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Impact of different organic management practices on physico-chemical properties of soil and fruit yield of Nagpur mandarin in farmer's field of Katol tehsil

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Abstract
The field investigation in relation to " Impact of organic different management practices on physico-chemical properties of soil and fruit yield of Nagpur mandarin in farmer's field of Katol tehsil " was conducted during 2024-25 at the Farmers field of Katol tehsil of Nagpur district to assess the physico-chemical properties of soil and fruit yield of Nagpur mandarin as influenced by different organic management practices. Soil samples of 0-20 cm and 20-40 cm depths from five locations *Viz.*, Ridhora, Gharatwada, Fetri, Kukdipanjra, and Pardi (Gotmare) were collected for recording various observations. The farmers were applying FYM @ 5-30 Kg tree^{-1}, Ghanjivamrut @ 500 Kg ha^{-1} and Jivamrut @ 500 lit ha^{-1} from the last 5-6 years for 8-10 years Nagpur mandarin orchards. From the present investigation, the results revealed that that soil bulk density ranged from 1.22 to 1.42 Mg m^{-3} resulted lowest in surface soil. The hydraulic conductivity varied from 0.69 to 0.92 cm hr^{-1}.The soil reaction was found moderately alkaline (7.10 to 8.12). In all locations there was no much variations in electrical conductivity of soil (0.24 to 0.48 dS m^{-1}) under organic management practices. Organic carbon levels decreased with depth and ranged between 5.2 to 7.3 g kg^{-1}. The highest value of 7.3 g kg^{-1} recorded in orchards treated with organic inputs FYM @ 30 kg + jivamrut @ 500 lit. ha^{-1} over a period of 5-6 years. $CaCO_3$ increases with the depth and ranged from 1.18 to 3.78 per cent. The physico-chemical properties of soil enhanced with the application of FYM (5-30 kg tree^{-1}), Jivamrut @ 500 lit ha^{-1} and Ghanjivamrut in the Nagpur mandarin orchards of Katol tehsil. The fruit yield of Nagpur mandarin were slightly favoured with the application of various organic sources. The fruit yield showed positive and significant correlations with hydraulic conductivity (r = 0.7161**), organic carbon (r = 0.5496**), different organic management practices.

Keywords: Nagpur mandarin, organic inputs, FYM

Introduction
Mandarin (*Citrus reticulata* Blanco.) is considered to be one of the most important cultivated species among citrus fruits. It is often regarded as the queen of fruits, stands as a vital subtropical crop and the world's largest fruit. Nagpur mandarin locally known as orange which is botanically called as *Citrus reticulata* Blanco is the native of India and S-E China.
Mandarins are the most important crop since they are widely consumed as a tasty and healthy fruit. Mandarins are the most widely grown citrus fruit worldwide, accounting for about two thirds of all citrus cultivation areas. It is the most extensively produced citrus fruit in India. In India total area under Mandarin in 2023-24 is 446.31 thousand ha with production 6170.46 thousand MT. In India Mandarin producing leading state includes Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Assam. In the year 2023-24 area under Mandarin cultivation in Maharashtra state is 135 thousand hectares with annual production 1335.29 thousand MT (Bhajan *et al.*, 2024) [1]. Organic manure plays a very important role in maintaining soil productivity. Incorporation of organic fertilizers is a common practice to improve yield of fruit crops. Citrus needs eco-friendly fertilizers to increase their efficiency of production, Therefore, the application of organic fertilizers providing an economical solution for reducing external inputs of synthetic agrochemical and sustaining the natural resources. (El-Badawy, 2017) [4], The use of organic fertilizers in citrus orchard is a part of a production system that avoids or largely excludes the use of synthetic chemical fertilizers to produce

healthy fruits. Additionaly, developing liquid organic fertilizers considered an excellent tool for improving citrus growth and sustaining soil health by increasing microorganisms' vitality (Martinez-Alcantara *et al.*, 2016) [7]

Materials and Methods

The field investigation in relation to "Impact of different organic management practices on practices on physico-chemical properties of soil and fruit yield of Nagpur mandarin in farmer's field of Katol tehsil" was carried out during 2024-25 at the farmer's field of Nagpur mandarin orchards to assess the soil properties and fruit yield of Nagpur mandarin considering the different organic mangaement practices.

For present study, the twenty Nagpur mandarin orchards of the age 8 to 10 years old were selected from the Katol tehsil of Nagpur district. The orchards sites were selected by surveying the organic citrus growing farmers, Representing Ridhora, Gharatwada, Fetri, Kukdipanjra, and Pardi Gotmare villages of Nagpur district during 2024-25. Two sample were collected from each orchards, sampling was done from 0-20 and 20-40 cm depth. The fruit yield data were recorded after the harvest of fruits.

Bulk density was determined by core method technique (Blake and Hartz, 1986) [2]. The saturated hydraulic conductivity was measured using constant head method of Richards (1954) [12]. Soils samples were analysed for soil pH and Electrical conductivity (Jackson, 1973) [6], organic carbon by Wet Oxidation Method (Walkley and Black, 1934) [17], calcium carbonate by Rapid Titration method (Piper, 1966) [10].

Results and Discussion

A) Physical properties of soil as influenced by organic management practices

Bulk density of soil (Mg m^{-3})

The data in respect to bulk density of soil were presented in table-1. Bulk density of soil is an index of soil compactness. Bulk density is of greater importance in understanding the physical behavior of soils. It decreases as mineral soils become finer in texture and use of organic sources, which give good estimate of the porosity of soil. The application of organic sources for 5-6 years under the Nagpur mandarin resulted not much variation in bulk density of soil at different locations. The bulk density of surface soil resulted the lowest (1.22 Mg m^{-3}) with the application of FYM 15 kg $tree^{-1}$ at Pardi Gotmare location. The value of bulk density decreases in all locations due the application of organic resources since 5-6 years and varied from 1.22 to 1.42 Mg m^{-3}. These application of organic sources favorably improved the carbon status of the soil. When organic manures are decomposed, the humified fraction of soil helps improve the soil structure and tilth, thereby increasing aeration and aggregation, which in turn reduces the bulk density of the soil (Rudrappa *et al.*, 2006) [13]. Surekha and Rao (2009) [15] reported that the organic sources applied for long period enhanced the soil physical parameters i.e. bulk density and penetration resistance over inorganic alone.

Hydraulic conductivity (cm hr^{-1})

The data pertaining to hydraulic conductivity of soil were reflected in table-1. The HC of soil is one of the important physical property which is associated to flux/movement of water in soil and tendency to measure the permeability of soil. In the present study, the result of hydraulic conductivity of soil exhibited difference between the continuous applications of organic sources. Increase in hydraulic conductivity of soil is associated with decrease in bulk density and inputs of organic sources which influenced on the amount of water and also air present in soil.

Among the use of different organic sources since 5-6 years, the value of hydraulic conductivity of soil ranged between 0.69 to 0.92 cm hr-^{1} in all locations. Hydraulic conductivity of soil increased numerically due to the application of FYM (5-30 Kg $tree^{-1}$), Ghanjivamrut @ 500 kg ha^{-1} and jivamrut @ 500 lit ha^{-1}. Thakur *et al.*, (2011) [16] reported that, saturated HC value was maximum under 100% NPK + FYM @ 15 t ha^{-1} (1.11 cm hr^{-1}) as compared to 100% NPK (0.69 cm hr^{-1}) indicates the favorable effect of FYM on HC of soil.

B) Chemical properties of soils as influenced by organic management practices

Soil pH

The data pertaining to soil pH were presented in table-2. Results revealed that reduced the soil pH in the locations could be ascribed to the acidifying effect of nitrogen and organic acid produced during the decomposition of organic materials. The pH of saturated soil (1:2.5 soil water suspension) ranged from 7.10 to 8.12 which indicate the soil of study area was slightly to moderately alkaline in soil reaction. In surface and subsurface soil the value of soil pH ranged between 7.10 to 8.02, 7.32 to 8.12 with mean value 7.63, 7.78, respectively. There was slightly increase in pH with depth in the all locations under organic management practices in Nagpur mandarin orchards which show somewhat irregular trend of soil reaction with depth. Sihi *et al.* (2017) [14] observed that, soil pH was 0.5 unit lower in organic fields as compared to conventional fields and associated with the formation of humus and organic acids on decomposition.

Electrical Conductivity (dS m^{-1})

The electrical conductivity measures the salt concentration of soil, higher amount of salt in soils restrict the nutrient uptake and thus affect the plant growth. Generally EC increases with depth. In all locations, there is no much variation In EC of soils with the application of organic sources. Low EC was observed in all locations which could be ascribed to increase permeability and thus leaching of salts. The EC of Nagpur mandarin soils ranged from 0.24 to 0.48 dS m^{-1} (table-2). Patil (1979) [9] suggested that EC should not exceed 3 dS m^{-1} for orange fruit crop.

Organic carbon (g kg^{-1})

Carbon is the chief element present in soil organic matter comprising about 56 to 58 per cent of the total weight. The result obtained of soil organic carbon as influenced by various organic management practices is presented in table-2. The organic carbon values generally decreased with depth and it ranged from 5.2 to 7.3 g kg^{-1} in different locations of Nagpur mandarin orchards. The maximum values of organic carbon in soil was observed in location of Fetri (7.3 g kg^{-1}) in the orchards treated with FYM 30 kg $tree^{-1}$ + jivamrut 500 lit ha^{-1} which may be attributed to the highest contribution of organic carbon content in soil in the form of solid and liquid sources with the effect of microbial activity. Panchabhai *et al.* (2006) [8] reported that average organic carbon content in the soil ranging from 0.40-1.1% with the mean of 0.65% (6.5 g kg^{-1}) which was optimum for soil health.

Table 1: Physical properties of soil as influenced by organic sources

Locations	Orchards sites	Application of organic inputs	Depth	BD (Mg m^{-3})	HC (cm hr^{-1})
Ridhora	1	FYM-10 kg $tree^{-1}$ + Ghanjivamrut-500 kg ha^{-1}	0-20	1.23	0.83
			20-40	1.34	0.72
	2	FYM-20 kg $tree^{-1}$ + Ghanjivamrut-500 kg ha^{-1}	0-20	1.26	0.79
			20-40	1.31	0.70
	3	FYM-10 kg $tree^{-1}$	0-20	1.27	0.82
			20-40	1.34	0.78
	4	FYM-8 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.32	0.73
			20-40	1.34	0.69
Gharatwada	1	FYM-20 kg $tree^{-1}$	0-20	1.31	0.88
			20-40	1.37	0.83
	2	FYM-15 kg $tree^{-1}$	0-20	1.38	0.85
			20-40	1.41	0.80
	3	FYM-20 kg $tree^{-1}$	0-20	1.34	0.90
			20-40	1.36	0.83
	4	FYM-20 kg $tree^{-1}$	0-20	1.23	0.91
			20-40	1.27	0.85
Fetri	1	FYM-30 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.30	0.92
			20-40	1.41	0.81
	2	FYM-30 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.38	0.92
			20-40	1.42	0.83
	3	FYM-30 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.31	0.89
			20-40	1.37	0.84
	4	FYM-20 kg $tree^{-1}$	0-20	1.30	0.87
			20-40	1.32	0.80
Kukdipanjra	1	FYM-10 kg $tree^{-1}$	0-20	1.30	0.78
			20-40	1.35	0.72
	2	FYM-7 kg $tree^{-1}$ + Ghanjivamrut-500 kg ha^{-1}	0-20	1.31	0.80
			20-40	1.36	0.75
	3	FYM-20 kg $tree^{-1}$	0-20	1.38	0.90
			20-40	1.42	0.86
	4	FYM-7 kg $tree^{-1}$ + Ghanjivamrut-500 kg ha^{-1}	0-20	1.30	0.80
			20-40	1.32	0.75
Pardi Gotmare	1	FYM-10 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.23	0.76
			20-40	1.27	0.71
	2	FYM-5 kg $tree^{-1}$ + Jivamrut-500 lit ha^{-1}	0-20	1.31	0.80
			20-40	1.32	0.77
	3	FYM-15 kg $tree^{-1}$	0-20	1.22	0.82
			20-40	1.27	0.69
	4	FYM-20 kg $tree^{-1}$	0-20	1.31	0.84
			20-40	1.33	0.71
		Mean	0-20	1.30	0.84
			20-40	1.35	0.77

Calcium carbonate (%)

The $CaCO_3$, is one of the important property of soil which is associated with the nutrient availability, effect of organic carbon, soil reaction, availability of micronutrients and exchangeable cations. The $CaCO_3$, content (table-2) in soil shows that it generally increased with depth and ranged from 1.18 to 2.95 per cent at surface layer and 1.93 to 3.78 per cent at subsurface layer under organic management practices. The $CaCO_3$ mostly found to accumulate in the lower part of profile, this trend has been mainly due to leaching of bicarbonate during rainy season from upper layers and subsequent precipitation during the hot and dry periods prevailing in the area. Orchards indicating all these soils are slightly calcareous to moderately calcareous in nature and it reflected with the availability of nutrients in Nagpur mandarin. Reddy *et al.* (2013) [11] reported orange growing soils are moderate to high calcareous (3.13 to 15.48%) in nature and it adversely affects the availability of macronutrients on yield of Nagpur mandarin.

Table 2: Chemical properties of soil as influenced by organic sources

Locations	Orchards sites	Application of organic inputs	Depth (cm)	pH	EC (ds/m)	OC (g kg^{-1})	$CaCo_3$ (%)
Ridhora	1	FYM-10 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}	0-20	7.32	0.34	6.4	1.43
			20-40	7.55	0.36	6.0	1.93
	2	FYM-20 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}	0-20	7.56	0.34	7.0	1.25
			20-40	7.62	0.34	6.3	2.65
	3	FYM-10 kg tree^{-1}	0-20	7.92	0.37	7.1	1.18
			20-40	7.97	0.38	6.8	2.62
	4	FYM-8 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	8.02	0.37	6.6	2.41
			20-40	8.12	0.38	6.5	3.03
Gharatwada	1	FYM-20 kg tree^{-1}	0-20	7.80	0.37	7.2	1.65
			20-40	8.01	0.38	7.0	2.88
	2	FYM-15 kg tree^{-1}	0-20	7.60	0.34	6.2	2.15
			20-40	7.75	0.35	5.7	2.63
	3	FYM-20 kg tree^{-1}	0-20	7.72	0.45	6.9	2.30
			20-40	7.81	0.48	6.8	2.91
	4	FYM-20 kg tree^{-1}	0-20	7.89	0.43	7.2	2.53
			20-40	8.01	0.48	6.6	3.23
Fetri	1	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	7.45	0.24	7.3	2.68
			20-40	7.57	0.26	6.6	2.91
	2	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	7.44	0.24	6.8	2.28
			20-40	7.47	0.26	6.6	2.88
	3	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	7.56	0.35	7.0	2.48
			20-40	7.78	0.38	6.6	3.33
	4	FYM-20 kg tree^{-1}	0-20	7.72	0.35	7.0	2.53
			20-40	7.91	0.37	6.2	3.44
Kukdipanjra	1	FYM-10 kg tree^{-1}	0-20	7.79	0.42	7.1	2.45
			20-40	8.01	0.44	6.5	3.17
	2	FYM-7 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}	0-20	7.24	0.41	7.0	2.28
			20-40	7.37	0.42	6.4	2.92
	3	FYM-20 kg tree^{-1}	0-20	7.70	0.34	6.0	2.72
			20-40	8.01	0.34	5.3	3.49
	4	FYM-7 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}	0-20	7.70	0.42	6.3	2.71
			20-40	8.02	0.44	6.0	3.45
Pardi (Gotmare)	1	FYM-10 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	7.56	0.35	6.0	2.73
			20-40	7.60	0.37	5.4	3.59
	2	FYM-5 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	0-20	7.54	0.35	5.9	2.81
			20-40	7.57	0.38	5.2	3.67
	3	FYM-15 kg tree^{-1}	0-20	8.01	0.40	6.8	2.80
			20-40	8.11	0.43	6.3	3.56
	4	FYM-20 kg tree^{-1}	0-20	7.10	0.45	7.1	2.95
			20-40	7.32	0.47	6.7	3.78
Mean			0-20	7.63	0.38	6.7	2.32
			20-40	7.78	0.39	6.3	3.10

C) Fruit yield performance of Nagpur mandarin as influenced by management of organic sources

Fruit yield (t ha^{-1})

The fruit yield (table-3) of Nagpur mandarin orchards were recorded from 7.8 to 14.0 t ha^{-1} with mean 10.1 and the No. fruit/tree varied from 235 to 380 with mean the value 281.1. The highest fruit yield (14.0 t ha^{-1}) was recorded in the location Fetri with the (294) no. of fruits tree^{-1} when the orchards treated with various organic sources in terms of solid / liquid that was FYM @ 30 kg tree^{-1} + jiavamrut @ 500 kg ha^{-1} since 5-6 years for 8-10 year orchards. from the data, the higher application of organic sources (20-30 Kg FYM per tree) has slightly favoured the fruit yield of Nagpur mandarin. Garhwal and Yadav (2014) [5] reported that fruit yield (25.22 kg/tree), number of fruits (212.75 fruits/tree), average weight (118.22 g) and juice percentage (48.83%) significantly increased in plants receiving 80 Kg FYM followed by 60 kg FYM.

D) Correlation of soil properties with fruit yield of Nagpur mandarin

Correlation of soil properties with fruit yield of Nagpur mandarin is presented in the table-4. The yield of Nagpur mandarin were positively and significantly correlated with hydraulic conductivity (r = 0.7161**) and organic carbon (r = 0.5496**). The hydraulic conductivity of soil were positively and significantly correlated with OC (r = 0.3918*). The organic carbon was negatively correlated with $CaCO_3$ (r = -4577). Chaudhry *et al.* (2012) [3] reported that organic amendment can enhanced the population of certain microorganism which can be correlated with soil properties such as pH, total organic C, total organic N and microbial biomass C.

Table 3: Fruit yield performance of Nagpur mandarin as influenced by organic sources

Locations	Orchards sites	Application of organic inputs	Spacing (meter)	No. of fruit tree^{-1}	fruit weight (g)	Fruit Yield t ha^{-1}
Ridhora	1	FYM-10 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}	6 m x 6 m	250	124	8.5
	2	FYM-20 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}		285	135	10.6
	3	FYM-10 kg tree^{-1}		235	120	7.8
	4	FYM-8 kg tree^{-1} + Jivamrut-500 lit ha^{-1}		260	125	9.0
Gharatwada	1	FYM-20 kg tree^{-1}	6 m x 6 m	380	130	13.6
	2	FYM-15 kg tree^{-1}		245	120	8.1
	3	FYM-20 kg tree^{-1}		362	125	12.5
	4	FYM-20 kg tree^{-1}		304	122	10.3
Fetri	1	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	6 m x 4 m	294	115	14.0
	2	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}		253	111	11.6
	3	FYM-30 kg tree^{-1} + Jivamrut-500 lit ha^{-1}		260	113	12.2
	4	FYM-20 kg tree^{-1}		265	109	12.1
Kukdipanjra	1	FYM-10 kg tree^{-1}	6 m x 6 m	277	115	8.8
	2	FYM-7 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}		250	117	8.1
	3	FYM-20 kg tree^{-1}		290	130	10.4
	4	FYM-7 kg tree^{-1} + Ghanjivamrut-500 kg ha^{-1}		260	109	7.9
Pardi (Gotmare)	1	FYM-10 kg tree^{-1} + Jivamrut-500 lit ha^{-1}	6 m x 6 m	260	117	8.4
	2	FYM-5 kg tree^{-1} + Jivamrut-500 lit ha^{-1}		252	115	8.0
	3	FYM-15 kg tree^{-1}		305	105	9.2
	4	FYM-20 kg tree^{-1}		335	115	10.6
		Mean		281.1	118.6	10.1

Table 4: Correlation of soil properties with fruit yield of Nagpur mandarin

	YIELD	BD	HC	pH	EC	OC	$CaCo_3$
YIELD	1						
BD	0.2238	1					
HC	0.7161**	0.1054	1				
pH	-0.0561	-0.0071	-0.1441	1			
EC	-0.3034	-0.2901	-0.2886	0.2511	1		
OC	0.5496**	-0.2255	0.3918*	-0.0863	0.0711	1	
$CaCO_3$	0.0411	0.2357	-0.3131	0.2039	0.2807	-0.4577	1

**Significant at 1% level * Significant at 5% level

Conclusions

On the basis of present study, It can be concluded that the continuous use of organic inputs since 5-6 years with the combination of solid and liquid influence the hydraulic conductivity and favoured the yield of Nagpur mandarin under different organic management practices.

The fruit yield of Nagpur mandarin were positively and significantly correlated with hydraullic conductivity(r = 0.7161**), organic carbon (r = 0.5496**).

References

1. Bhajan S, Bagde NT, Rathod VJ, Deotale SL, Gajbhiye S. Economics of mandarin production in Nagpur district of Vidarbha region. International Journal of Research in Agronomy. 2024;7(9S):614-619.
2. Blake GR, Hartz KH. Bulk density. In: Klute A, editor. Methods of soil analysis. Part 1. Madison (WI): American Society of Agronomy; 1986. p. 363-375.
3. Chaudhry V, Rehman A, Mishra A, Chauhan PS, Nautiyal CS. Changes in bacterial community structure of agricultural land due to long-term organic and chemical amendments. Microbial Ecology. 2012;64:450-460.
4. El-Badawy HEM. Partial substitution of Valencia orange chemical fertilization by bio-organic fertilization conjoint with algae extract foliar spray. Middle East Journal of Applied Sciences. 2017;7(4):1016-1030.
5. Garhwal PC, Yadav PK, Sharma BD, Singh RS, Ramniw AS. Effect of organic manure and nitrogen on growth, yield and quality of kinnow mandarin in sandy soils of hot arid region. African Journal of Agricultural Research. 2014;9(34):2638-2647.
6. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973.
7. Martínez-Alcántara B, Martínez-Cuenca MR, Bermejo A, Legaz F, Quiñones A. Liquid organic fertilizers for sustainable agriculture: Nutrient uptake of organic versus mineral fertilizers in citrus trees. PLOS ONE. 2016;11(10):e0161619.
8. Panchbhai DM, Mahorkar VK, Jogdande ND, Patil MN, Katkar RN. Studies on soil nutrient status of acid lime orchards in Western Vidarbha. Journal of Agricultural Science. 2006;2(2):573-576.
9. Patil VK. Salinity and alkalinity in citrus-a review. Journal of Maharashtra Agricultural Universities. 1979;4(1):1-6.
10. Piper CS. Soil and plant analysis. Bombay: Hans Publishers; 1966. p. 368.
11. Reddy B, Guldekar VD, Balakrishnan N. Influence of soil calcium carbonate on yield and quality of Nagpur mandarin. African Journal of Agricultural Research. 2013;8(42):5193-5196.
12. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Handbook no. 60. Washington (DC): United States Department of Agriculture; 1954.
13. Rudrappa L, Purakayastha TJ, Singh D, Bhadraray S. Long-term manuring and fertilization effects on soil organic carbon pools in a Typic Haplustept of semi-arid subtropical India. Soil and Tillage Research. 2006;88(1-2):180-192.
14. Sihi D, Dari B, Sharma DK, Pathak H, Nain L, Sharma OP. Evaluation of soil health in organic vs. conventional farming of basmati rice in North India under organic and conventional production systems. Communications in Soil Science and Plant Analysis. 2014;45:415-428.

15. Surekha K, Rao KV. Direct and residual effects of organic sources on rice productivity and soil quality of Vertisols. Journal of the Indian Society of Soil Science. 2009;57(1):53-57.
16. Thakur R, Sawarkar SD, Vaishya UK, Singh M. Impact of continuous use of inorganic fertilizer and organic manure on soil properties and productivity under soybean-wheat intensive cropping of Vertisol. Journal of the Indian Society of Soil Science. 2011;59(1):74-81.
17. Walkley NM, Black AI. Estimation of organic carbon by chromic acid titration method. Soil Science. 1934;25:259-263.