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SP Gediya
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

AV Rajani
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
SP Gediya
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

Long term effect of balance nutrient management on dynamics of important physical properties of a calcareous under AICRP-LTFE soils

SP Gediya and AV Rajani

Abstract
Surfaces soil samples (0-15 cm) were collected to study Long term effect of balance nutrient management on Soil physical properties from soils of the LTFE's conducted on groundnut-wheat cropping sequence at Instructional Farm, Junagadh Agricultural University, Junagadh during the year 2002-03 (4th year), 2006-07 (8th year), 2010-11 (12th year) and 2014-15 (16th year) after completion of crop cycle. The application of FYM @ 10 t/ha to groundnut and @ 15 t/ha to wheat increased porosity, maximum water holding capacity, moisture retention and hydraulic conductivity of soil. This was significantly reduced bulk density and particle density of soil with application of FYM compare to fertilized and control plots.

Keywords: TFE soils, bulk density, particle density, hydraulic conductivity, FYM, groundnut-wheat sequence

Introduction

Plant growth have influenced very much by Physical properties of a soil. The plant support root penetration, drainage, retention of moisture and plant nutrients are related with the physical conditions of the soil. Physical properties also influence the chemical and biological behavior of all soils. The physical properties of a soil depend on the amount, size, shape, arrangement and mineral composition of its particles. It is also depend on organic matter content and pore spaces.

Long-term fertilizer experiments play an important role in understanding the changes in physical, chemical properties and productivity of the crop. The decline in soil fertility due to the imbalanced fertilizers use has been recognized as one of the most important factors limiting crop yields (Nambiar and Abrol, 1989) [9]. Continuous application of manures and fertilizer for a longer time brings definite change in soil physical properties. But what would the future of soil physical properties under intensive cultivation with the use of manures and fertilizers? Answer to this basic question formed a theme of investigation for us. There is need to the study the effect of long term fertilization on soil physical condition and hence, the present investigation was taken up to study the influence of inorganic alone and in combination with manures on changes in physical properties of calcareous soil of Junagadh.

Materials and Methods

Surface soil samples (0-15 cm) were collected from the AICRP-LTFE Soils of the LTFE's conducted on groundnut-wheat cropping sequence in RBD replicated four time at Instructional Farm, Junagadh Agricultural University, Junagadh during the year 2002-03 (4th year), 2006-07 (8th year), 2010-11 (12th year) and 2014-15 (16th year) after completion of crop cycle. The treatment were T_1-50% NPK of recommended doses in Groundnut-Wheat sequence, T_2-100% NPK of recommended doses in Groundnut-Wheat sequence, T_3 -150% N P K of recommended doses in Groundnut-Wheat sequence, T_4-100% NPK of recommended doses in Groundnut-Wheat sequence + ZnSO4 @ 50 kg/ha once in three year to Groundnut only (i.e. '99, 02, 05 etc), T_5-NPK as per Soil Test, T_6-100% NP of recommended doses in Groundnut -Wheat sequence, T_7 -100% N of recommended doses in Groundnut-Wheat sequence, T_8 - 50% N P K of recommended doses in Groundnut -Wheat sequence + FYM @ 10 t/ha Groundnut and 100% N P K to Wheat, T_9-Only FYM @ 10 t/ha to Groundnut and @15 t/ha to wheat, T_{10} - 50% N P K of recommended doses in Groundnut-Wheat sequence + Rhizobium + PSM to

Groundnut and 100% NPK to Wheat, T_{11} -100% NPK of recommended doses in Groundnut –Wheat sequence (P as S S P) and T_{12}-Control. (Recommended dose for G'nut= 12.5-25.0-0.0 N-P_2O_5-K_2O kg/ha and Wheat = 120-60-60 N-P_2O_5-K_2O kg/ha). The bulk density of the disturb soil was estimated by the core method. The particle density of the soil was estimated by the pycnometer method (Richards, 1954) [14]. The porosity of the soil was estimated by the air pycnometer method (Richards, 1954) [14]. The per cent pore space was also calculated by using the value of bulk density and the particle density, using the following formula:

Percent pore space = 100-[Db/Dp ×100]

Where,

Db = Bulk density (Mg m-3)

Dp = Particle density (Mg m-3)

The water holding capacity of the soil was estimated by the air Keen Raczkowski method (Piper, 1950). The saturated hydraulic conductivity of the disturbed soil sample was measured by falling head method, as the described by Klute (1965) [5]. Moisture Retention Capacity of soil sample at FC (0.03 MPa) and PWP (1.5 MPa) tension was measured by pressure plate membrane apparatus (Richards, 1954) [14].

Results and Discussion

Bulk Density

Bulk density was significantly affected by long term application of FYM and fertilizers. The application of FYM @ 10 t ha^{-1} to G'nut and @ 15 t/ha to wheat (T_9) found significantly decreased bulk density in 4th, 8th, 12th year and pooled result. It was at par with T_8 in 4th, 8th year and pooled result. It is evident from the data that the application of only FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat (T_9) significantly reduced the bulk density from 1.34 Mg m^{-3} in 4th year to 1.32 Mg m^{-3} in pooled over year and also found that the lowest bulk density (1.33 Mg m^{-3}) was observed under treatment FYM @ 10 t ha^{-1} to G'nut and @ 15 t/ha to wheat (T_9) in 16th year result. The interaction effect of year and treatment on bulk density was also found significant. In the present study, application of farm yard manure alone or in combination with chemical fertilizers the bulk density of soil decreased with increase in organic matter. This may be described due to application of organic manure that increase in organic matter content might have resulted in better aggregation and hence lower bulk density. Several workers observed improvement of soil physical parameters with incorporation of FYM with or without fertilizers. Bajpai *et al.* (2006) [1], Sharma *et al.* (2007) [15] and Choudhary *et al*. (2008) [2].

Particle density

Particle density was significantly affected in 8th, 12th and 16th year of experiment and also in pooled over time by long term application of FYM and fertilizers. It was found non significant in 4th year. In 8th and 12th year T_9 gave significantly lower result. It is recorded from the data that the application of FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat (T_9) significantly decreases the particle density from 2.40 Mg m^{-3} (T_{12} & T_1) to 2.21 Mg m^{-3} (T_9) in 16th year result. The lowest particle density (2.30 Mg m^{-3}) was noted under treatment T_9 in pooled result. The interaction effect of year and treatment on particle density was also observed significant. The particle density was continuously reduced in T_9. Gathala *et al.* (2007) [4] also observed decreased in particle density with application of FYM alone or in combination with chemical fertilizers. Decreased in particle density was due to higher organic carbon content of the soil, more pore space resulting in better soil aggregation.

Porosity

The porosity was remain unchanged during in 4th, 8th and 16th of experiment, found significantly in 12th year and pooled over time by long term application of FYM and fertilizers. But mean values numerically increase over the time. The interaction effect year and treatment on porosity of soil was found non-significant.

Maximum water holding capacity

The maximum water holding capacity was found non-significant in 8th and 16th year but it was numerically increasing in treatment of FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat. (T_9). In same treatment obtained significant higher result in 4th and 12th year. It was at par with T_1, T_6, T_7, T_8, T_{10} in 4th year and T_{10} in 12th year. Pooled result showed that maximum water holding capacity after completion of wheat crop ranged from 42.75 to 48.64 %. The treatment receiving FYM alone (48.64%) showed significantly higher maximum water holding capacity as compared to all chemical fertilizers at par with treatments T_4, T_7, T_8, and T_{10}. There were non-significant interaction effect of year (Y) and treatment (T) on maximum water holding capacity. The increased maximum water holding capacity of soil in FYM treated plots may be due to rise in organic matter and improved soil aggregation. These results corroborates with the findings of Nikam *et al.* (2006) [12], Yadav & Kumar (2009) [16] Gagoi (2011) [3]. The study revealed that use of organics with or without fertilizers improved the physical condition of the soil.

Moisture retention

The moisture retention at FC (0.03 MPa) was non significant at 16th year but found the significantly highest in 4th, 8th and 12th year and pooled under the application of FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat (T_9). Moisture retention at PWP was found significantly higher in T_9, at par with T_2, T_3, T_4, T_5, T_8 and T_{10} in 4th year. The treatment receiving FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat noted the highest moisture retention (27.82 and 16.07% at FC and PWP respectively) in pooled. The interaction effect of year and treatment on moisture retention was also found significant. Application of FYM as well as fertilizer improved the water retention capacity of the soil. The superiority of FYM found compare to other treatments in maintaining all over water balance. Lal and Mathur (1989) [6] also reported similar findings. Mayalagu (1983) [8] observed higher value for moisture content and water holding capacity with application of FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat in clay loam soil. Similar result also obtained Bhattacharyya *et al.* (2004), Nikam (2006) [12], Laxminarayan (2006) [7] and Niraj Kumar *et al*. (2015) [11].

Hydraulic conductivity

The hydraulic conductivity found significant in 4th, 8th, 12th and 16th year. The pooled was also significantly affected by long term application of FYM and fertilizers. It is evident from the data that the application of FYM @ 10 t/ha to G'nut and @ 15 t/ha to wheat (T_9) alone significantly increased the hydraulic conductivity from 0.591 cm hr^{-1} (T_7 & T_4) to 0.631

cm hr-1 (T_9) in pooled result. Significantly the highest hydraulic conductivity (0.631 cm hr^{-1}) was observed under treatment T_9 in pooled result. Among the fertilizer treatments, the lowest hydraulic conductivity (0.591 cm hr^{-1}) was noted in treatment T_7 and T_4 in pooled result. Significantly the highest hydraulic conductivity (0.605 cm hr^{-1}) was observed under treatment T_9 in 4th year result and it was at par with treatment T_8 and it was also found at par with treatment T_8 in 16th year result. The interaction effect of year and treatment on hydraulic conductivity of soil was observed significant.

Hydraulic conductivity of soil increased significantly with the application of FYM. The increased hydraulic conductivity of the soil in FYM treated plots may be due to rise in organic matter and improved soil aggregation, there by increased in hydraulic conductivity. These results corroborates with the findings of Nikam *et al.* (2006) [12], Yadav & Kumar (2009) [16] and Naandapure *et al* (2011) [10]. The study revealed that use of organics with or without fertilizers improved the physical condition of the soil.

Table 1: Bulk density (Mg m^{-3}) in 4th, 8th, 12th and 16th year of LTFE Soils.

Treat.	Bulk density (Mg m^{-3})				
	4th year	**8th year**	**12th year**	**16th year**	**Pooled**
T1	1.39	1.39	1.39	1.38	1.38
T2	1.38	1.38	1.37	1.36	1.37
T3	1.38	1.38	1.37	1.36	1.37
T4	1.37	1.37	1.37	1.38	1.37
T5	1.37	1.37	1.37	1.38	1.37
T6	1.36	1.36	1.36	1.36	1.36
T7	1.36	1.35	1.35	1.35	1.36
T8	1.34	1.33	1.31	1.35	1.33
T9	1.34	1.33	1.29	1.33	1.32
T10	1.36	1.36	1.35	1.36	1.36
T11	1.36	1.37	1.37	1.36	1.37
T12	1.39	1.39	1.40	1.39	1.39
S.Em.±	0.003	0.005	0.004	0.008	0.003
C.D. at 5 %	0.01	0.01	0.01	0.02	0.01
C.V. %	0.39	0.67	0.60	1.18	0.77
Mean	1.37	1.37	1.36	1.36	1.36
Y x T	S.Em.±	0.01		C.D. at 5 %	0.010

Table 2: Particle density (Mg m^{-3}) in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Particle density (Mg m^{-3})				
	4th year	**8th year**	**12th year**	**16th year**	**Pooled**
T1	2.40	2.40	2.40	2.40	2.40
T2	2.40	2.40	2.39	2.38	2.39
T3	2.41	2.39	2.40	2.38	2.39
T4	2.39	2.38	2.38	2.37	2.38
T5	2.37	2.37	2.37	2.36	2.37
T6	2.36	2.38	2.37	2.36	2.37
T7	2.35	2.37	2.36	2.35	2.36
T8	2.35	2.32	2.33	2.30	2.33
T9	2.36	2.34	2.30	2.21	2.30
T10	2.36	2.38	2.37	2.37	2.37
T11	2.40	2.38	2.37	2.36	2.38
T12	2.40	2.40	2.41	2.40	2.41
S.Em.±	0.02	0.01	0.01	0.01	0.01
C.D. at 5 %	NS	0.026	0.024	0.033	0.028
C.V. %	1.55	0.76	0.72	0.99	1.06
Mean	2.38	2.37	2.37	2.35	2.37
Y x T	S.Em.±	0.013		C.D. at 5 %	0.035

Table 3: Porosity (%) in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Porosity (%)				
	4th year	**8th year**	**12th year**	**16th year**	**Pooled**
T1	42.10	42.22	42.17	42.44	42.23
T2	42.73	42.42	42.19	42.99	42.58
T3	42.25	42.43	42.05	43.22	42.49
T4	42.30	42.28	42.14	42.36	42.27
T5	42.40	42.19	42.22	42.22	42.26
T6	42.89	42.48	42.37	42.99	42.68
T7	43.01	42.40	42.29	42.44	42.54
T8	42.30	42.57	42.12	42.30	42.32
T9	42.05	41.69	39.73	42.07	41.39
T10	43.18	42.74	42.59	42.59	42.78
T11	42.88	42.39	41.92	42.75	42.48
T12	41.84	42.37	42.06	42.22	42.12
S.Em.±	0.31	0.19	0.42	0.41	0.17
C.D. at 5 %	NS	NS	1.22	NS	0.48
C.V. %	1.45	0.90	2.02	1.92	1.63
Mean	42.49	42.35	41.99	42.55	42.35
Y x T	S.Em.±	0.35		C.D. at 5 %	NS

Table 4: Maximum water holding capacity (%) in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Maximum water holding capacity (%)				
	4th year	**8th year**	**12th year**	**16th year**	**Pooled**
T1	43.98	43.63	42.44	50.00	45.01
T2	42.21	43.28	44.07	49.40	44.74
T3	41.99	44.16	44.04	48.58	44.69
T4	43.25	41.77	44.28	56.06	46.34
T5	42.81	43.28	41.02	50.81	44.48
T6	43.98	43.18	44.40	39.43	42.75
T7	44.98	43.94	43.85	51.04	45.95
T8	44.27	44.61	45.04	55.19	47.28
T9	45.21	46.42	47.16	55.75	48.64
T10	44.07	44.56	45.58	55.70	47.48
T11	42.76	42.43	43.73	49.65	44.64
T12	43.07	43.93	43.59	48.84	44.86
S.Em.±	0.56	1.15	0.72	3.55	0.96
C.D. at 5 %	1.61	NS	2.06	NS	2.69
C.V. %	2.57	5.24	3.25	13.96	8.43
Mean	43.55	43.77	44.10	50.87	45.57
Y x T	S.Em.±	1.92		C.D. at 5 %	NS

Table 5: Moisture retention (%) at field capacity in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Moisture retention (%) at FC (0.03 MPa)				
	4th year	**8th year**	**12th year**	**16th year**	**Pooled**
T1	22.09	22.50	22.41	25.34	23.09
T2	22.58	22.32	23.11	24.58	23.15
T3	23.47	23.03	23.49	23.95	23.48
T4	23.59	23.04	23.34	26.43	24.10
T5	24.39	22.25	23.11	27.03	24.19
T6	23.66	24.03	24.07	26.83	24.65
T7	22.79	23.04	22.87	17.93	21.66
T8	23.99	25.69	26.72	27.04	25.86
T9	26.68	27.80	29.80	26.99	27.82
T10	24.81	23.04	24.62	25.07	24.39
T11	24.16	23.07	23.62	25.83	24.17
T12	23.61	23.21	23.88	26.76	24.36
S.Em.±	0.71	0.59	0.51	1.86	0.54
C.D. at 5 %	2.05	1.69	1.46	NS	1.50
C.V. %	5.97	4.99	4.19	14.68	8.83
Mean	23.82	23.59	24.25	25.40	24.26
Y x T	S.Em.±	1.07		C.D. at 5 %	3.00

Table 6: Moisture retention (%) at permanent wilting point in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Moisture retention (%) at PWP (1.5 MPa)				
	4th year	8th year	12th year	16th year	Pooled
T1	11.22	10.59	10.67	16.02	12.12
T2	11.79	10.73	11.07	16.87	12.61
T3	11.67	10.93	10.86	16.05	12.38
T4	11.55	10.27	11.19	14.44	11.86
T5	12.07	11.23	11.19	16.21	12.67
T6	11.34	11.67	11.46	15.51	12.50
T7	11.08	10.70	10.62	12.85	11.31
T8	12.09	13.74	14.33	14.98	13.78
T9	12.54	17.08	17.53	17.14	16.07
T10	11.54	11.48	11.90	12.99	11.98
T11	10.48	10.61	10.86	13.38	11.34
T12	9.75	10.84	10.82	13.76	11.29
S.Em.±	0.35	0.47	0.41	0.80	0.27
C.D. at 5 %	1.00	1.34	1.17	2.32	0.75
C.V. %	6.07	8.01	6.87	10.72	8.59
Mean	11.43	11.66	11.88	15.01	12.49
Y x T	S.Em.±	0.54		C.D. at 5 %	1.50

Table 7: Hydraulic conductivity (cm hr^{-1}) in 4th, 8th, 12th and 16th year of LTFE Soils

Treat.	Hydraulic conductivity (cm hr^{-1})				
	4th year	8th year	12th year	16th year	Pooled
T1	0.594	0.594	0.592	0.592	0.593
T2	0.594	0.593	0.593	0.595	0.594
T3	0.596	0.596	0.595	0.597	0.596
T4	0.591	0.587	0.593	0.593	0.591
T5	0.594	0.594	0.601	0.600	0.597
T6	0.590	0.594	0.597	0.590	0.593
T7	0.590	0.595	0.587	0.592	0.591
T8	0.601	0.611	0.631	0.640	0.621
T9	0.605	0.624	0.650	0.643	0.631
T10	0.596	0.597	0.598	0.600	0.598
T11	0.595	0.594	0.598	0.612	0.600
T12	0.594	0.594	0.595	0.596	0.595
S.Em.±	0.001	0.002	0.002	0.005	0.002
C.D. at 5 %	0.004	0.006	0.005	0.015	0.004
C.V. %	0.450	0.640	0.610	1.740	1.010
Mean	0.595	0.598	0.602	0.604	0.600
Y x T	S.Em.±	0.003		C.D. at 5 %	0.008

Conclusion
Based on result summarized above, it has been concluded that the application of FYM alone or combine with chemical fertilizers increased porosity, maximum water holding capacity, moisture retention and hydraulic conductivity. This was significantly reduced bulk density and particle density, by application of FYM compare to fertilizer and control.

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