



Assessment of Soil Physical Properties under Major Cropping Systems of SPSR Nellore District, Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was carried out during 2021-22 in SPSR Nellore district of Andhra Pradesh, India to know the impact of major cropping systems on soil physical properties. A total of 240 soil samples (120 surface and 120 subsurface) under six major cropping systems such as paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram were collected and analysed for physical properties. The results revealed that the color of the soils ranged from pale red to very dark gray (2.5 YR 6/2 to 7.5 YR 3/1). The soils of study area were sandy clay loam,

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sandy loam, clay loam and clay in texture. Soils from paddy-paddy and paddy-cotton cropping systems recorded highest bulk density (1.55 mg m^{-3}) in surface soils and paddy-cotton (1.66 mg m^{-3}) cropping system in sub-surface soils whereas lowest bulk density observed in paddy-blackgram cropping system in both surface (1.13 mg m^{-3}) and sub-surface soils (1.29 mg m^{-3}). In surface and subsurface soils particle density was ranged from 2.45 mg m^{-3} in paddy-cotton and paddy-blackgram cropping system to 2.75 mg m^{-3} in paddy-cotton and paddy-greengram cropping systems. The soils of paddy-blackgram cropping system showed higher water holding capacity (54.65 and 49.71%, respectively) while the lowest was recorded in paddy-cotton cropping system in surface and sub-surface soils (31.39 and 28.28%, respectively). Volume expansion was found to be high in paddy-blackgram cropping system in both surface and subsurface soils (22.34 and 23.61%, respectively) while lowest volume expansion was noticed in paddy-paddy cropping system in surface soils (12.46%) and paddy-cotton cropping system in sub-surface soils (11.94%).

Keywords: *Cropping systems; soil physical properties; surface and subsurface soils; SPSR Nellore district.*

1. INTRODUCTION

“Soil physical properties are important for favourable crop growth and maintaining soil quality. Cropping systems exert significant impact on soil physical properties, which ultimately affect crop yield. In some cases, continuous monocropping has detrimental effects on soil quality. Soil health is negatively affected by unsuitable management practices, which decrease crop productivity. Soil physical properties are positively influenced by cropping systems and management practices, *i.e.*, residues retention and tillage” [1].

“The sustainability of crop and soil management practices to improve soil quality depends on the understanding, how soils respond to different site-specific cropping and landuse practices. Scientific information on site-specific soil properties is a basic tool for proper soil management in order to provide sustainable soil functions at present and in the future” [2]. “Site-specific data on soil properties could also support in dealing with the spatial variability of soil nutrients and physical indicators and their influencing factors. Soil properties as indicators of soil functions and soil quality status are suggested for understanding the sustainability of soil resources” [2].

“Many practices like crop type, cultivation and application of crop residues are known to influence soil properties. Therefore, sustainable cropping and land management practices are essential for maintaining crop productivity while enhancing various soil properties. Better crop rotations, reduced tillage, intensive use of cover crops and efficient use of organic manures offers a powerful combination of practices to improve

soil and agroecosystem health. Whereas, continuous use of inorganic fertilizers under intensive cropping systems leads to deterioration of soil properties resulting decline in soil productivity” [1]. In this view the present study was taken up to know in detailed the influence of various cropping systems on physical properties of soil.

2. MATERIALS AND METHODS

The present study was carried out in SPSR Nellore district of Andhra Pradesh, India which falls under southern Agro-climatic zone and geographically, located between $14^{\circ}4'12.9''$ and $14^{\circ}57'56.8''$ North latitudes and $79^{\circ}30'29.6''$ and $80^{\circ}4'24.7''$ East longitudes. In study area, 240 soil samples were collected (120 surface at 0-15 cm and 120 sub-surface at 15-30 cm) for physical analysis such as paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram of SPSR Nellore district by following random sampling technique during the year 2022. The exact sample location was recorded by using hand held GPS.

“Munsell's colour notation of Hue, Value and Chroma were observed for both air dried and moist soil samples” [3]. “Texture of the soils was determined by the Bouyoucos hydrometer method” as described by Baruah and Barthakur [4]. “Based on particle size distribution, textural classification was given using the *nomograph* (textural diagram) of USDA. The physical constants such as bulk density, particle density, water holding capacity and volume expansion in the soil samples were determined by following Keen Raczkowski's method” as described by Sankaram [5].

3. RESULTS AND DISCUSSIONS

The data pertaining to soil physical properties (soil colour, texture, bulk density, particle density, water holding capacity, volume expansion) was presented in Tables 1 to 4.

3.1 Soil Colour

The data presented in Table 1 revealed that the colour of soils under major cropping systems of SPSR Nellore ranged from pale red to very dark gray (2.5 YR 6/2 to 7.5 YR 3/1) with a hue varied from 2.5 YR to 7.5 YR, value ranged from 3 to 6 and chroma varied from 1 to 6 at both surface and sub-surface soils.

The color appears to be the function of chemical and mineralogical composition of the soil [6]. These colors indicated the release of iron oxides and their occurrence in various hydrated forms due to difference in drainage of the soils [7]. Similar findings were also reported by Thangasamy et al. [8], Sanjeev et al. [9] and Vajantha et al. [10].

3.2 Texture

From the Table 2 it was revealed that the texture of soils under paddy-paddy, fallow-paddy, groundnut-paddy cropping systems were sandy clay loam and clay loam while paddy-cotton cropping systems were sandy clay loam and clay loam in texture however, clay loam and clay texture was noticed in soils of paddy-greengram and paddy-blackgram cropping systems in SPSR Nellore district. The variation in soil texture might be due to variation in topographic position, nature of parent material, in situ weathering, translocation of clay and age of the soils [11]. Charan et al. [12] reported that texture of different cropping systems in Nellore district were sandy clay loam to clay.

3.3 Bulk Density

The maximum bulk density was observed in soils of paddy-paddy and paddy-cotton cropping system in surface soils (1.55 mg m^{-3}) and in paddy-cotton cropping system in sub-surface soils (1.66 mg m^{-3}) while the lowest in paddy-blackgram cropping system in both surface (1.13 mg m^{-3}) and sub-surface soils (1.29 mg m^{-3}), respectively. The range of bulk density for surface soils varied from 1.45-1.67, 1.12-1.38, 1.10-1.27, 1.35-1.67, 1.10-1.39 and 1.10-1.20 mg m^{-3} in paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram cropping systems (Fig 1) and CV was 14.24 and 11.74 per

cent for bulk density in both surface and subsurface soils of different cropping systems. The lowest bulk density was found under paddy-blackgram cropping system due to higher amount of added biomass from leguminous crops made soil loose, porous and less squeezed [13,14].

3.4 Particle Density

In surface and subsurface soils particle density was ranged from 2.45 mg m^{-3} in paddy-cotton and paddy-blackgram cropping system to 2.75 mg m^{-3} in paddy-cotton and paddy-greengram cropping systems (Table 3). The particle density did not show any trend with depth and more or less uniform values were recorded in surface and subsurface soil layers [15,14].

3.5 Water Holding Capacity (WHC)

The data presented in Table 4 revealed that the mean water holding capacity values of surface soils under major cropping systems of SPSR Nellore district namely paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram were 43.52, 45.98, 42.47, 31.39, 52.83 and 54.65% respectively. The water holding capacity in paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram was 36.21-49.45, 39.16-53.00, 26.00-53.88, 21.07-40.89, 45.76-57.86 and 48.90-57.90 (Fig. 2). The CV was 20.25 per cent for water holding capacity in the surface soils of different cropping systems.

In subsurface soils the mean water holding capacity values in paddy-paddy, fallow-paddy, groundnut-paddy, paddy-cotton, paddy-greengram and paddy-blackgram cropping systems were 40.70, 41.88, 35.70, 28.28, 47.72 and 49.71%, respectively. The CV was 21.64% for water holding capacity in the subsurface soils of different cropping systems.

In both surface and subsurface soils the highest water holding capacity was observed in paddy-blackgram (54.65 and 49.71%, respectively), cropping system and the lowest in paddy-cotton cropping system (31.39 and 28.28%, respectively). The highest water holding capacity in paddy-blackgram cropping system is due to rice-legume cropping systems store large amount of carbon in to the soil, which bind soil particles, increase mean weight diameter, improve water stable aggregates, and consequently increase in water holding capacity of soil [16].

Table 1. Soil color under major cropping systems of SPSR Nellore district, Andhra Pradesh.

Cropping system	Soil colour			
	Dry colour		Moist colour	
	Range			
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Paddy-paddy	2.5 YR 6/1 - 7.5 YR 4/1	2.5 YR 6/1 - 7.5 YR 3/1	2.5 YR 5/1 - 7.5 YR 3/1	2.5 YR 5/1 - 7.5 YR 3/1
Fallow-paddy	2.5 YR 7/1 - 7.5 YR 5/1	2.5 YR 6/1 - 7.5 YR 4/1	2.5 YR 6/1 - 7.5 YR 4/1	2.5 YR 6/3 - 7.5 YR 3/1
Groundnut-paddy	2.5 YR 6/2 - 5 YR 5/6	2.5 YR 5/4 - 5 YR 5/3	2.5 YR 5/2 - 5 YR 5/4	2.5 YR 5/2 - 5 YR 3/4
Paddy-cotton	2.5 YR 6/1 - 7.5 YR 4/2	2.5 YR 6/1 - 7.5 YR 4/1	2.5 YR 6/1 - 7.5 YR 4/1	2.5 YR 5/1 - 7.5 YR 3/1
Paddy-greengram	2.5 YR 6/1 - 7.5 YR 5/1	2.5 YR 6/1 - 7.5 YR 4/2	2.5 YR 5/1 - 7.5 YR 4/2	2.5 YR 5/1 - 7.5 YR 3/2
Paddy-blackgram	2.5 YR 5/1 - 5 YR 3/4	2.5 YR 5/3 - 5 YR 3/4	2.5 YR 4/1 - 5 YR 3/4	2.5 YR 4/3 - 5 YR 3/4

Table 2. Textural class of soils under major cropping systems of SPSR Nellore district, Andhra Pradesh

Cropping system	Texture			
	Sand (%)	Silt (%)	Clay (%)	Textural class
Paddy-paddy	56.65-75.00	4.61-15.79	10.71-29.11	Sandy clay loam & Sandy loam
Fallow-paddy	54.56-83.04	2.80-14.04	9.84-33.40	Sandy clay loam & Sandy loam
Groundnut-paddy	56.28-73.56	5.25-15.28	14.10-29.36	Sandy clay loam & Sandy loam
Paddy-cotton	41.95-71.82	3.16-27.24	21.36-37.45	Sandy clay lom & Clay loam
Paddy-greengram	31.32-45.26	15.59-25.78	29.27-45.60	Clay loam & Clay
Paddy-blackgram	30.25-47.09	13.88-26.59	29.27-55.87	Clay loam & Clay

Table 3. Bulk density and Particle density of soils under major cropping systems of SPSR Nellore district, Andhra Pradesh

Cropping system	Bulk density (Mg m ⁻³)				Particle density (Mg m ⁻³)			
	0-15 cm		15- 30 cm		0-15 cm		15- 30 cm	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Paddy-paddy	1.45-1.67	1.55	1.54-1.70	1.64	2.52-2.74	2.61	2.50-2.67	2.60
Fallow-paddy	1.12-1.38	1.23	1.22-1.46	1.34	2.48-2.74	2.61	2.48-2.74	2.60
Groundnut-paddy	1.10-1.27	1.20	1.25-1.36	1.30	2.60-2.75	2.66	2.60-2.73	2.66
Paddy-cotton	1.35-1.67	1.56	1.47-1.75	1.66	2.45-2.67	2.60	2.45-2.75	2.63
Paddy-greengram	1.10-1.39	1.19	1.26-1.53	1.35	2.61-2.75	2.68	2.63-2.75	2.68
Paddy-blackgram	1.10-1.20	1.13	1.23-1.37	1.29	2.45-2.75	2.68	2.60-2.74	2.67
CV (%)		14.24		11.74		2.56		2.34

Table 4. Water holding capacity and volume expansion of soils under major cropping systems of SPSR Nellore district, Andhra Pradesh

Cropping system	Water holding capacity (%)				Volume expansion (%)			
	0-15 cm		15- 30 cm		0-15 cm		15- 30 cm	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Paddy-paddy	36.21-49.45	43.52	34.39-44.26	40.70	7.65-18.58	12.46	11.30-19.57	14.15
Fallow-paddy	39.16-53.00	45.98	34.23-47.38	41.88	7.17-19.56	13.70	5.41-19.17	13.71
Groundnut-paddy	26.00-53.88	42.47	21.65-50.26	35.70	9.24-25.65	18.02	9.03-26.63	18.50
Paddy-cotton	21.07-40.89	31.39	20.05-38.57	28.28	7.16-18.85	12.85	6.02-17.36	11.94
Paddy-greengram	45.76-57.86	52.83	41.00-54.30	47.72	11.79-27.29	19.41	13.71-26.62	21.22
Paddy-blackgram	48.90-57.90	54.65	43.00-53.28	49.71	16.78-28.32	22.34	17.57-28.67	23.61
CV (%)		20.25		21.64		31.44		32.00

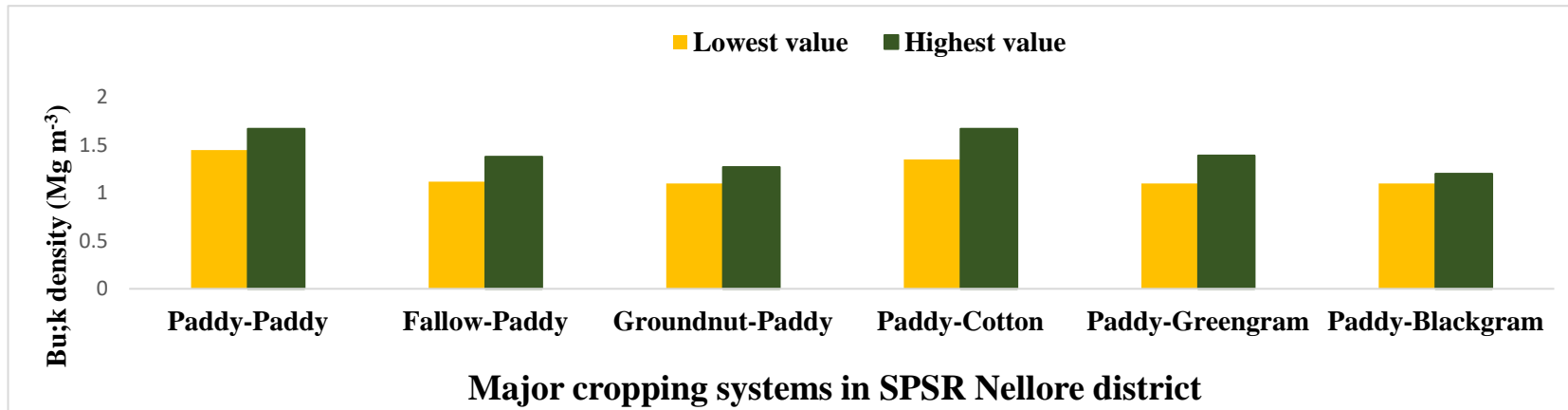


Fig. 1. Range of bulk density in major cropping systems of SPSR Nellore district of Andhra Pradesh

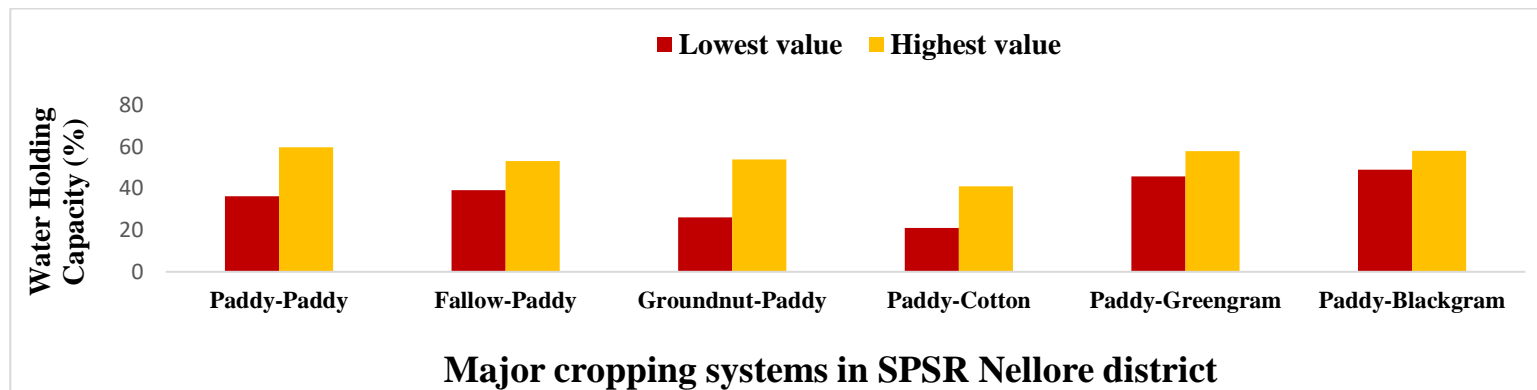


Fig. 2. Range of water holding capacity in major cropping systems of SPSR Nellore district of Andhra Pradesh

3.6 Volume Expansion

In surface soils the mean volume expansion in different cropping systems was in the order of paddy-paddy (12.46%) followed by paddy-cotton (12.85%), fallow-paddy (13.70%), groundnut-paddy (18.02%), paddy-green gram (19.41%) and paddy-black gram (22.34%) while in sub-surface soils the mean volume expansion in different cropping systems was in the order of paddy-cotton (11.94%) followed by fallow-paddy (13.71%), paddy-paddy (14.15%), groundnut-paddy (18.50%), paddy-green gram (21.22%) and paddy-black gram cropping system (23.61%). From the data it was observed that the soils under paddy-black gram cropping system showed the highest mean volume expansion in both surface (22.34%) and subsurface soils (23.61%). Whereas the soils of paddy-paddy (12.46%) in surface soils and paddy-cotton (11.94%) cropping systems in subsurface soils reported the lowest volume expansion. The CV for volume expansion in both surface and subsurface soils of different cropping systems was 31.44 and 32.00 per cent. The volume expansion indicates the presence of shrinking and swelling type of clay minerals. This variation in volume expansion was due to presence of significant amount of smectite type of clay. Similar results were reported by Leelavathi et al. [17] and Kavitha et al. [14].

4. CONCLUSIONS

From this study, it was concluded that the different rice based cropping systems affects the physical properties of soils of SPSR Nellore district of Andhra Pradesh. Among, the cropping systems paddy-black gram followed by paddy-green gram cropping system sustained better physical properties of soil in terms of lower bulk density, higher water holding capacity and volume expansion than that of soils under paddy-paddy, fallow-paddy, groundnut-paddy and paddy-cotton cropping systems. Therefore, present study recommended that to sustain soil health to become productive for next generation rice-legume cropping systems could be more effective.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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