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Long-term Effects of Fertilizers and Manures on Physical Properties of Vertisol

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ABSTRACT

Field experiment was conducted during 2013-14 at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh. The continuous addition of balanced fertilization did not show any deteriorating effect on physical properties of the soil rather it significantly increased the water holding capacity, porosity, volume expansion and reduced bulk density of the soil in the long-run. Significant improvement in the physical properties of the soil was observed under the combined application of organics and inorganics. The unmanured control resulted poor physical properties.

Key words: *Fertilizers, Long-term effect, Manure, Physical properties.*

The importance of long-term fertilizer experiments in studying the effects of continuous cropping and fertilizer or manure application on soil fertility and sustenance of crop production is widely recognized (Swarup, 2002). The changes in physical properties of soil occurring due to continuous use of fertilizers and manure assume great significance for sustainability of this cropping system. The present study was carried out to monitor the long-term effects of fertilizers and manure on soil physical properties at 23rd crop cycle of cotton mono-cropping in Vertisol.

MATERIAL AND METHODS

The long-term manures and fertilizer experiment is being conducted at Regional Agricultural Research Station, Lam, Guntur in Andhra Pradesh(Altitude of 31.5m above mean sea level, 16^0 2' N latitude and longitude of 80^0 3' E). The present investigation was undertaken during 2013-14. The experiment consisted of eleven treatments *viz*., T_1 - Control, T_2 - 50% of the recommended dose of NPK, T_3 - 100% of the recommended dose of NPK, T_4 - 150% of the recommended dose of NPK, T_5 - 100% of the recommended dose of NP, T_6 - 100% of the recommended dose of N, T_7 - T_3+FYM @ 10 t ha^{-1}, T_8 - T_3+ $ZnSO_4$ @ 50 kg ha^{-1}, T_9 - T_3+$MgSO_4$ @ 50 kg ha^{-1}, T_{10} - 200% of the recommended dose of NPK and T_{11} - T_3+gypsum @ 5 q ha^{-1}.

The recommended dose Fertilizers was applied through urea (46 % N), single superphosphate (16 % P2O5) and muriate of potash (60 % K2O), as per the treatments. FYM was applied 10 days before sowing in the respective treatment. Application of Phosphorus, $ZnSO_4$ and MgSO4and gypsum (soil application) was done before sowing. Nitrogen and potassium were applied as three equal splits.

Bulk density of soil was determined by clod method (Dastane, 1967). Water holding capacity and Volume expansion was estimated by Keen cup method as described by Sankaram (1966). Porosity was determined in the soils after harvest of crop using bulk density and particle density (Majumdar and Singh, 2005).

RESULTS AND DISCUSSION

The physical properties were tremendously influenced by theapplication of FYM along with inorganic fertilizers to the soil (T_7). A glance of the data revealed that bulk density slightly decreased from initial to harvesting stage which might be due to secondary cultural operations. Obviously the highest bulk density was observed in subsurface soils on comparing with surface soils due to compaction. Irrespective of growth stages, bulk density was not varied significantly among the treatments.

Table 1. Effect of long-term use of manures and fertilizers on soil bulk density (Mg m^{-3}) and soil water holding capacity (%).

Treatments	Bulk density (Mg m^{-3})				Water holding capacity (%)			
	Surface		Sub-surface		Surface		Sub-surface	
	Initial	Harvest	Initial	Harvest	Initial	Harvest	Initial	Harvest
T_1: Control	1.39	1.39	1.40	1.40	33.7	33.1	33.6	32.7
T_2: 50% RD of NPK	1.38	1.37	1.39	1.38	36.7	36.9	36.2	36.2
T_3: 100% RD of NPK	1.37	1.35	1.38	1.36	35.9	36.2	35.5	35.6
T_4: 150% RD of NPK	1.37	1.35	1.37	1.36	34.6	34.2	34.1	34.0
T_5: 100% RD of NP	1.36	1.35	1.37	1.36	35.1	35.8	34.8	34.6
T_6: 100% RD of N	1.35	1.33	1.36	1.34	36.2	36.0	35.7	35.0
T_7: T_3 + FYM @10 t ha^{-1}	1.34	1.32	1.35	1.34	42.9	42.2	42.6	41.0
T_8: T_3 + $ZnSO_4$ @ 50 kg ha^{-1}	1.35	1.36	1.36	1.37	39.5	40.4	39.1	40.3
T_9: T_3 + $MgSO_4$ @ 50 kg ha^{-1}	1.35	1.33	1.36	1.34	39.5	39.7	39.3	38.8
T_{10}: 200% RD of NPK	1.35	1.35	1.37	1.35	34.5	33.2	34.3	33.1
T_{11}: T_3 + gypsum @ 5 q ha^{-1}	1.36	1.36	1.37	1.37	39.5	39.8	38.6	38.6
SEm±	0.04	0.04	0.05	0.04	1.32	1.27	1.46	1.96
CD (0.05)	NS	NS	NS	NS	3.9	3.7	4.3	NS
CV (%)	5.2	5.3	5.5	5.4	6.8	6.5	7.3	10.1

Initial soil bulk density of 0–15 cm layer varied from 1.34 (100% NPK + FYM) to 1.39 Mgm^{-3} (control) whereas in 15–30 cm layer it varied from 1.35 to 1.40 Mg m^{-3}.At harvest stage, bulk density in both the layers ranged from 1.32 to1.39 and 1.34 to 1.40 Mg m^{-3}.The higher bulk density in the sub-surface layer indicated the presence of compacted sub-surface layer.Babhulkar (2000) also reported the presence of compacted (plough pan) sub-surface layer dueto accumulation of outwash from the upper horizon and the pressure produced from theanimals and machineries used for the cultivation of lands.The higher bulk density in control plotcould bedue to low organic matter content in soil and formation of compact layer.

Data as regards the effect of various treatments on water holding capacities of soil during different stages (initial and harvesting) are presented in table 1indicated that the treatments effect was significant.The water holding capacity (WHC) of the soil which may depends on micro porosity of soil, varied significantly with application of organic nutrients.

Water holding capacity initially at surface and subsurface layers ranged from 33.7 to 42.9 per cent and 33.6 to 42.6 per cent in different treatments. The highestwater holding capacity was recorded (42.9, 42.6 per cent) at both the surfaces of soil in T_7which,received of 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1}(T_7) which was on par with T_8, T_{11} and T_9.

At harvest stage, similar trend was followed for water holding capacityinsurface and subsurface soils whichranged from 33.1 to 42.3 and 32.7

Table 2. Effect of long-term use of manures and fertilizers on soil porosity (%) and volume expansion per 100 g soil (cm^3)

Treatments	Soil porosity (%)				Volume expansion per 100 g soil (cm^3)			
	Surface		Sub-surface		Surface		Sub-surface	
	Initial	Harvest	Initial	Harvest	Initial	Harvest	Initial	Harvest
T_1: Control	42.9	41.8	42.1	41.3	34.1	33.9	33.5	32.9
T_2: 50% RD of NPK	45.9	45.3	45.7	44.5	38.4	38.0	37.3	37.1
T_3: 100% RD of NPK	45.6	44.3	45.5	43.9	37.1	35.9	36.4	34.9
T_4: 150% RD of NPK	44.3	44.5	43.9	43.6	36.3	35.4	35.9	35.1
T_5: 100% RD of NP	45.2	44.2	44.4	43.4	36.0	35.3	35.8	35.1
T_6: 100% RD of N	45.1	43.7	47.3	41.7	36.3	36.4	34.6	35.2
T_7: T_3 + FYM @10 t ha^{-1}	51.2	50.8	51.2	50.0	42.4	42.1	41.9	41.1
T_8: T_3 + $ZnSO_4$ @ 50 kg ha^{-1}	46.7	45.8	46.2	45.5	38.1	37.9	37.9	37.0
T_9: T_3 + $MgSO_4$ @ 50 kg ha^{-1}	45.6	45.0	45.0	44.5	37.6	37.5	36.8	36.6
T_{10}: 200% RD of NPK	43.6	43.3	43.1	43.4	36.3	34.4	35.7	34.3
T_{11}: T_3 + gypsum @ 5 q ha^{-1}	47.4	45.7	46.5	2.22	36.8	36.5	36.3	35.1
SEm±	2.33	2.38	2.13	2.12	1.74	2.68	1.32	2.32
CD (0.05)	NS	7.0	NS	NS	NS	NS	NS	NS
CV (%)	8.8	10.0	8.1	8.7	8.1	12.6	6.2	11.2

to 41 per cent, respectively. The highest water holding capacity (42.3 per cent) was recorded with the application of 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1} (T_7) which was on par with T_8, T_{11} and T_9. Among the treatments, the highest water holding capacity was observed in $T_7$with the application of 100 per cent recommended dose of NPK+FYM @ 10 t $ha^{-1}$and the results were in conformity with the findings of Katkar*et al.,* 2012.

The increase in WHC of soil after harvest of crop in treatment that received organic manure was evidently due to effect of organic sources (Talathi*et al.*, 2010).Organic matter improved soil water holding capacity and helped the soil to maintain good tilth and thereby better aeration for germinating seeds and plant root development.

The perusal data revealed that porosity at different stages as affected by different treatments. The higher porosity was noticed with plots receiving 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1} (T_7).These were not significantly influenced by different treatments in both the surfaces.The highest porosity of 51.6per cent was recorded in $T_7$with application of 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1} which was on par with T_8, T_9, T_{11}, T_2, T_3, T_5, T_4 and T_6. At harvesting stage, similar trend was followed at both the layers. Porosity was statistically non-significant in sub-surface layer. The highestporosity (50.8 and 50.0 per cent) was observed in $T_7$and which was on par with T_8, T_{11}, T_2, T_9, $T_3$and T_5. Earlier studies conducted by Selvi *et al.* (2005) revealed the decrease in bulk density and increase inporosity with the addition of FYM. It could be attributed to thefixing

of the low density materials with the dense mineral fraction of the soilresulting in good soil aggregation and increased pore space.

The data furnished in table 2, indicated that volume expansion of soil at different stages. The volume expansion was higher with plots receiving 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1} (T_7).The values were statistically non-significant in surface and sub-surface soils. The highest volume expansion in both surfaces was 42.4, 41.9 per 100 g of soil which was significantly superior over rest of the treatments in sub-surface soils.At harvesting stage, volume expansion of surface soils was in between 33.5 and 41.9 per 100g of soil. The highestvolume expansion of 41.9 per 100 g of soil was observed in T_7, followed by T_8 which was on par with T_2, T_9, T_3, T_{11}, T_4, T_5, $T_{10}$and T_6. The volume expansionin sub-surface soils is statistically non-significant.

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