78	25.84	27.14	26.49
T_6	100 % N P	18.29	19.82	19.05	19.23	20.53	19.88
T_7	100 % N	10.86	10.03	10.44	11.33	10.27	10.80
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	20.77	21.00	20.88	22.42	22.54	22.48
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	30.33	31.03	30.68	31.51	32.33	31.92
T_{10}	100 % NPK + FYM @ 10 t ha^{-1}	29.03	29.50	29.26	29.50	30.68	30.09
T_{11}	FYM @ 10 t ha^{-1}	11.09	12.27	11.68	12.27	13.22	12.74
T_{12}	Control	8.38	7.91	8.14	8.50	8.26	8.38
SE (m) ±		0.73	0.72	0.73	0.77	0.79	0.78
CD at 5%		2.10	2.09	2.10	2.21	2.28	2.25
Initial value			11.80				

which is responsible for holding more amount of exchangeable K and helped in the release of exchangeable K form non exchangeable pool. This may also ascribed to the reduction in the potassium fixation and release of K from non exchange site of the reserves held in the clay interlayer's or due to the interaction of K from non-exchange site of the reserves held in the clay interlayer's or due to the interaction of organic matter with clay besides the direct addition of potassium to available pool of the soil by Bharadwaj and Omanwar (1994). Effect of various long term treatments showed significant influence on available sulphur of soil. The data presented in Table 4.

Showed significantly highest soil available sulphur due to application of 100% NPK + S @ 37.5 kg ha^{-1} treatment after sorghum (30.33, 31.03 mg kg^{-1}) and wheat crops (31.50, 32.33 mg kg^{-1}) during respective years of experimentation and the lowest value was observed in absolute control. The pooled data of experimentation revealed that, significantly highest soil available sulphur was recorded in 100% NPK + S @ 2.5 kg ha^{-1} treatment after sorghum (30.68, 31.92 mg kg^{-1}) in sorghum and wheat crop and the lowest value was observed in absolute control (8.14,8.38 mg kg^{-1}). Due to the continuous cropping and manuring for 25 years, the nutrient status of soil with respect to S showed increase in all the plots treated with FYM. This was apparently due to the supply of S through organic sources which exceeded that supplied through fertilizers as impurities. The similar results were reported by the Ravankar *et al.* (2005). Thus, the available S status of soil was increased significantly with the application of 100% NPK + S (T_9) and 100% NPK + FYM (T_{10}). However treatments were found at par with each other indicating sulphur application under T_9 treatment has pronounced influence on improving sulphur status of soil. Whereas incase of 100% NPK + FYM @ 10 t ha^{-1} , the sulphur status was improved due to continuous application of FYM as FYM act as a source of secondary (S) as well as micronutrients.

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