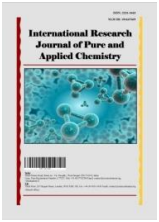

International Research Journal of Pure & Applied Chemistry

21(21): 47-59, 2020; Article no.IRJPAC.62401
ISSN: 2231-3443, NLM ID: 101647669

Influence of Organic Manures on Soil Physical Properties, Organic Carbon and Crop Yield in Okra-Dhaincha-broccoli Cropping Sequence

Vishaw Vikas[1*], Jag Paul Sharma[2], A. K. Mondal[1], Vikas Sharma[1], Abhijit Samanta[3], Sandeep Chopra[4], S. E. H. Rizvi[5], S. K. Singh[6], Rohit Sharma[7] and Balbir Dhotra[6]

[1]Division of Soil Science and Agriculture Chemistry, SKUAST Jammu, India.
[2]SKUAST Jammu, India.
[3]Water Management Research Centre, SKUAST Jammu, India.
[4]Division of Vegetable Science, SKUAST Jammu, India.
[5]Faculty of Basic Sciences, SKUAST Jammu, India.
[6]Organic Farming Research Centre, SKUAST Jammu, India.
[7]RARS Rajouri, SKUAST Jammu, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors VV, JPS, AKM and VS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AS, SC and SEHR managed the analyses of the study. Authors SKS, RS and BD managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2020/v21i2130289
Editor(s):
(1) Dr. Wolfgang Linert, Vienna University of Technology, Austria.
Reviewers:
(1) Ibrahim Iro Ibrahim, Federal College of Forest Resources Management, Nigeria.
(2) Bala Gambo Jahun, Abubakar Tafawa Balewa University, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/62401

Original Research Article

Received 27 August 2020
Accepted 02 November 2020
Published 27 November 2020

ABSTRACT

A study was conducted at Organic Farming Research Centre of SKUAST -Jammu during 2016 to 2017 to find out the impact of organic manures on soil organic carbon, physical and crop growth parameters Okra-Dhaincha-Broccoli cropping sequence. The Soil Organic Carbon was analyzed by Chromic acid wet digestion method. However, in soil physical properties Bulk density was analyzed by Core method, water holding capacity by Keen Rackzowski Method and Infiltration rate by Double Ring Method. In the experiment, soil organic carbon was found non-significant in experiment. Bulk

**Corresponding author: E-mail: vishaw.vikas@gmail.com;*

density was found to be significant in year 2016 and 2017 as very captivating change was observed as compared to control; T_8 as the lowest value treatment with value 1.26 g cm^{-3} was recorded. Water holding capacity was found to be significant in year 2016 and 2017 as very positive change was observed as compared to control as WHC with highest value 43.68% was noted in T_8 in 2017. Infiltration rate was also found to be significant in year 2016-17 as very positive change was observed as compared to control. Significant improvement in root volume, root length was observed in Okra and same was noted in size of curd in broccoli as compared to control. The significant impact of organic manures on soil quality parameters will provide a new way to improve the soil health and productivity in a sustainable way.

Keywords: Infiltration rate; organic manures; root volume; root length; soil organic carbon; size of curd; water holding capacity; bulk density.

1. INTRODUCTION

Modernization of agriculture and crop improvement techniques began with the golden era of green revolution in India. With improvisation in agriculture techniques and introduction of synthetic fertilizers, chemicals like pesticides; the modernization now has become a burden of problems to tackle for the sake of humanity. The day is not far when these second generation problems of agriculture will soon be an epidemic in the entire world. Well, to come up with a solution, the word organic can act as a savior to overcome the present issues of land degradation and reduced soil quality. The concept of soil sustainability, better productivity and good health is well nurtured and addressed in organic farming techniques. Moreover, its early adoption, easy access and availability to raw material will soon declare organic agriculture, a beginning of new era in farming trends. In 70's, with the rise of environmental movement, the concept of organic farming grew and was later related to food and health concerns. In agriculture technology, the impact of organic manures is now being studied worldwide. Scientists' results related to organic agriculture depict a very imperative impact on soil physical, chemical and biological properties. Similarly, in current study we have investigated the impact of organic manures: FYM, Vermicompost, Poultry Manure, Neem cake and their combinations on soil physical properties viz. Bulk density (BD), Water holding capacity (WHC) and Infiltration rate (IR). The organic manures were applied with specific dosage lead to the increase in soil organic carbon (SOC) content which is an important soil indicator of quality and productivity [1,2]. One of the important and basic concepts of organic farming to reduce greenhouse gas emissions and to lower carbon footprint of farming can be effectively achieved by these inputs [3]. According to Haynes and Naidu, [4]; organic fertilizer applications could directly or indirectly affect soil physical properties such as aggregate stability, water holding capacity, porosity, infiltration rate and bulk density due to increase in soil organic matter and SOC content. The property of Dhaincha as green manure to improve soil structure by stabilizing soil aggregation, increase in pore size, deep tap root system to break down compaction and binding effect on soil particles also improvement in soil organic matter (SOM) content, thereby affecting water holding property of soil is of great significance. However, the instant decaying property of legumes have relative little effect on soil organic matter but they do stimulate microbial activity in soil thereby increasing nutrient availability to plants [5,6]. In traditional agriculture, the practice of applying organic manures like green manures and organic manures is very common and their applications improved all basic soil physical properties like soil aggregation [7,1,8], increase in macropores content than micropores [9], increased saturated hydraulic conductivity [10] and water infiltration rate [11,12,13] thereby improving soil water holding capacity at both field capacity and wilting point [14,15]. In the present era, where sustainability concept is lacking in crop cultivations and nutrient deficiencies in soil are on rise, there is need to implicate organic measures in cropping plans and practices. Despite dependency on cereals is more for calorie consumption but vegetables cropping pattern need to have at par view in relation to soil health, sustainability and productivity aspects. Therefore, the objective of this study was to assess the effect organic manures and combinations on soil physical parameters in okra-dhaincha-broccoli sequence.

2. MATERIALS AND METHODS

The study was conducted at Organic Farming Research Centre of SKUAST -Jammu during

2016-17 and 2017-18. Geographically the experimental site is located at 32°39'35.5"N latitude and 74°47'35.0"E longitude at an elevation of 332 meters above the mean sea level in site the Shivalik foothill plains of North-Western Himalayas. The initial values of pre-experimental field have been described in Table 1. The treatments were supplemented with certain organic manures and their combinations which have been explained in Table 2. The methodology used to analyze the soil organic carbon was done according to the Chromic Acid Digestion method [16]. The bulk density of the soil sample was assessed by the core method proposed by Gupta and Dakshinamoorthy [17]. The water holding capacity was estimated by Keen Roezkowsik box method (Chopra and Kanwar, 1986) [18]. The infiltration rate was estimated by double ring method [19]. By measuring the average root diameter and the root length, the root volume was calculated. The root lengths is calculated by first placing the roots on paper, then measure each of the tracings, and calculate root length from the tracings. The size of curd was estimated using ruler. The treatment details with input applied on the basis of Nitrogen requirement T1: No application, T2: Farm Yard Manure: 10.00 tonne ha^{-1}, T3: Vermicompost: 6.60 tonne ha^{-1}, T4: Poultry Manure: 2.91 tonne ha^{-1}, T5: Neem Cake: 2.00 tonne ha^{-1}, T6: Farm Yard Manure + Poultry Manure: 5.00 + 1.45, T7 Farm Yard Manure + Neem Cake 5.00 + 1.00, T8 Vermicompost + Poultry Manure 3.30 + 1.45, T9 Vermicompost + Neem Cake: 3.30 + 1.00 tonne ha^{-1}, T10: Neem Cake + Poultry Manure: 1.00 + 1.45 tonne ha^{-1}

2.1 Okra

- Spacing:- 45cms (Row) X 30cms (Plant)
- Variety:- Seli Special
- Seed rate:- 20-25 kg ha^{-1}
- N:P:K requirement:- 100:60:60

2.2 Broccoli

- Spacing:- 60cms (Row) X 45cms (Plant)
- Variety:- Early Green
- Seed rate:- 300-400g ha^{-1}
- N:P:K requirement:- 120:60:60

2.3 Dhaincha

- Dhaincha seed was broadcasted in the experimental field @ 50 kg ha^{-1} and green matter was incorporated 45 DAS.

Experimental site: Organic Farming Research Centre of SKUAST -Jammu

The sources of nitrogen, phosphorus and potassium were organic fertilizers, respectively. The data recorded in respect of physico-chemical properties of the soil of the experimental site revealed that the soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction, medium in organic carbon, low in Available N, medium in Available P and Available K, low in Available S, Available Zn and high in Available Cu, Mn and Fe.

2.4 Statistical Analysis

The data on various characters studied during the course of investigation were statistically analyzed by using Tukey's test with an aim to figure out which groups in our sample differ by using "Honest Significant Difference," a number that represents the distance between groups, to compare every mean with every other mean.

3. RESULTS AND DISCUSSION

After the successful completion of two year (2016-17) experiment with application of organic manures in Okra-Dhaincha-Broccoli cropping sequence, the results obtained were statistically analyzed and are presented below with each parameter.

Table 1. Initial soil physico-chemical properties of experimental site

Physical Properties	Initial Values
Particle Size Analysis (Texture): Sandy Clay Loam	Sand- 54.22 Silt- 15.82 Clay- 29.96
Soil Organic Carbon (g kg^{-1})	6.27
Bulk Density (Mg m^{-3})	1.47
Water Holding Capacity (%)	36.67
Water Infiltration Rate (cm min^{-1})	0.647

Table 2. Effect of organic manures on soil organic carbon (g kg^{-1})

Treatment	Okra			Dhaincha			Broccoli		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
T_1	6.26	6.42	6.34	6.58	6.75	6.67	6.91	7.08	7.00
T_2	6.42	6.58	6.50	6.74	6.91	6.83	7.08	7.26	7.17
T_3	6.43	6.59	6.51	6.75	6.92	6.84	7.09	7.27	7.18
T_4	6.45	6.61	6.53	6.77	6.94	6.86	7.11	7.29	7.20
T_5	6.33	6.51	6.42	6.54	6.71	6.63	6.98	7.15	7.07
T_6	6.46	6.62	6.54	6.79	6.96	6.88	7.13	7.31	7.22
T_7	6.53	6.66	6.60	6.86	7.03	6.95	7.21	7.39	7.30
T_8	6.56	6.72	6.64	6.89	7.07	6.98	7.30	7.49	7.40
T_9	6.52	6.69	6.61	6.85	7.03	6.94	7.20	7.38	7.29
T_{10}	6.53	6.70	6.62	6.88	7.04	6.96	7.28	7.42	7.35

**As per Tukey's Post-hoc analysis, the values are non-significant*

3.1 Soil Organic Carbon

The values related to OC are presented in Table 2. As per Tukey's post-hoc analysis, soil organic carbon was found to be non-significant in year 2016-17 as very minor change was observed as compared to control. Although non-significance in experiment some compelling results were obtained at the end of experiment in 2017 in T_4 increasing OC content to 7.29 g kg^{-1} as compared to control treatment T_1 value 6.26 g kg^{-1} in 2016. Improved soil properties with addition of individual and mixed combination of organic manures and green manure i.e. Dhaincha depicted an improvement in OC as compared to control treatment; however in combinations the best treatment performed was T_8 as the highest value 7.49 g kg^{-1} was recorded in broccoli in 2017. The ascending pattern in OC was observed in 2016 and 2017. This might be correlated to the fact that organic manures like poultry manure consisting of higher organic matter content may have increased the moisture holding capacity that may have resulted in considerable residual carbon. Further, the improvement in physical properties of soil might have resulted in creating a significant environment for humus formation. The statements above are in match with the views of Chandrasekaran [20]. Also, the additive effects of Poultry manure, FYM and vermicompost have the tendencies to maintain higher organic carbon level for longer duration due to their slow decomposition nature. Similar, results were also reported by Ranjan et al. [21] and Zhu et al. [22]. The incorporation of green manure i.e. Dhaincha has resulted in improved organic carbon content due to the fact that fraction of green manure is fairly resistant to decomposition and because of this characteristic property, it mineralizes at slower rate [23]. Biswas and Mukherjee [24] reported that incorporation of green manures had boosted the percentage of SOM and available phosphorus. On the other hand the buildup of organic carbon in T_8 consisting he combination of Vermicompost + Poultry Manure might be correlated to the supply of energy by these organic manures to microbes that lead to the decomposition of organic matter and converted them to mineralized organic colloids; which finally adds to the SOM reserves and ultimately to the multiplication of microbial population [25]. In numerous studies, it has been found that addition of organic residues and organic manures increased the soil organic C level [26]. Increase in organic carbon content from control to maximum resulted in 19.65% higher SOM accumulation.

3.2 Bulk Density

The values related to BD are presented in Table 3. As per tukey's post-hoc analysis, BD was found to be significant in year 2016 and 2017 as very captivating change was observed as compared to control. Significant results were obtained with highest value 1.42 g cm^{-3} noted in T_1 in 2016 and lowest in T_4 in individual treatments which was 1.31 g cm^{-3} in 2017; however in combinations the best treatment performed was T_8 as the lowest value 1.26 g cm^{-3} was recorded. The descending pattern in BD was observed in 2016 and 2017. In this two year experiment, the addition of root and plant biomass lead to the conversion of micro-pores to macro-pores because of cementing action of organic acids and polysaccharides released due to higher microbial decomposition in soil. Better aggregation due to increased SOM leading to improved microbial activity has lowered the bulk density; however the results are similar to the views of Tripathi et al. [2] and Pant et al. [27] who

also noticed the lowered bulk density in soil due to the application of combination of organic fertilizers. Brye et al. [28] justified that addition of poultry manure as a soil conditioner resulted in lowered bulk density. In an experiment conducted by Katkar et al. [29], it was reported that application of FYM and organic manures significantly reduced the bulk density. Dhaincha accumulated maximum green biomasses and that might be the reason for increase in organic carbon content and lowering the bulk density. These results are in complete agreement with the findings of Datt and Bharadwaj [30]. Decreased bulk density compared from control to minimum was 12.70%.

3.3 Water Holding Capacity

The values related to WHC are presented in Table 4. As per tukey's post-hoc analysis, WHC was found to be significant in year 2016 and 2017 as very positive change was observed as compared to control. Significant results were obtained with highest value 43.68% was noted in T_8 in 2017 as compared to control T_1 which was 38.67% in 2016. Dhaincha depicted an improvement in WHC as compared to control treatment. In individual applications, the T_4 performed better as the highest value observed was 42.35% in 2016 and in combinations the best treatment performed was T_8 as the highest value was 43.68% in 2017.The ascending pattern in WHC was observed in 2016. The highest value observed in T_8 which included the combination of Vermicompost + Poultry manure resulted in high humus content along with increased surface area and favorable aggregates might had resulted in increased water holding capacity in the treatments. These results are similar to the work of Maheswarappa et.al. [31] which described that organic manures application increased soil porosity and water holding capacity after growing East Indian galangal. The result of the study indicated higher water holding capacity in response to addition of manures as a result of increased number of storage pores [32]. In the present investigation, Okra-Dhaincha-Broccoli cropping sequence improved the physical condition as similar to results of Baishya et al.

Table 3. Effect of organic manures on bulk density (g cm^{-3}) of soil

BD	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T_1	1.42^{c}	1.39^{c}	1.40^{c}	1.41^{c}	1.38^{c}	1.40^{c}	1.41^{c}	1.37^{c}	1.39^{c}
T_2	1.38^{b}	1.36^{b}	1.37^{b}	1.37^{b}	1.35^{b}	1.36^{b}	1.36^{b}	1.34^{b}	1.35^{b}
T_3	1.36^{b}	1.35^{b}	1.35^{b}	1.35^{b}	1.34^{b}	1.34^{b}	1.34^{b}	1.32^{b}	1.33^{b}
T_4	1.35^{ab}	1.33^{ab}	1.34^{ab}	1.34^{ab}	1.32^{ab}	1.33^{ab}	1.33^{ab}	1.31^{ab}	1.32^{ab}
T_5	1.39^{b}	1.37^{b}	1.38^{b}	1.38^{b}	1.36^{b}	1.37^{b}	1.37^{b}	1.36^{b}	1.36^{b}
T_6	1.34^{ab}	1.32^{ab}	1.33^{ab}	1.33^{ab}	1.31^{ab}	1.32^{ab}	1.32^{ab}	1.30^{ab}	1.31^{ab}
T_7	1.34^{ab}	1.32^{ab}	1.33^{ab}	1.33^{ab}	1.32^{ab}	1.32^{ab}	1.33^{ab}	1.30^{ab}	1.32^{ab}
T_8	1.30^{a}	1.28^{a}	1.29^{a}	1.29^{a}	1.27^{a}	1.28^{a}	1.27^{a}	1.26^{a}	1.26^{a}
T_9	1.34^{ab}	1.32^{ab}	1.33^{ab}	1.33^{ab}	1.31^{ab}	1.32^{ab}	1.31^{ab}	1.30^{ab}	1.30^{ab}
T_{10}	1.33^{ab}	1.32^{ab}	1.32^{ab}	1.32^{ab}	1.31^{ab}	1.32^{ab}	1.30^{ab}	1.29^{ab}	1.29^{ab}

**Mean values with similar alphabet in a subset are statistically at par*

Table 4. Effect of organic manures on water holding capacity (%)

WHC	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T_1	38.67^{a}	39.98^{a}	39.32^{a}	39.10^{a}	40.43^{a}	39.76^{a}	39.53^{a}	40.88^{a}	40.20^{a}
T_2	40.03^{ab}	41.40^{ab}	40.71^{ab}	40.48^{ab}	41.88^{ab}	41.18^{ab}	40.94^{ab}	42.35^{ab}	41.64^{ab}
T_3	40.15^{ab}	41.53^{ab}	40.84^{ab}	40.60^{ab}	42.00^{ab}	41.30^{ab}	41.06^{ab}	42.48^{ab}	41.77^{ab}
T_4	40.03^{ab}	41.40^{ab}	40.71^{ab}	40.48^{ab}	41.87^{ab}	41.17^{ab}	40.93^{ab}	42.35^{ab}	41.64^{ab}
T_5	39.86^{ab}	41.23^{ab}	40.54^{ab}	40.31^{ab}	41.70^{ab}	41.00^{ab}	40.77^{ab}	42.17^{ab}	41.47^{ab}
T_6	41.18^{b}	42.60^{b}	41.89^{b}	41.65^{b}	43.10^{b}	42.37^{b}	42.12^{b}	43.59^{b}	42.85^{b}
T_7	40.64^{ab}	42.04^{ab}	41.34^{ab}	41.10^{ab}	42.52^{ab}	41.81^{ab}	41.56^{ab}	43.01^{ab}	42.28^{ab}
T_8	41.26^{b}	42.69^{b}	41.97^{b}	41.73^{b}	43.18^{b}	42.45^{b}	42.21^{b}	43.68^{b}	42.94^{b}
T_9	40.34^{ab}	41.72^{ab}	41.03^{ab}	40.80^{ab}	42.20^{ab}	41.50^{ab}	41.26^{ab}	42.69^{ab}	41.97^{ab}
T_{10}	40.46^{ab}	41.85^{ab}	41.11^{ab}	40.92^{ab}	42.33^{ab}	41.62^{ab}	41.38^{ab}	42.82^{ab}	42.10^{ab}

**Mean values with similar alphabet in a subset are statistically at par*

[33]. Concerning the Dhaincha role, the deep root system may have enabled the absorption of nitrates and sulphates to avoid buildup of P that might help in binding soil particles thereby improving water holding capacity. Prakash et al., [34] opined the same results after the incorporation of green manure in soil. Also, the tendency of green manure to release various humic fractions may also be considered to lower the bulk density of soil and improvise the water holding capacity. The after effects were significant; comparison to control there was 13.00% increase in water holding capacity of soil in 2017.

3.4 Infiltration Rate

The values related to IR are presented in Table 5. As per tukey's post-hoc analysis, IR was found to be significant in year 2016-17 as very positive change was observed as compared to control. Significant results were obtained with highest value 0.82 cm min^{-1} was noted in T_8 in 2017 as compared to control T_1 which was 0.64 cm min^{-1} in 2016. The ascending pattern in IR was observed in 2016-17. The observation of Mubarak et al. [35], however, is in line with the findings of our study that the combination of manures specifically; vermicompost and poultry manure highlightened increase in infiltration rate due to increase in macropores number created by soil microbial activity. Also, the inconsistent increased infiltration rate with the application of poultry manure and combinations could be ascribed to the findings of Nwachukwu and Uzu, [36] who observed similar results in cow dung and poultry manure. Busari et al., [37] inferred the application of poultry manure improvised the capacity and potential to transmit water sorptivity under unsaturated [38], especially hydrologic and hydraulic properties such as infiltration rate and hydraulic conductivity [39]. Infiltration rates were also recorded higher under green manuring, Dhaincha in both the years. So, there was a significant improvement of infiltration rate by 28.12% as compared to control. Thus, it is recommended to use PM @ 2.91 tonne ha^{-1}, VC + PM @ 3.30 + 1.45 tonne ha^{-1} to improve infiltration rate.

Table 5. Effect of organic manures on infiltration rate (cm min^{-1})

IR	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T_1	0.64^{a}	0.69^{a}	0.67^{a}	0.66^{a}	0.71^{a}	0.68^{a}	0.67^{a}	0.73^{a}	0.70^{a}
T_2	0.69^{abc}	0.75^{abc}	0.72^{abc}	0.71^{abc}	0.76^{abc}	0.74^{abc}	0.72^{abc}	0.77^{abc}	0.75^{abc}
T_3	0.68^{abc}	0.74^{abc}	0.71^{abc}	0.70^{abc}	0.75^{abc}	0.73^{abc}	0.72^{abc}	0.78^{abc}	0.75^{abc}
T_4	0.69^{abc}	0.74^{abc}	0.72^{abc}	0.71^{abc}	0.76^{abc}	0.73^{abc}	0.73^{abc}	0.78^{abc}	0.75^{abc}
T_5	0.67^{ab}	0.73^{ab}	0.70^{ab}	0.69^{ab}	0.74^{ab}	0.72^{ab}	0.71^{ab}	0.76^{ab}	0.73^{ab}
T_6	0.71^{bc}	0.76^{bc}	0.74^{bc}	0.73^{bc}	0.78^{bc}	0.76^{bc}	0.75^{bc}	0.80^{bc}	0.77^{bc}
T_7	0.70^{bc}	0.75^{bc}	0.73^{bc}	0.72^{bc}	0.77^{bc}	0.74^{bc}	0.73^{bc}	0.79^{ab}	0.76^{bc}
T_8	0.73^{c}	0.78^{c}	0.76^{c}	0.75^{c}	0.80^{c}	0.78^{c}	0.77^{c}	0.82^{c}	0.80^{c}
T_9	0.69^{abc}	0.75^{abc}	0.72^{abc}	0.71^{abc}	0.76^{abc}	0.74^{abc}	0.73^{abc}	0.78^{abc}	0.76^{abc}
T_{10}	0.71^{bc}	0.76^{bc}	0.73^{bc}	0.72^{bc}	0.78^{bc}	0.75^{bc}	0.74^{bc}	0.80^{bc}	0.77^{bc}

**Mean values with similar alphabet in a subset are statistically at par*

Table 6. Effect of organic manures on root length (cm) and root volume (cm^3) in okra

Treatment	2016	2017	Mean	2016	2017	Mean
T_1	20.71^{a}	21.75^{a}	21.23^{a}	10.60^{a}	10.81^{a}	10.71^{a}
T_2	23.12^{b}	24.27^{b}	23.70^{b}	11.83^{b}	12.07^{b}	11.95^{b}
T_3	23.84^{bc}	25.03^{bc}	24.44^{bc}	12.20^{bc}	12.44^{bc}	12.32^{bc}
T_4	25.92^{d}	27.22^{d}	26.57^{d}	13.26^{d}	13.53^{d}	13.40^{d}
T_5	24.62^{c}	25.85^{c}	25.24^{c}	12.60^{c}	12.85^{c}	12.73^{c}
T_6	24.29^{c}	25.51^{c}	24.90^{c}	12.43^{c}	12.68^{c}	12.55^{c}
T_7	24.75^{c}	25.99^{c}	25.37^{c}	12.66^{c}	12.92^{c}	12.79^{c}
T_8	30.03^{f}	31.53^{f}	30.78^{f}	15.36^{f}	15.69^{f}	15.53^{f}
T_9	25.73^{d}	27.02^{d}	26.37^{d}	13.16^{d}	13.42^{d}	13.29^{d}
T_{10}	28.63^{e}	30.09^{e}	29.83^{e}	14.66^{e}	14.96^{e}	14.81^{e}

**Mean values with similar alphabet in a subset are statistically at par*

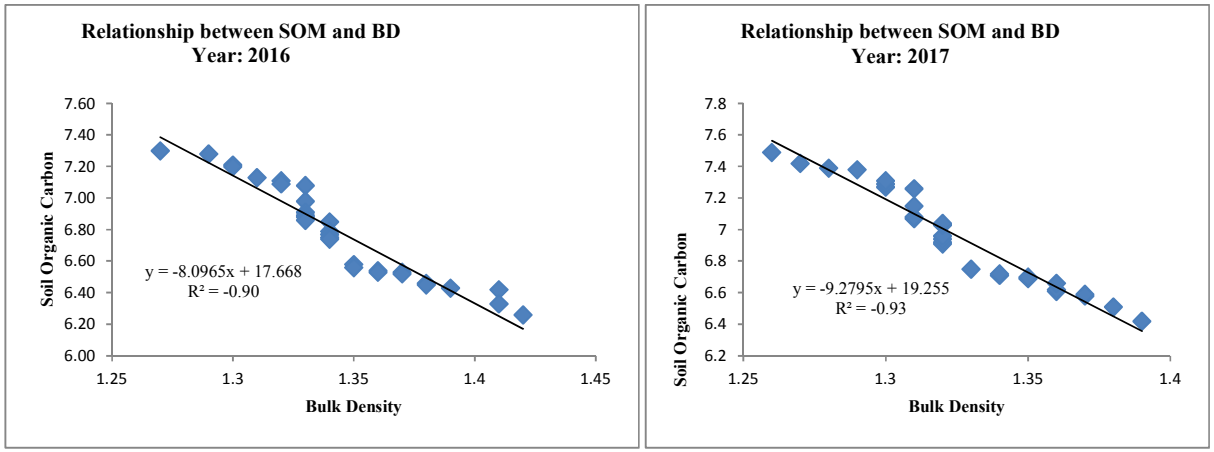

Fig. 1. Relationship between soil organic carbon and bulk density was found negatively correlated in 2016 (R^2 = -0.90) and 2017 (R^2 = -0.93)

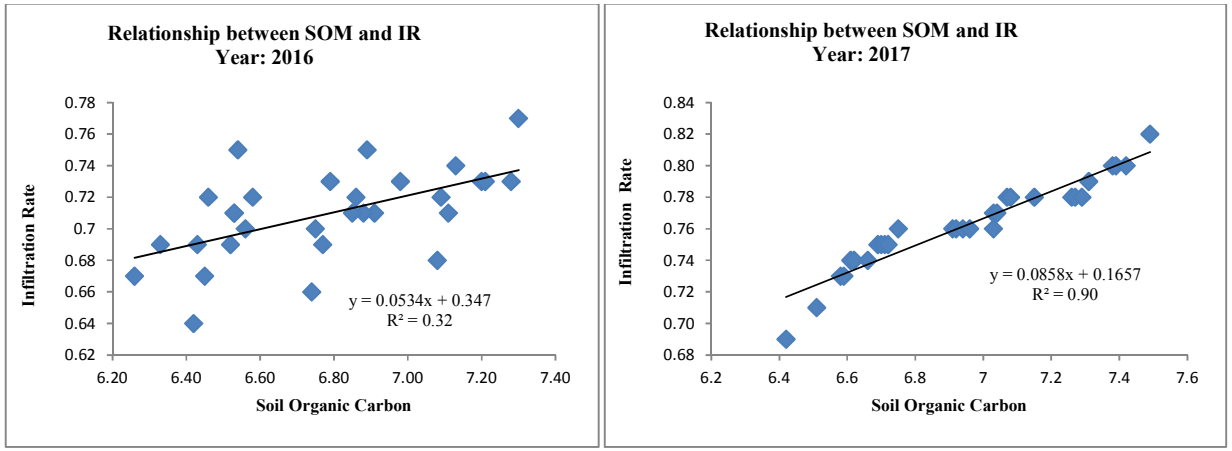

Fig. 2. Relationship between soil organic carbon and infiltration rate was found positively correlated in 2016 (R^2 = 0.32) and 2017 (R^2 = 0.90)

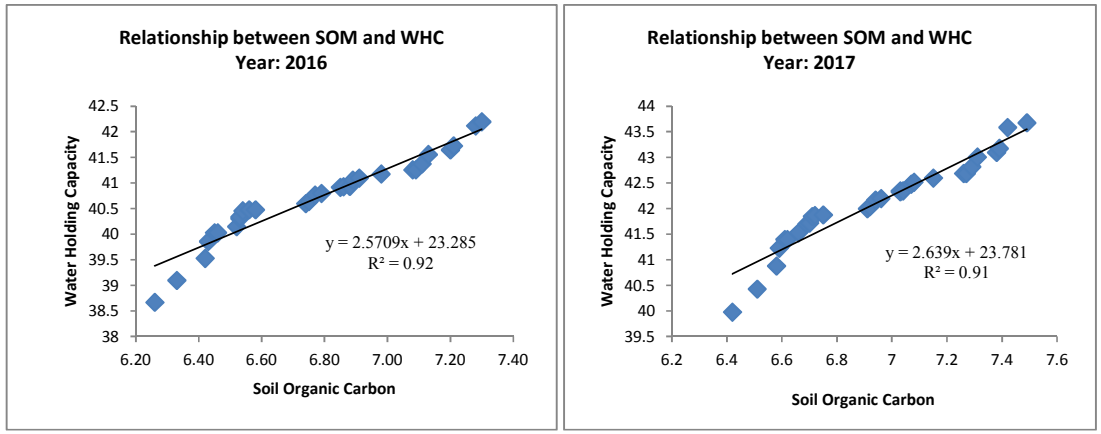

Fig. 3. Relationship between soil organic carbon and water holding capacity was found positively correlated in 2016 (R^2 = 0.92) and 2017 (R^2 = 0.91)

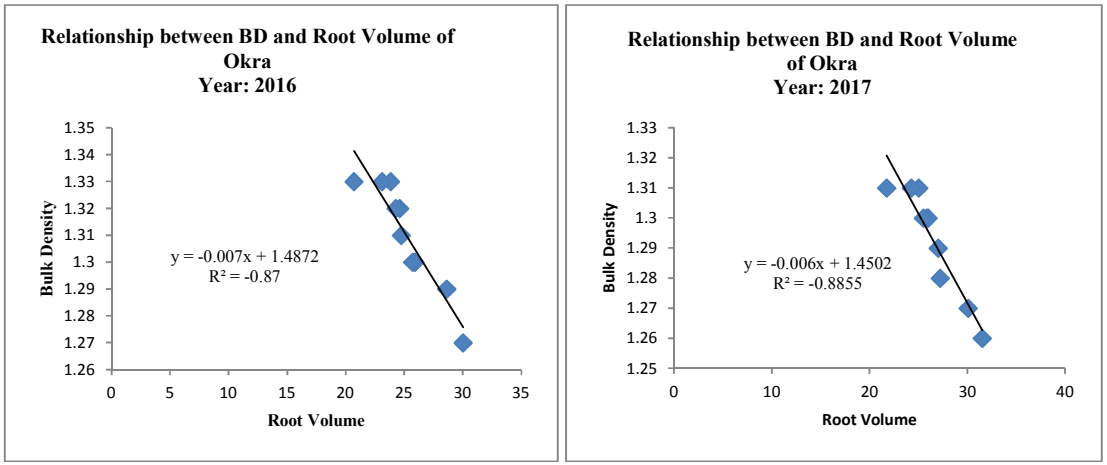

Fig. 4. Relationship between bulk density and root volume was found negatively correlated in 2016 (R^2 = -0.87) and 2017 (R^2 = -0.88)

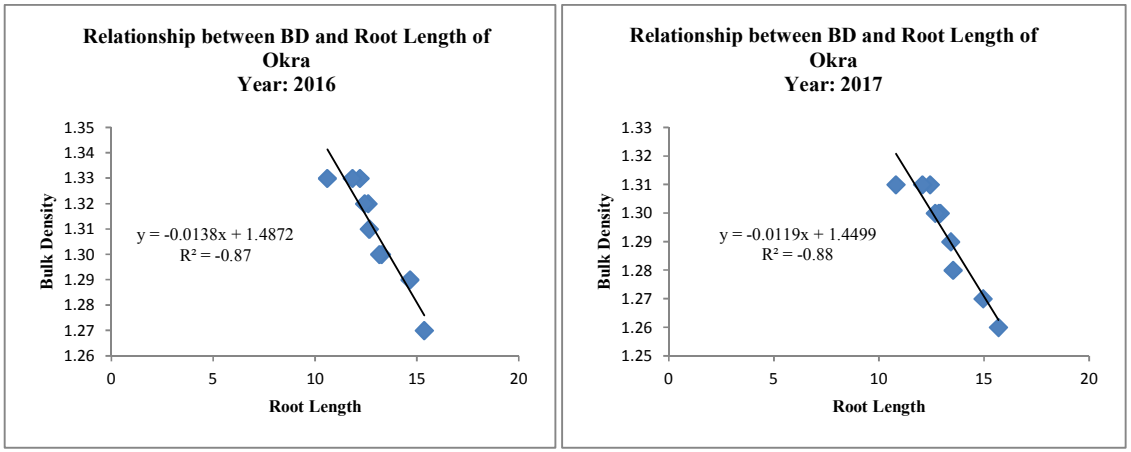

Fig. 5. Relationship between bulk density and root volume was found negatively correlated in 2016 (R^2 = -0.87) and 2017 (R^2 = -0.88)

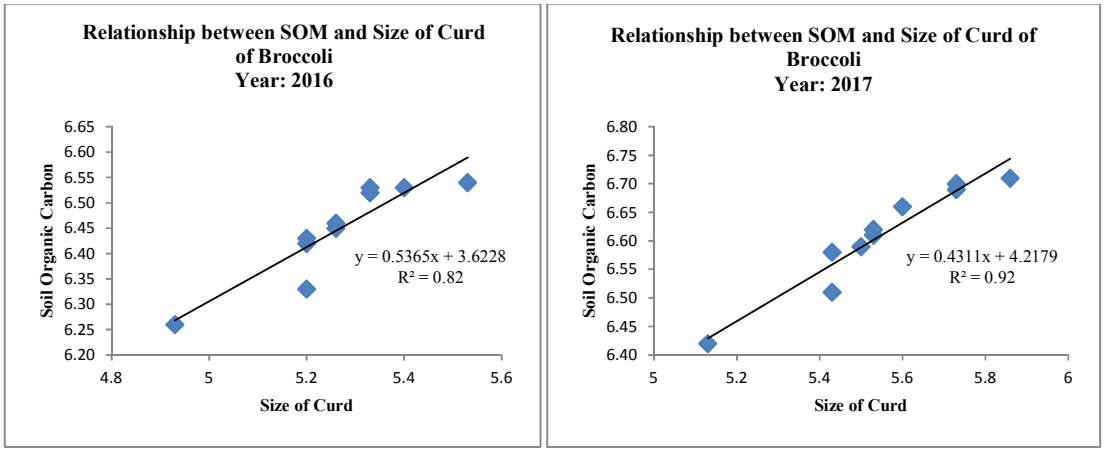

Fig. 6. Relationship between soil organic carbon and size of curd was found positively correlated in 2016 (R^2 = 0.32) and 2017 (R^2 = 0.90)

Table 7. Impact of organic manures on size of curd (cms) of broccoli

Treatment	2016	2017	Mean
T_1	4.93^{a}	5.13^{a}	5.03^{a}
T_2	5.20^{b}	5.43^{b}	5.30^{b}
T_3	5.20^{b}	5.50^{b}	5.33^{bc}
T_4	5.33^{bc}	5.60^{bc}	5.46^{cde}
T_5	5.20^{b}	5.43^{b}	5.33^{bc}
T_6	5.40^{c}	5.73^{cd}	5.56^{e}
T_7	5.26^{bc}	5.53^{bc}	5.43^{bcde}
T_8	5.53^{d}	5.86^{d}	5.73^{f}
T_9	5.26^{bc}	5.53^{bc}	5.40^{bcd}
T_{10}	5.33^{bc}	5.73^{cd}	5.53^{de}

**Mean values with similar alphabet in a subset are statistically at par*

3.5 Root Volume, Root Length of Okra and Size of Curd of Broccoli

The data is presented in Table 6 and 7 in which during 1st and 2nd year of experiment, significant improvement in root volume, root length was observed in Okra and size of curd in broccoli as compared to control. The maximum value of root volume observed was 31.53 cm^3 in T_8 at the end of crop harvest and minimum observed was 20.71 cm^3 in T_1 in 2016; however in root length maximum value observed was 15.53 cms in T_8 in 2017 and minimum observed was 10.60 cms in T_1 in 2016. The size of curd in broccoli was observed maximum 5.53 cms in T_8 in 2017 and minimum observed was 4.93 cms in T_1 in 2016. The root volume, root length of okra and size of curd of broccoli increased significantly in almost all treatments and high values were observed in poultry manure and combinations which shows that poultry manure was available in the best form for easy absorption by the plant roots; hence there was a boost in the morphological growth of the plant [40]. Reduce in compaction and increase in infiltration rate and water holding capacity of the soil due to impact of organic manures might have resulted in increasing the length of root of okra. The increase in length and volume of root can also be attributed to higher solubilization of plant nutrients by addition of poultry manure and vermicompost leading to increase uptake of NPK. Finding corroborates with their results obtained by Rajan and Mahalakshmi [41], Kumar et al., [42] and Fanish [43]. The increase in size of curd in poultry manure and combinations may be attributed to the presence of readily available form of nutrient i.e. ammonia and nitrate and also to its property to enhanced soil aggregation, soil aeration and water holding capacity, offers good environmental conditions for the root system of broccoli plants. As compared to control, there was significant improvement by 48.62% in root volume, 46.50% in root length and 16.22% in size of curd.

4. CONCLUSION

Application of organic manures along with the incorporation of dhaincha resulted in increased SOC compared to control. Increased SOC resulted in significantly improvement of physical properties such as Bulk density, Infiltration rate and water holding capacity. However, organic manures also showed improvised impact on root volume, length and size of curd. Combination of organic manures (Vermicompost + Poultry Manure) resulted in maximum Bulk density, Infiltration rate and water holding capacity. Improved soil physical conditions and increase in soil organic carbon content might have improvised okra and broccoli parameters significantly. Higher soil organic carbon lead to higher accumulation of organic matter content thereby significantly improving nutrient uptake. It can be concluded that application of organic manures and placing a green manure in crop rotation can have positive effect on SOC, soil physical and crop growth parameters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lal R. Soil erosion and the global carbon budget. Environ. Int. 2003; 29:437–450.
2. Tripathi R, Nayaka AK, Bhattacharyya P, Shukla AK, Shahid M, Raja R, Panda BB, Mohanty S, Kumar A, Thilagama VK. Soil aggregation and

distribution of carbon and nitrogen in different fractions after 41 years long-term fertilizer experiment in tropical rice–rice system. Geoderma. 2014;213: 280–286
3. Jarecki MK, Lal R. Crop management for soil carbon sequestration. Crit. Rev. Plant Sci. 2003;22:471–502.
4. Haynes R, Naidu R. Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: A review. Nutr. Cycl. Agroecosys. 1998;51:123–137.
5. Francis Rayns, Anton Rosenfeld. Green manures – effects on soil nutrient management and soil physical and biological properties: Garden Organic. 2010:1-8.
6. Zhang JC. et al. Research progresson innocuous treatment technology of livestock and poultry manure. Journal of Domestic Animal Ecology. 2017;38:85–90.
7. Hati KM, Swarup A, Dwivedi A, Misra A, Bandyopadhyay K. Changes in soil physical properties and organic carbon status at the topsoil horizon of a vertisol of central india after 28 years of continuous cropping, fertilization and manuring. Agric. Ecosyst. Environ. 2007; 119:127–134.
8. Shukla M, Lal R, Owens L, Unkefer P. Land use and management impacts on structure andinfiltration characteristics of soils in the north appalachian region of ohio. Soil Sci. 2003; 168:167–177.
9. Hati K, Swarup A, Singh D, Misra A, Ghosh P. Long-term continuous cropping, fertilisation, and manuring effects on physical properties and organic carbon content of a sandy loam soil. Soil Res. 2006;44:487–495.
10. Ndiaye B, Molénat J, Hallaire V, Gascuel C, Hamon Y. Effects of agricultural practices on hydraulic properties and water movement in soils in brittany (france). Soil Till. Res. 2007;93: 251–263.
11. Bhattacharyya R, Chandra S, Singh R, Kundu S, Srivastva A, Gupta H. Long-term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat-soybean rotation. Soil Till. Res. 2007;94:386–396.
12. Ghuman B, Sur H. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a subhumid subtropical climate. Soil Till. Res. 2001; 58:1–10.
13. Miller J, Sweetland N, Chang C. Hydrological properties of a clay loam soil after long-term cattle manure application. J. Environ. Qual. 2002;31: 989–996.
14. Zhang MK, Fang LP. Effect of tillage, fertilizer and green manure cropping on soil quality at an abandoned brick making site. Soil Till. Res. 2007;93: 87–93.
15. Pernes-Debuyser A, Tessier D. Soil physical properties affected by long-term fertilization. Eur. J. Soil Sci. 2004; 55:505–512.
16. Walkley A, Black CA. An examination of the Degtjareff method for determining soil organic matterand aproposed modification of the chromic acid titration method; 1934.
17. Gupta C, Dakshinamoorthi RP. Practical in soil physics. IARI, New Delhi; 1981.
18. Chopra, S.L. and Kanwar, J.S. 1986. Analytical Agricultural Chemistry, Kalyani Publishers, New Delhi.
19. Bouwer H. Methods of soil analysis, Part 1. Physical and mineralogical properties, monograph 9; ASA: Madison, WI, USA; 1986.
20. Chandrasekaran R, Sankaran N. Influence of ricebased cropping systems on soil health in cauvery delta zoneof Tamil Nadu, Madras Agric. J. 2004;82(3):165-168.
21. Ranjan B, Prakash Ved, Kundu S, Srivastava AK, Gupta HS. Effect of long-term manuring on soil organic carbon, bulk density and water retention characteristics under soybean-wheat cropping sequence in north-western Himalayas. J. Indian Soc. Soil Sci. 2004; 52(3):238-242.
22. Zhu L, Hu N, Zhang Z, Xu J, Tao B, Meng Y. Short-term responses of soil organic carbon and carbon pool management index to different annual straw return rates in a rice–wheat cropping system. CATENA. 2015;135:283–289.
23. Bouldin DR, Klausner SD, Reid WS. Use of N from manure. In: R.D. Harck (ed.), Nitrogen in crop production. American Society of Agronomy, Madison, WI. 1988; 221-248.
24. Biswas TD, Mukherjee SK. Textbook of soil science. Tata McGraw - Hill

Publishing Company Limited. New Delhi; 1991.
25. Chaudhary S, Dheri GS, Brar BS. Long-term effects of NPK fertilizers and organic manures on carbon stabilization and management index under rice-wheat cropping system. Soil Tillage Res. 2017; 166:59–66.
26. Manivannan K, Karthikai Devi G, Thirumaran G, Anantharaman P. Mineral composition of marine macroalge from Mandapam coastal regions; Southeast Coast of India. American-Eurasian Journal of Botany. 2009;2(1):42-51.
27. Pant Pawan Kumar, Shri Ram, Veer Singh. Yield and soil organic matter dynamics as affected by the long-term use of organic and inorganic fertilizers under rice–wheat cropping system in subtropical mollisols. Agric Res. 2017;6:5-12
28. Brye KR, Slaton NA, Norman RJ, Savin MC. Short-term effects of poultry litter form and rate on soil bulk density and water content. Communications in Soil Science and Plant Analysis. 2004;35: 23:11-2325.
29. Katkar RN, Kharche VK, Sonune BA, Wanjari RH, Singh M. Long term effect of nutrient management on soil quality and sustainable productivity under *Sorghum*-wheat crop sequence in Vertisol of Akola, Maharashtra. Agropedology. 2012;22(2): 103–114.
30. Datt N, Bharadwaj KKR. Nitrogen contributionand soil improvement by legume green manuring in rice-wheat cropping on an acid clay loam soil. Journal of the Indian Society of Soil Science. 1995;43:603-607.
31. Maheswarappa HP, Nanjappa HV, Hegde MR. Influence of organic manures on yield of arrow root, soil physico-chemical and biological properties when grown as intercrop in coconut garden. Annals of Agricultural Research. 1999;20(3):318-323.
32. Bhattacharyya, R., Chandra, S.; Singh, R.; Kundu, S.; Srivastva, A. and Gupta, H. 2007. Long-term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat-soybean rotation. Soil Till. Res., 94, 386–396.
33. Baishya LK, Sarker D, Ansari MA, Singh KR, Meitei CB, Prakash N. Effect of micro-nutrients, organic manure and lime on bio-fortified rice production in acid soils of eastern Himalayan region. Ecology, Environment & Conservation 2016;22(1): 199–206.
34. Prakash HC, Shekara BG, Jagadeesh BR, Kalayanamurthy KN, Shivalingaiah ML. Paddy pulse croppingsystem for sustaining soil health and rice yield in cauverycommand area. Res. Crops. 2008; 9(1):7-9.
35. Mubarak AR, Omaima ER, Amal AA, Nemat EH. Short-term studies on use of organic amendments for amelioration of a sandy soil. AJAR. 2009; 4(7):621–627.
36. Nwachukwu MA, Uzu FO. Updated classification of some soil series in southwestern Nigeria &. Niger J Agron. 2008;7:76–81.
37. Busari MA, Salako FK, Adetunji MT, Bello NJ. Effect of selected soil amendments on physical properties of an alfisol in Abeokuta South-western Nigeria. NJSS. 2009;19(1):93–99
38. Chen Z. et al. Water-nutrient management enhances root morpho-physiological functioning, phosphorus absorption, transportation and utilization of cotton in arid region. Industrial Crops and Products. 2020;143: 111975
39. Eusufzai MK, Fujii K. Effect of organic matter amendment on hydraulic and pore characteristics of a clay loam soil. Open J Soil Sci. 2012;02(04):372–381.
40. Schoebitz M, Vidal G. Microbial consortium and pig slurry to improve chemical properties of degraded soil and nutrient plant uptake. J. Soil Sci. Plant Nutr. 2016; 16(1):226-236
41. Mahalakshmi R., Rajan MR. Effect of vermicompost prepared from hotel wastes on growth and production of radish and cowpea. Environment and Ecology. 2007; 25(4):1194-1197.
42. Kumar S, Maji S, Kumar S, Singh HD. Efficacy of organic manures on growth and yield of radish (*Raphanus sativus* L.) cv. Japanese White. Inter. J. PlantSci. 2014; 9(1):57-60
43. Fanish SA. Impact of Green Manure Incorporation on soil properties and crop growth environment: A review. World Journal of Agricultural Sciences. 2017;13: 122–132

44. Ashraf U, Salim MN, Sher A, Sabir SR, Khan A, Pan G, Tang X. Maize growth, yield formation and water-nitrogen usage in response to varied irrigation and nitrogen supply under semi-arid climate. Turk. J. Field Crops. 2016; 21(1): 87-95.
45. Brar BS, Singh K, Dheri GS, Kumar B. Carbon sequestration and soil carbon pools in a rice–wheat cropping system: Effect of long-term use of inorganic fertilizers and organic manure. Soil Tillage Res. 2013; 128:30–36.
46. Naturally by Michael Pollan, The New York Times Magazine; 2001.
47. Piper CS. Soil and Plant Analysis. Inter Science Publications. New York; 1966.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/62401