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Soil Properties of Sorghum-Wheat Sequence as Affected by Long-Term Fertilization

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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 the soil properties of sorghum (Sorghum bicolor (L.) Moench) - wheat (Triticum aestivum) crop sequence as affected by long term fertilization. The long term impact of manure and fertilizer application on soil properties 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, among the chemical properties significantly lowest soil pH was recorded (7.95, 8.00) under integration treatment (100 % NPK+ FYM @ 10 t ha^{-1}). The electrical conductivity of soil was also significantly lowest (0.290, 0.284 dS m^{-1}) under treatment of NPK + FYM (T_{10}) and only FYM (T_{11}). The highest organic carbon was observed in treatment receiving chemical fertilizers along with FYM. It was significantly improved (8.00, 7.88, g kg^{-1}) with the application of 100% NPK + FYM @ 10 t ha^{-1} and lowest value (3.33, 2.98 g kg^{-1}) was observed in absolute control.*

Keywards: *long term manure and fertilizer application, FYM, pH, EC, Organic carbon, Vertisols.*

INTRODUCTION

Green revolution in the late sixties gave tremendous boost to the agricultural production in India. The production of major crops increased three to four fold between 1966-67 and 1996-97. High yielding varieties and infestation of agriculture played an important role in bringing the era of Green Revolution propelled India toward self-sufficiency of food production. However, continuous use of the high analysis fertilizers accelerated the mining of secondary and micronutrients which brought down the productivity of cropping systems at several places in the country (Singh, 2010).

Over-exploitation and unscientific management of limited soil resource without regard to long-term sustainability have resulted in different kinds of soil degradation, which is worldwide phenomenon, posing a serious threat to soil productivity and food security. Degradation of soil health in many intensively cultivated areas is manifested in terms of loss of soil organic matter, depletion of native soil fertility due to imbalanced and unscientific use of fertilizer, which is now one of the major constraints in improving crop productivity.

Rothamsted classical experiments were initiated as Long-term experiments by J.B. Lawes and J.H. Gilbert between 1843 and 1856. In India, Indian Council of Agricultural Research (ICAR) decided to launch the All India Coordinated Research Project on Long-Term Fertilizer Experiments in September 1970. The importance of long - term manurial experiments was realized in India as early as 1885 when the first experiments was laid out at Kanpur (Uttar Pradesh) on the Rothamsted model followed by the setting up of two more such experiments. One at Pusa (Bihar) in 1908 and the other at Coimbatore (Tamil Nadu) in 1909. As a sequel to these, many such experiments were set up at several parts of the country. These Experiments provide valuable information on the effect of rotational cropping, use of organic manures, application of single nutrients and multi nutrients on crop yields and there by

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changes in some soil properties. 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. Now a day the area under sorghum is enormous decreases due to many problems related to its exhaustive less, cultivation problems. Hence, it is important to tackle this problem through judicious use of fertilizer, proper management intervention etc.

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 effects of long-term fertilization of Vertisol on soil properties of sorghum-wheat cropping sequence 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 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

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	–	–	–

for the soil chemical analysis as soil pH, electrical conductivity, organic carbon content. Hydrogen ion activity expressed as pH was determined by potentiometry using 1:2.5 soil water suspensions (Jackson, 1973). The clear water supernatant obtained from the suspension used for pH was utilized for the electrical conductivity measurement using conductivity bridge (Jackson, 1973). Wet-oxidation method as described by Nelson and Sommers (1982) was used to determine soil organic carbon content.

RESULT AND DISCUSSSION

The effect of long term fertilization and manuring with continuous cropping system on soil pH was found to be significant. The data presented in Table No. 2 showed significantly highest soil pH due to application of 100% NPK + FYM @ 10 t ha^{-1} treatment after sorghum (7.96 and 7.95) and wheat crops (8.01 and 7.99) during respective years of experimentation and the lowest value was observed in absolute control. The pooled data of experimentation revealed that, significantly lowest *i.e.* 7.95 and 8.00 soil pH was recorded in 100% NPK + FYM @ 10*t* ha^{-1} treatment and it was at par with FYM only @ 10*t* ha^{-1} (7.99 and 8.01) in sorghum and wheat crop and the highest value was observed in 100% NPK + S @ 37.5 kg ha^{-1} (8.14 and 8.15).

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

Tr.	*Treatment details*	*Sorghum*			*Wheat*		
		2011-12	*2012-13*	*Pooled*	*2011-12*	*2012-13*	*Pooled*
T_1	50% NPK	8.04	8.05	8.05	8.05	8.06	8.06
T_2	75 % NPK	8.09	8.09	8.09	8.10	8.11	8.10
T_3	100 % NPK	8.07	8.09	8.08	8.08	8.09	8.08
T_4	100 % NPK-S Free	8.06	8.07	8.07	8.07	8.08	8.08
T_5	150 % NPK	8.13	8.14	8.13	8.15	8.16	8.15
T_6	100 % NP	8.12	8.13	8.13	8.13	8.14	8.14
T_7	100 % N	8.07	8.08	8.07	8.09	8.10	8.10
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	8.12	8.13	8.12	8.13	8.14	8.14
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	8.13	8.15	8.14	8.14	8.16	8.15
T_{10}	100% NPK + FYM @ 10*t* ha^{-1}	7.96	7.95	7.95	8.01	7.99	8.00
T_{11}	FYM @ 10*t* ha^{-1}	8.00	7.99	7.99	8.02	8.00	8.01
T_{12}	Control	8.07	8.11	8.09	8.15	8.17	8.16
SE (m) ±		0.020	0.024	0.022	0.036	0.023	0.029
CD at 5%		0.058	0.070	0.064	0.104	0.066	0.085
Initial value			8.00				

After wheat soil pH was higher than sorghum crop, this was might be due to evaporation of water from surface and soluble salts in soil may be depleted at surface level (Bellaki, 1998). It was observed that the soil pH was maintained at the conjunctive use of organics and chemical fertilizers over a period of 23 years, which could be attributed to the buffering effect caused due to organic matter and secondly due to the high buffering capacity of the clayey soil (Katkar, 2011). The initial soil pH at the start of long term experiment during 1988-89 was 8.0, which was observed to be increased in general under all the treatments except integration treatment (100% NPK + FYM @ 10 t ha^{-1}) and also high in all the treatments of only chemical fertilizers, however, it was significantly lowered down under the treatments of integration indicating the need of addition of organics for maintaining pH of soil (Jadhao, 2014). A relatively lower soil pH under 100% NPK in combination with organic manures may be ascribed to the increased retention of exchangeable bases and increase CEC of the soil (Shiva kant, 2012). The slightly higher pH value under 100 % NPK + S @ 37.5 kg ha^{-1} may be due to gypsum was applied as a source of sulphur (Lakade 2002, Tayade 2002). The effect of long term fertilization and manuring with continuous cropping system on soil EC was found to be significant. The data presented in Table 3. showed significantly lowest soil EC due to application of 100% NPK + FYM @ 10 t ha^{-1} treatment after sorghum (0.293, 0.288 dS m^{-1}) and wheat crops (0.285, 0.283 dS m^{-1}) during irrespective years of experimentation and the lowest value was observed in absolute control. The pooled data of experimentation revealed that, significantly lowest EC *i.e.* 0.290, and 0.284 dS m^{-1} was recorded in 100% NPK + FYM @ 10 t ha^{-1} treatment and it was at par with FYM @ 10 t ha^{-1} (0.290, 0.284 dS m^{-1}) in sorghum and wheat crop and the highest value was observed in 150% NPK (0.364, 0.370 dS m^{-1}). The application of 150% NPK during the period of experimentation recorded highest electrical conductivity followed by 100% NPK. The initial value of electrical conductivity at the start of experiment was 0.30 dS m^{-1} which was increased under all the treatments except control, only FYM, 50% NPK and in 100% NPK + FYM @ 10*t* ha^{-1}. Electrical conductivity of soil was found to be low at almost all the treatments under study and found well below the critical limit of soil. Electrical conductivity caused soil salinity (Tayade, 2002) It was also observed that, the difference of electrical conductivity among the different treatments were significant. Lowest electrical conductivity found in control. The small increase in electrical conductivity might be due to accumulation of soluble salts at the surface were fertilizer applied alone. It was observed that electrical conductivity of FYM only was maintained due to continuous application of FYM over a period of 25 years (Changade, 2011). The application of 100% NPK to sorghum and wheat resulted significant improvement in electrical conductivity which was 0.364 and 0.370 dS m^{-1} respectively at sorghum and wheat. The higher EC in 150% NPK May be due to accumulation soluble salts as a result of higher quantity of chemical fertilizer in contrast to the 150% NPK treatment.

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

		Electrical conductivity (dS m⁻¹)					
		Sorghum			*Wheat*		
Tr.	*Treatment details*	*2011-12*	*2012-13*	*Pooled*	*2011-12*	*2012-13*	*Pooled*
T_1	50% NPK	0.30	0.29	0.29	0.30	0.30	0.30
T_2	75 % NPK	0.30	0.29	0.30	0.31	0.31	0.31
T_3	100 % NPK	0.32	0.32	0.32	0.33	0.32	0.33
T_4	100 % NPK S Free	0.30	0.29	0.29	0.31	0.29	0.30
T_5	150 % NPK	0.36	0.36	0.36	0.36	0.37	0.37
T_6	100 % N P	0.31	0.31	0.31	0.31	0.31	0.31
T_7	100 % N	0.27	0.28	0.28	0.29	0.28	0.29
T_8	100 % NPK + Zn @ 2.5 Kg ha^{-1}	0.31	0.32	0.31	0.31	0.33	0.32
T_9	100 % NPK + S @ 37.5 Kg ha^{-1}	0.30	0.29	0.29	0.32	0.32	0.32
T_{10}	100 % NPK + FYM @ 10 t ha^{-1}	0.29	0.28	0.29	0.28	0.28	0.28
T_{11}	FYM @ 10 t ha^{-1}	0.29	0.28	0.28	0.29	0.28	0.29
T_{12}	Control	0.27	0.27	0.27	0.22	0.22	0.22
SE (m) +		0.007	0.005	0.006	0.007	0.006	0.007
CD at 5 %		0.021	0.016	0.019	0.021	0.019	0.020
Initial value			0.30				

Sorghum-wheat cropping sequence without manures and fertilizers resulted relatively less amount of accumulated soluble salts in the soils which evidence in lesser EC value of soil (Bellaki 1998, Lakade 2002). Soil organic carbon is the key soil property for evaluation soil health. Effect of various long term treatments showed significant influence on organic carbon of soil The data presented in Table 4 showed significantly highest soil organic carbon due to application of 100% NPK + FYM @ 10*t* ha^{-1} treatment after sorghum (7.96, 8.05 g kg^{-1}) and wheat crops (7.85, 7.92 g 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 organic carbon was recorded in 100% NPK + FYM @ 10 t ha^{-1} treatment (8.00, 7.88 g kg^{-1}) in sorghum and wheat crop and the lowest value was observed in absolute control (3.33,2.98 g kg^{-1}). The continuous cropping without manure and fertilizer (T_{12} – control) recorded lowest organic carbon. This can be attributed to oxidation of organic matter in soil owing to prevailing high temperature in semi-arid climatic areas as well as long absence of addition of any organic and inorganic inputs which caused relatively poor crop growth which further

Table4
Soil Organic Carbon as influenced by long term manure and fertilizers application under sorghum-wheat cropping sequence
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		Soil organic carbon (g kg⁻¹)					
		Sorghum			*Wheat*		
Tr.	*Treatment details*	*2011-12*	*2012-13*	*Pooled*	*2011-12*	*2012-13*	*Pooled*
T_1	50 % NPK	4.56	4.43	4.50	4.54	4.50	4.52
T_2	75 % NPK	4.99	6.65	5.82	5.44	5.75	5.59
T_3	100 %NPK	5.13	5.08	5.10	5.27	5.33	5.30
T_4	100 % NPK-S Free	5.02	5.05	5.04	5.16	5.22	5.19
T_5	150 % NPK	6.55	6.65	6.60	6.60	6.64	6.62
T_6	100 % N P	4.88	4.77	4.83	4.92	4.93	4.92
T_7	100 % N	4.35	4.30	4.32	4.47	4.43	4.45
T_8	100 % NPK + Zn @ 2.5 kg ha^{-1}	6.37	6.45	6.41	6.46	6.47	6.46
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	6.44	6.52	6.48	6.32	6.47	6.39
T_{10}	100 % NPK + FYM @10 t ha^{-1}	7.96	8.05	8.00	7.85	7.92	7.88
T_{11}	FYM @ 10 t ha^{-1}	7.47	7.50	7.48	7.74	7.79	7.76
T_{12}	Control	3.32	3.34	3.33	2.93	3.04	2.98
SE (m) +		0.04	0.05	0.04	0.04	0.03	0.03
CD at 5 %		0.12	0.15	0.13	0.12	0.09	0.10
Initial value			4.60				

resulted into relatively less quantity of root biomass production (Vaidya and Gabhane 1998). However, the conjoint use of chemical fertilizers with FYM were found beneficial for maintaining organic carbon content compared to the use of only chemical fertilizers. The increase in organic carbon content under integrated use of chemical fertilizers and organic manure treatments might have been due to direct incorporation of organic matter, better root growth and more plant residues addition (Ravankar 2000, Tiwari 2002, Tayade 2002 and Mali 2015). Thus it is notion that intensive cropping coupled with chemical fertilizers causing decline in the organic carbon content of soil. Under long term fertilizer experiment, it is proved that balanced fertilization or super optimal dose of fertilizers improved soil organic carbon status due to better crop growth and production of high root biomass. From the study, it is proved that, continuous application of FYM alone to sorghum-wheat sequence could not sustain the productivity, in spite of improving organic carbon status of soil. (Ravankar *et al.* 2005 and Jadhao *et al.* 2014).

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