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Evaluation of soil physical properties of different block of semi-arid zone of Pali District, Rajasthan

Rakesh Kakraliya, Narendra Swaroop, Tarence Thomas and Raghu Nandan Khatana

Abstract
Agricultural intensification is placing tremendous pressure on the soil's capacity to maintain its functions leading to large-scale ecosystem degradation and loss of productivity in the long term. Therefore, there is an urgent need to find early indicators of soil health degradation in response to agricultural management. In this study, morphological and all physical properties of soil with their spatial variability in different blocks of Pali district in Rajasthan was conducted. It was concluded that the colour was changing with the sites. The textural classes identified were sandy clay loam, sandy loam and clay loam. The bulk density of soil varied from 1.21 to 1.54 Mg m^{-3} and the maximum bulk density was found in Sojat (1.54 Mg m^{-3}) block district Pali. The particle density of soil varied from 2.32 to 2.97 Mg m^{-3} the maximum density was noticed in Bansor (2.97 Mg m^{-3}) block, district Pali. The per cent pore space of soil ranged from 41.36 to 53.91%. The specific gravity ranged from 1.97 to 2.25. The water holding capacity of soil varied from 46.48 to 60.62% and the maximum water holding capacity was found in Rampura block (60.62%) Pali district concluded that the soil parameters were studied during the course of investigation responded good physical properties. The judicious use of organic manure in combination with inorganic fertilizers not only paves the way for achieving sustainable yields of crops but also maintains health of our finite soil without deterioration for future generations.

Keywords: Soil health, soil quality, physical properties

Introduction
Soil physical properties play an important role in agriculture production and the sustainable land use. A vital role of the supporting ability to supply water, air and nutrient to plant absorbed from the soil solution; movement and retention; ease in penetration of roots and flow of heat and air are directly associated with physical properties of the soil (Phogat *et al.,* 2015 and Almendro-Candel *et al.,* 2018) [14, 1]. Soil organic matter is a key component of soil that maintaining physical, chemical and biological properties of the soil and also improve crop productivity and yield (Micheni *et al.,* 2004, Kakraliya *et al.,* 2017) [12, 8]. Good soil structure is vital for sustainable agriculture (Kakraliya *et al.,* 2017) [8]. It regulates soil erosion and gaseous exchange rates, the movement and storage of water, soil temperature, respiration and development, nutrient cycling, resistance to structural degradation and supports biological activity. It also promotes germination, emergence, crop yields, grain quality and soil health" (Johns 2015) [5]. Soil texture and structure determine the total porosity and the size distribution of pores which influence water, heat and air relationships in the soil. Looking at the current stress on soil as a natural resource for food security and safety, due emphasis is needed for maintaining soil physical fertility by adding organic materials, introduction of legumes in rotation, adoption of conservation tillage, (Johns, 2015) [5]. Deficiencies of primary, secondary and micronutrients have been observed in intensive cultivated areas. Several states including Andhra Pradesh, Gujarat, Haryana, Rajasthan and Uttar Pradesh have made commendable progress in soil testing programme in various ways such as expansion of soil testing facilities, popularization of the programme in campaign mode, development of soil fertility maps and use of information technology in delivering soil nutrient status and appropriate recommendation to farmers. Since soils in general are degrading due to poor management and faulty land use at a rate faster than their natural degeneration, it becomes imperative to protect them from further degradation; as there is a concomitant decline in soil quality to produce healthy crop. The soils of Pali district can be broadly classified as the Deep Brown Loamy, Deep Brown Clay, Medium Brown Loamy, Deep Black Clay, Red Gravelly Loam Hilly soils. Under the new system, most soils of Rajasthan belongs to only 5 orders-Aridisols, Alfisols,

Entisols, Inceptisols and Vertisols. (Roy *et al.*, 1978) [15]. The main problem associated of these soils is poor physical conditions like poor infiltration, water stagnation, low permeability and hardness. This study indices that poor soil management practices in the study area has caused soil physical degradation. Therefore, an urgent need was felt for extensive and well planned investigation both in the field and laboratory for suggesting guidelines towards better utilization of soil and irrigation water of this tract.

Materials and Methods

The present study entitled "Evaluation of Soil Physical-Properties of Different Blocks of Pali District, Rajasthan" was conducted during the 2020-21 for the evaluation of physical soil properties in three stages i.e. soil survey and collection of samples and their analysis for different soil parameters. The study area was selected in Rajasthan state of Pali district and lies under transitional plain of Luni Basin zone-IIB, it is situated between 25˚25'57.3132" N and 75˚38'53.7828" E (south-east region of Rajasthan). It has an average elevation of 268 meters (879 feet) from sea level. The district has an area of 5,550 square kilo meters. The climate of the study area was semi-arid with an average annual rainfall of 772mm which receive during the main crop growing season from June to September. The average daily maximum and minimum temperature ranged from 45.8 and 27.8 ºC in May and 24.5 to 7.8 ºC in January. Soil samples were collected from the three blocks of Pali District; Raipur, Sojat and Marwar and from each block were three village selected for sampling site. Total twenty seven composite soil samples were collected at 0-15, 15-30 and 30-45cm of soil depth from selected village of Pali district during survey 2020. Around 2 kg of soil was taken in cloth bag with help of auger and khurpi. Samples were air dried ground and passed through 2 mm sieve and stored in properly labeled plastic bottles.

Methods of analysis

Soil colour: It provides valuable information regarding soil conditions and some properties of soils. The property of an object that depends on the wavelength of light it reflects on emits. The soil was determined by Munsell Soil Colour Chart as described in Handbook of United State Department of America (USDA, 1994) [17].

Physical properties

Soil texture (Sand, Slit and Clay %): The relative proportions of the various soil separates in a soil. Analysis of soil texture was done by Bouyoucos Hydrometer Method (Bouyoucos, 1927) [3].

$$\text{Silt} + \text{Clay}\ \% = \frac{(\text{S} - \text{B}) - (68 - \text{SUt at 2 min.of °F} \times 0.2)}{\text{m}} \text{ x } 100$$

$$Clay\ \% = \frac{(\text{S–B}) - (68 - \text{SUtat2hourof°F} \times 0.2)}{\text{m}} \text{ x } 100$$

Sand % = 100 - Silt + Clay

Where,

S = Hydrometer reading of sample solution after 2 minute and 2 hours respectively. B = Hydrometer reading of blank solution after 2 minute and 2 hours respectively. SUt=Suspension temperature in degree Fahrenheit at 2 minute and 2 hours respectively. M = Mass of organic carbon free soiling.

Pore space (%): The volume of void spaces found in an oven dry undisturbed soil expressed as a percentage of volume of the soil is termed % total pore space. It is estimated by subtracting % solid space from 100. The ratio of bulk density to particle density is a measure of solid space in the soil (Muthuaval *et al*., 1992) [13].

$$\%\ \text{Solidspace} = \frac{\text{Bulk Density}}{Partical\ Density} X\ 100$$

% Total pore space = 100 - % solid space

Bulk density (Mg m^{-3})

The mass of dry soil per unit volume including the air space. The bulk volume is determined before drying to constant weight at 10 ºC. The bulk density of soil organic matter is usually between 1.3 to 1.5 Mg m^{-3}. The Bulk Density was calculated on Graduated Measuring Cylinder (Muthuaval *et al*., 1992) [13].

$$\text{Bulk Density (Mg m}^{-3}) = \frac{\text{Weight of dry Soil (g)}}{\text{Total volume of soil}}$$

Particle density (Mg m-3)

The mass per unit volume of the soil particles. The value of particle density of the soil varies between 2.65 to 2.75Mg m^{-3}g. Particle density of soil is estimated by dividing the mass of oven dry soil by the volume of particles without pore space or else by the volume of water displaced by the soil (Muthuaval *et al*., 1992) [13].

$$\text{Particle Density} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} \times dW$$

Water holding capacity (%): Water holding capacity (%) is estimated by Volume basis (Muthuaval *et al*., 1992) [13].

$$\text{Water holding capacity \%} = \frac{\text{volume of water absorbed by the soil}}{\text{volume of soil sample}} \times dW$$

Statistical analysis and data interpretation

The data of experiment was analysed using completely randomized design. CRD is the most simplest and flexible design. It is used when experimental units are homogenous. Since the principle of local control is not used in CRD therefore it is very clear that this design is applicable in ideal condition. CRD is used for laboratory purpose only. Loss of information due to missing data is small compared to other due to the larger no. of degree of freedom for the error source of variant ion (Fisher, R.A., 1925) [4].

$$\text{SEM} \pm \text{(Standard error of mean)} = \sqrt{2}\frac{MESS}{R}$$

CD (critical differences) = SEM × t-test (error d.f.). @ 5%.

Results and Discussion

Morphological characteristics

Soil colour (Dry method)

According to dry method of soil colour at 0-15 cm of soil depth was observed brown colour in the village of Amarpura and Karnapur and the Pale brown was found at the village of Chainpura and Light olive brown was found in the village of Ajeetpura and Sojat. Light yellowish brown was found at the village of Haripura and Rampur, Grayish brown was found in the village of Bansor and Jaitpura. At 15-30cm soil depth olive brown and brown colour was found at the village of Amarpura, Chainpura and Karnapur, Ajeetpura and Sojat.

Olive yellow colour was found at the village of Haripura and Rampura and Gray colour was found in the village of Bansor and Jaitpura. Olive brown and brown colour was noticed at the village of Amarpura, Chainpura and Karnapur, Ajeetpura and Sojat and Olive yellow was found at the village of Haripura and Rampura. It was gray colour was recorded Bansor and Jaitpura at 30-45cm soil depth (Table1). Similar results were reported by Mehta *et al*., (2012) [11].

Table 1: Soil Colour of soil of different villages of Pali district, Rajasthan

Village/Soil Depth	Soil colour in dry condition			Soil colour in wet condition		
	0-15 cm	15-30 cm	30-45 cm	0-15cm	15-30cm	30-45 cm
Amarpura	10YR, 5/3 Brown	2.5Y, 4/4 Olive brown	2.5Y, 4/4 Olive brown	10YR, 4/2 Dark grayish brown	10YR,4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Chainpura	10YR, 6/3 Pale brown	2.5Y,4/4 Olive brown	2.5Y, 4/4 Olive brown	10YR, 4/2 Dark grayish brown	10YR,4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Karanpura	10YR,5/3 Brown	10YR,5/3 Brown	10YR, 5/3 Brown	10YR, 4/2 Dark grayish brown	10YR,4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Ajeetpura	2.5Y, 5/6 Light olive brown	10YR, 4/3 Brown	10YR,4/3 Brown	10YR, 3/3 Dark brown	10YR,3/2 Very dark grayish brown	10YR, 3/2 Very dark grayish brown
Haripura	2.5Y, 6/4 Light yellowish brown	2.5Y, 6/8 Olive yellow	2.5Y, 6/8 Olive yellow	2.5Y, 5/4 Light olive brown	2.5Y,5/4 Light olive brown	2.5Y, 5/4 Light olive brown
Sojat	7.5YR, 5/6 Light olive brown	2.5Y,6/6 Brown	2.5Y,6/6 Brown	7.5YR, 4/4 Brown	2.5Y,5/6 Light olive brown	2.5Y, 5/6 Light olive brown
Bansor	2.5Y, 5/2 Grayish brown	10YR, 5/1 Gray	10YR, 5/1 Gray	10YR, 3/1 Very dark gray	10YR, 5/1Gray	10YR, 5/1Gray
Jaitpura	10YR, 5/2 Grayish brown	10YR, 5/1 Gray	10YR, 5/1 Gray	10YR, 3/2 Very dark grayish brown	10YR, 3/2 Very dark grayish brown	10YR, 3/2 Very dark grayish brown
Rampura	10YR, 5/3 Brown	10YR, 5/1 Gray	10YR, 5/1 Gray	2.5Y, 3/2 Very dark grayish brown	2.5Y, 3/2 Very dark grayish brown	2.5Y, 3/2 Very dark grayish brown

Soil colour (wet condition)

Dark grayish brown and brown colour was found in the village of Amarpura, Chainpura, Karanpura and Ajeetpura it was recorded that light olive brown colour was found Haripura and brown colour was reported by Sojat. Whereas the very dark gray colour was found Bansor and very dark grayish brown was found Jaitpura and Rampura at depth 0-15 cm and 15-30 cm the soil colour. (Table 1). At 30-45 cm soil depth the soil colours dark grayish brown and brown colour was found in the village of Amarpura, Chainpura, Karanpura and Ajeetpura it was recorded that light olive brown colour was found Haripura and brown colour was found Sojat. Whereas the very dark gray colour was found Bansor and very dark grayish brown was found Jaitpura and Rampura (Table 1). Similar results were reported by Mehta *et al*., (2012) [11].

Soil texture (Sand, Silt and Clay %)

Data presented in Table-2 reveals that depicts the soil texture (Sand, Silt and Clay %) of different depths (0-15cm, 15-30cm and 30-45cm) soil of different villages of Pali district, Rajasthan. The sand, silt and clay percentage varied from 43.05-53.83%, 27.22-34.77% and 17.93-25.03% at 0-15 soil depth, 43.04-50.38%, 25.56-36.16% and 19.93-24.10% at 15-30 and 44.34-53.29%, 28.16-35.56% and 18.37-20.93% at 30-45cm soil depth of different village of Pali district respectively. The soil texture-sandy clay loam was of village, Ajeetpura, Sojat, Bansor and Rampura, sandy loam was found in Amarpura, Chainpura and Karanpura, and clay loam soil was recorded in, Jaitpura and Haripura at 0-15cm soil depth, while sandy clay loam was found in Amarpura, Chainpura Karanpura, Sojat and Jaitpura, sandy loam was in Ajeetpura, Bansor and Rampura, Clay loam was recorded under Haripura village at 15-30cm soil depth, whereas the sandy loam was recorded in Amarpura, Chainpura, Karanpura, Bansor and Rampura, while sandy clay loam was found in Ajeetpura, Haripura, Sojat and Jaitpura at 30-45cm soil depth respectively. The results of our study were similar were reported by Meena *et al*., (2017) [10].

Table 2: Soil Texture (Sand, Silt and Clay %) of different villages of Pali district, Rajasthan

Village	0-15cm			Texture Class	15-30cm			Texture Class	30-45cm			Texture Class
	Sand %	Silt %	Clay %		Sand %	Silt %	Clay %		Sand %	Silt %	Clay %	
Amarpura	53.19	28.26	18.55	SL	43.04	36.16	20.80	SCL	50.28	29.41	20.31	SL
Chainpura	53.83	28.24	17.93	SL	43.65	35.13	21.22	SCL	50.01	29.47	20.48	SL
Karanpura	53.37	28.46	18.15	SL	43.29	34.34	22.37	SCL	50.07	29.37	20.58	SL
Ajeetpura	46.13	32.22	21.65	SCL	50.38	29.69	19.93	SL	46.22	33.24	20.55	SCL
Haripura	46.44	29.03	24.53	CL	44.55	30.95	24.50	CL	44.34	35.56	20.11	SCL
Sojat	46.08	32.01	21.91	SCL	50.34	25.56	24.10	SCL	44.38	34.69	20.93	SCL
Bansor	43.23	34.68	22.03	SCL	49.98	28.96	21.06	SL	44.50	34.95	20.55	SL
Jaitpura	43.65	31.32	25.03	CL	47.22	29.47	23.31	SCL	50.29	28.16	21.80	SCL
Rampura	43.05	34.77	22.18	SCL	49.10	30.42	20.48	SL	53.29	28.34	18.37	SL

*SL=Sandy Loam, *SCL= Sandy Clay loam

Bulk density

Soil bulk density indicates soil physical condition in terms of compaction or looseness of soil and plays an important role in plant growth affecting the soil porosity, water retention, water movement and root penetration and development (Fig. 1.). Bulk density of these soil varied between 1.21 Mg m^{-3} to 1.54 Mg m^{-3} at 0-15 and 30-45cm of soil depth. The maximum bulk density was recorded in village Sojat (1.54 Mg m^{-3})

followed by Haripura (1.45 Mg m^{-3}), while the minimum bulk density was observed in Rampura village (1.21 Mg m^{-3}) respectively. The high organic matter content lowers the bulk density, whereas compaction increases the bulk density. The bulk density increases with increase in soil depth. Khan *et al.*, (1999) [9], Meena *et al.*, (2017) [10] and Urmila *et al.*, (2018) [16] also found are similar results. They reported that effect of different tillage practices on soil properties and conventional tillage affected soil bulk density and also caused decrease in soil penetration resistance which resulted in increased drainage respectively.

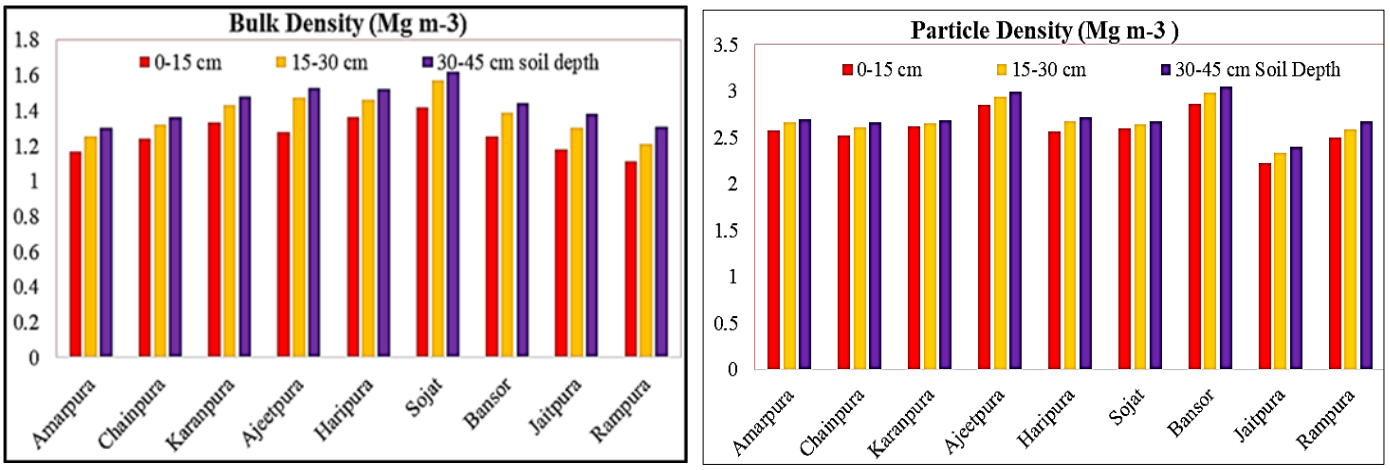

Fig 1: Physical properties of soil of different villages of Pali district, Rajasthan

Particle density (Mgm-3)

Data showed in (Fig. 1.) the statistical analysis on particle density of villages and depth which was found to be significant due to depth and due to site. In soil depth the highest particle density was found at 30-45 cm (2.73 Mg m^{-3}) which is significantly higher than 15-30 cm (2.67 Mg m^{-3}) of soil depth. The maximum mean particle density was found in Bansor (2.97 Mg m^{-3}) followed by (2.93 Mg m^{-3}) in village Ajeetpura and the minimum mean particle density was recorded in Jaitpura (2.32 Mg m^{-3}) respectively. Particle density increases with increases in soil depth and it dependent on the soil organic carbon and mineral composition of the soil. Similar findings were reported by Meena *et al.*, 2017 [10] and Urmila *et al.*, 2018 [16] respectively.

Table 3: Pore space (%) and water holding capacity (%) of soil of different villages of Pali district

Villages	Pore space (%)				Water holding capacity (%)			
	0-15 cm	15-30 cm	30-45 cm	Mean	0-15 cm	15-30 cm	30-45 cm	Mean
Amarpura	54.65	53.01	52.40	53.35	57.58	52.94	50.42	53.65
Chainpura	50.79	49.43	48.22	49.48	58.82	54.29	50.63	54.58
Karanpura	49.24	46.04	45.01	46.76	59.38	54.55	51.32	55.08
Ajeetpura	55.09	52.13	50.37	52.53	55.88	48.65	42.20	48.91
Haripura	46.87	45.32	44.18	45.46	84.29	47.37	43.71	48.46
Sojat	45.38	40.53	38.16	41.36	51.85	45.95	42.25	46.68
Bansor	56.29	53.36	51.43	53.69	59.38	54.55	50.77	54.90
Jaitpura	46.85	44.21	43.06	44.87	58.82	54.29	50.48	54.53
Rampura	55.60	53.28	52.86	53.91	63.64	60.61	57.61	60.62
Mean	51.12	48.59	47.36		57.74	52.58	48.82	
	F-test	S.Ed (±)	C.D. @ 5%		F-test	S.Ed (±)		C.D. @ 5%
Due to depth	S	1.92	0.000213		S	2.63		0.000003
Due to site	S	4.62	0.00002		S	3.11		0.0001

Pore space (%)

In soil depth the highest mean pore space was recorded at 0-15 cm (51.12%) which was significantly higher than at 15-30 cm (48.59%) and 30-45 cm (47.36%) soil depth. The maximum mean pore space was recorded in Rampura (53.91%) followed by Bansor (53.69%), Amarpura (53.35%), and Ajeetpura (52.53%), while the minimum mean pore space was recorded in Sojat (41.36%) respectively. The pore space (%) decrease abruptly with increase in depth (Table 3). Similar results were reported by Meena *et al.*, (2017) [10] and Urmila *et al.*, (2018) [16].

Water holding capacity (%)

In soil depth the (Table 3) highest mean value of water holding capacity was recorded at 0-15cm (57.74%) which is significantly higher than 15-30 cm (52.58%) and 30-45 cm () soil depth, decreased with depth. The maximum mean value of water holding capacity was recorded in village of Rampura (60.62%) followed by in village of Karanpura (55.08%), while the minimum mean value of water holding capacity was found in Sojat (46.68%). These variations were due to clay, silt and organic carbon content and low WHC in sandy soils due to high sand and less clay content. Similar results were reported by Kadu *et al.*, (2009) [6] and Brunel-Saldias *et al.*, (2016) reported that the soil had low water holding capacity in the profile due to the low water retention at the permanent wilting, associated with a high bulk density and clay content.

Conclusion

It is concluded that soil parameters were studied during the

course of investigation responded good physical properties. By analysing the taken soil sample, soil was sandy Clay loam and Clay loam, it has mixture of sand, silt and clay. Sorghum, black gram, maize and green gram are the main *Kharif* crops whereas wheat, mustard, barley and gram are the major *rabi* crops of the district. We concluded that there is a need of adding soil amendments for maintaining soil physical properties. Soil amendment will improve soil texture and structure which improves all the other physical properties of the soil. Therefore, soil amendment will be helpful in maintaining to soil health and soil quality. The judicious use of organic manure in combination with inorganic fertilizers not only paves the way for achieving sustainable yields of crops but also maintains health of our finite soil without deterioration for future generations.

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References

1. Almendro-Candel MB, Lucas IG, Pedreno JN, Zorpas AA. Physical properties of soils affected by the use of agriculture waste 2018. DOI:10.5772/intechopen.77993.
2. Anonymous. Munsell Soil Colour Chart. Munsell Color Company Inc. 2441 N, Calvert Street, Baltimore, Maryland 21212, USA 1971.
3. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soils. Soil Science 1927;23:343-353.
4. Fisher RA. Statistical methods and scientific induction. Journal of the royal statistical society series 1925;17:69-78.
5. Johns Christopher. Soil structure and the physical fertility of soil, Northern Australia and Land Care 2015.
6. Kadu PR, Kanaskar SR, Balpande SS. Characterization of irrigated soils in Upper Wardha command area of Maharashtra. Agropedology 2009;19(1):24-29.
7. Effect of Integrated Nutrient Management on Growth.
8. Kakraliya SK, Kumar N, Dahiya S, Kumar S, Yadav DD, Singh M. Dynamics and productivity trend of wheat (*Triticum aestivum* L.) Under irrigated cropping system. Journal of Plant Development Sciences 2017;9(1):11-15.
9. Khan FUH, Tahir AR, Yule IJ. Impact of different tillage practices and temporal factor on soil moisture content and soil bulk density. International Journal Agri. Bio 1999;3:163-166.
10. Meena GL, Singh RS, Singh RK, Meena HR, Meena Suman, Mina BL. Assessment of productivity potential of some soils of Aravali Hills based on parametric approach. Indian Journal of Soil Conservation 2017, 28-39.
11. Mehta KM, Shankaranarayana HS, Jaisinghani CJ. Study of Pedo Genesis of soils of Bundi district (Rajasthan). Soil Science and Plant Nutrition 2012;8(5):32-38.
12. Micheni Andrews SS, Karlen DL, Mitchell JP. A comparison of soil quality indexing methods for vegetable production systems in Northern California. Agriculture, Ecosystems & Environment 2004;90(1):25-45.
13. Muthuaval P, Udaysoorian C, Natesan R, Ramaswami PP. Introduction to soil analysis. Tamil Nadu Agricultural University, Coimbatore 1992.
14. Phogat VK, Tomar VS, Dahiya Rita. Soil Physical Properties, The Nation that destroys its soil destroys itself-Franklin D. Roosevelt, 32nd President of the United States 2015, 135-171.
15. Roy BB, Dhir RP, Kolarkar AS. Soil of Rajasthan and their characteristics, Indian National Science Academy 1978;44-B(4):161-167.
16. Urmila Purohit HS, Singh D, Meena SC, Jain HK, Kumar Amit, Verma SN. Effect of tillage on physico-chemical indices of soil in maize based cropping sequence of southern Rajasthan. International Journal of Chemical Studies 2018;6(4):2490-2493.
17. USDA. The soil was determined by Munsell Soil Colour Chart as described in Handbook of United State Department of America 1994.