International Journal of Research in Engineering and Applied Sciences (IJREAS)
Available online at http://euroasiapub.org/journals.php
Vol. 6 Issue 10, October - 2016, pp. 6~15
ISSN(O): 2249-3905, ISSN(P) : 2349-6525 | Impact Factor: 6.573 | Thomson Reuters ID: L-5236-2015

SOIL CHEMICAL, BIOLOGICAL AND MORPHOLOGICAL PROPERTIES OF ORGANIC FARM SOILS OF AGRICULTURE COLLEGE, DHULE (M.S.)

M. V. Chavan[1],
R. D. Chaudhari[2],
Ritu Thakare[3]
Department of Soil Science and Agricultural Chemistry,
College of Agriculture (Mahatma Phule Agriculture University), Dhule - 424 004 (M.S.) India

ABSTRACT

The present study was conducted during the year 2015-2016 at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule with objectives to assess the chemical and biological properties of organic farm soil and to assess the morphology of representative soil. The geo-referenced 65 soil samples were collected from organic farm College of Agriculture, Dhule by using Global Positioning System (GPS). The pH of soil was varied from 7.0 to 7.9, while, EC was varied from 0.58 to 0.69 dSm^{-1}. The organic carbon and calcium carbonate content in soil were varied from 5.9 to 6.7 g kg^{-1} and 1.1 to 4.2 per cent, respectively. Soils of organic farm were found neutral to slightly alkaline and non saline in nature. While, moderate to moderately high in organic carbon and low to moderately high in calcium carbonate. The available nitrogen, phosphorus and potassium were ranged from 137 to 299, 12.00 to 23.72 and 252.00 to 293.9 kg ha^{-1}, respectively. Which indicates that soils were very low to moderate in available nitrogen, low to moderately high in available phosphorus and high in available potassium. The exchangeable calcium and magnesium and available sulphur were ranged from 21.9 to 28.9, 11.2 to 16.8 cmol (p+) kg^{-1} and 13.19 to 26.32 mg kg^{-1}, respectively. The 100 per cent soils were sufficient in exchangeable calcium, magnesium and available sulphur. The available iron, manganese, zinc and copper were varied from 4.65 to 17.51, 2.99 to 7.58, 0.57 to 1.78 and 2.65 to 4.82 mg kg^{-1}, respectively. The microbial population like fungi, bacteria and actinomycetes were ranged from 21 to 31 x 10^4 cfu g^{-1} soil, 36 to 61 x 10^7 cfu g^{-1} soil and 29 to 39 x 10^6 cfu g^{-1}soil, respectively.

Key words: Organic farm, macronutrients and micronutrients, microbial population, GPS-GIS technique.

Introduction

Organic agriculture relies on ecosystem management rather than external agricultural inputs. It is a system that begins to eliminate the use of synthetic inputs such as synthetic fertilizers, pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and irradiation. These are replaced with site specific management practices that maintain and increase long term soil fertility and quality of the environment (Subbarao *et al.*, 2007). Organic agriculture system produced significant improvement in soil chemical and biological properties mainly organic carbon, available nitrogen, phosphorus and potassium (Babalad *et al.*, 2009). Organic principles will be highlighted in reference to Philipps (2003) who states that 'organic farming aims to achieve sustainability through the application of the natural biological cycles present in soils.' The organic farming methods aim to manage the soil so as to sustain and build soil fertility. This is achieved by recycling of nutrients, maintaining soil structural stability and soil biological activity to achieve crop and livestock health, thus reducing the need for artificial inputs. The use of organic manure not only supply sufficient nutrient but also improve physico-chemical and biological properties of soil. Moreover, release of many organic acids during decomposition of FYM convert unavailable soil nutrients into available nutrients (Lakum *et al*., 2011). The present investigation was therefore carried out with objectives to study the soil fertility of organic farm soils of Agriculture College, Dhule.

Material and methods

Agriculture College Farm, Dhule (Maharashtra) lies between 210 23" North latitude and 740 19" East longitudes. Agro-climatically, Dhule comes under scarcity zone and is situated at an elevation of 258 m above mean sea level. The average annual rainfall of the place is 597 mm. The initial soil sample (0-22.5 cm) was collected from adjacent field, where organic matter was not added. The 65 surface soil samples (0-22.5 cm) were collected by using systematic soil sampling methodology based on GPS at 20 m grid from organic farm, College of Agriculture, Dhule. One representative profile sample was taken from organic farm for morphology study. The collected soil samples were processed and analyzed for their nutrient status by standard analytical methods at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule.

Soil samples were analyzed for chemical characteristics by following standard analytical techniques. Soil reaction was determined in 1:2.5 suspension using standard pH meter by potentiometry and the electrical conductivity was determined by 1:2.5 suspension using EC meter by Conductometry (Jackson, 1973). Soil organic carbon was estimated using wet oxidation method (Nelson and Sommer, 1982) and $CaCO_3$ was determined by Acid neutralization method by (Alison and Moodie, 1965). The available nitrogen was estimated by Modified alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus was estimated by 0.5M $NaHCO_3$ pH 8.5 method (Watanabe and Olsen, 1965), available potassium was estimated by Neutral Normal NH_4OAc Flame Photometer (Jackson, 1973). The exchangeable cations (Ca and Mg) were estimated by versenate titration (Hoffman and Shapiro 1954) and Available Sulphur was estimated by 0.15% $CaCl_2$ extractable method (Williams and Steinbergs, 1959). The DTPA micronutrient (Fe, Mn, Zn, Cu) were estimated by Atomic Absorption Spectrophotomèter (Lindsay and Norvell, 1978). The biological properties like fungal, bacterial and actinomycetes count were determined by Serial dilution pour plate (Dhingra and Sinclair, 1993). Morphological properties like soil colour was determined by Munsell colour chart (Soil survey staff, 1975).

Results and discussion

Chemical and biological properties of initial soil sample

The data pertaining to different parameters of initial soil sample was presented in Table 1.The pH of the initial soil sample was 8.1 which showed that soil was moderately alkaline in nature. This might be due to medium deep black soils brought under irrigation since long which shifted to alkaline condition. The EC of initial soil sample was 0.75 dSm^{-1}. It was observed that soils were normal in nature. The similar results were reported by Waikar *et al*., (2004) for the soils of Maharashtra. The organic carbon content was 5.4 g kg^{-1} which comes under the moderate category. The moderate organic carbon content might be due to high temperature prevailing during the summer under the semi-arid climate of Dhule Tehsil which favours for high rate of decomposition of organic matter in soil. The calcium carbonate content in soil was 5.2 per cent which comes under high category.

The available nitrogen content in initial soil sample was 126 kg ha^{-1} (Table 1) which indicated that soils have very low available nitrogen content. Available phosphorus content in initial soil sample was 8.00 kg ha^{-1}. Low status of soil available P in soils of studied area might be due to alkaline soil reaction and high content of $CaCO_3$ in the soil. The initial soil sample was in moderately high category (241 kg ha^{-1}) in respect of available K. The high content of available K in the soil could be attributed due to the dissolution and diffusion of K from internal crystal lattice of silicate clay minerals under the condition of high clay content especially of montmorillonitic clay minerals present in soil (Durgude, 1999). The exchangeable calcium and magnesium in soil was 21.3 and 10.9 [cmol (p+) kg^{-1}], respectively. The available sulphur in initial soil sample was 9.0 mg kg^{-1}.

Table 1.Chemical and biological properties of initial soil sample

Particulars	**Value**
pH	8.1
EC (dSm^{-1})	0.75
Organic carbon (g kg^{-1})	5.4
$CaCO_3$(%)	5.2
Available N (kg ha^{-1})	126
Available P (kg ha^{-1})	8.00
Available K (kg ha^{-1})	241
Exchangeable Ca(cmol(p+) kg^{-1})	21.30
Exchangeable Mg(cmol(p+) kg^{-1})	10.90
Available S (mg kg^{-1})	9.0
Available Fe (mg kg^{-1})	4.60
Available Mn (mg kg^{-1})	2.90
Available Zn (mg kg^{-1})	0.52
Available Cu (mg kg^{-1})	1.3
Fungi (x 10^4 cfu g^{-1} soil)	11
Bacteria (x 10^7cfu g^{-1} soil)	26
Actinomycetes (x 10^6cfu g^{-1} soil)	14

Initially, iron, manganese, zinc and copper contents in soil were 4.60, 2.90, 0.52 and 1.3 mg kg^{-1}, respectively. The fungal, bacterial and actinomycetes population was 11 x 10^4 cfu g^{-1}soil, 26 x 10^7 cfu g^{-1}soil and 14 x 10^6 cfu g^{-1}soil of, respectively.

Chemical and biological properties of organic farm soils

The 65 soil samples collected from organic farm, College of Agriculture, Dhule were chemically analyzed. The data pertaining to 65 soil samples of organic farm for different chemical parameters were categorized as per the standard categorization ratings and the mean and range was given.

pH, EC, organic carbon and $CaCO_3$

The pH of organic farm soils ranged from 7.0 to 7.9. The mean pH was 7.44 (Table 2). Soils are in general neutral to slightly alkaline in nature, it might be due to medium deep black soils brought under irrigation since long that have shifted to alkaline condition. The similar nature of observations was also reported by Patil *et al*., (2003) in soils of Vertisols. The EC of soils were ranged from 0.58 to 0.69 dSm^{-1}, the mean of EC for all soil samples was 0.64 dSm^{-1}. It was observed that all 65 soils were non saline in nature. Similar results were reported by Patil *et al*., (2011) at Karlawad village in Navalgund taluka of Dharwad district of Karnataka. The electrical conductivity of soil varies depending on the amount of moisture held by soil particles. The EC indicated that soils were normal in respect of salt content and hence, suitable for healthy plant growth. The organic carbon content ranged from 5.9 to 6.7 g kg^{-1} with the mean of 6.34 g kg^{-1}. The soils were moderate to moderately high in organic carbon content. The similar nature of observations were recorded for organic carbon by Okur *et al*. (2009) in vineyard soils under organic and conventional farming systems. Besides this high input of FYM and crop residues and coarse textured soil is also responsible for high organic carbon. The calcium carbonates in soil samples were ranged from 1.1 to 4.2 per cent with an average of 1.94 per cent. The soils were very low to moderately high in calcium carbonate content. Similar observations were recorded for calcium carbonate by Ibanez *et al*. (2013) in soil attributes of semiarid areas. The calcareousness of soils is common feature in soils of arid and semi arid climate particularly in Vertisols (black soils) due to precipitation of carbonates and bicarbonates under water stress.

Table. 2 Soil pH, EC, Organic Carbon and $CaCO_3$ status of organic farm, College of Agriculture, Dhule

Particulars	pH	EC (dSm^{-1})	Organic Carbon (g kg^{-1})	$CaCO_3$ (%)
Mean	7.44	0.64	6.34	1.94
Range	7.0-7.9	0.58-0.69	5.9-6.7	1.1-4.2

N, P, K, Ca Mg and S

The data presented in (Table 3) revealed that the available nitrogen contents in soils varied from 137 to 299 kg ha^{-1} with an average of 249.94 kg ha^{-1}. The soils were very low to moderate content in case of nitrogen, the low available nitrogen in most of the soils might be due to the higher temperature in semiarid climate of Dhule district, which might have declined the organic matter status by faster degradation resulted in low status of available nitrogen. The available phosphorus in soils was ranged from 12 to 23.72 kg ha^{-1} with a mean value of 18.30 kg ha^{-1}. The soils were low to moderately high content in available phosphorus. Low to high status of available P in soils of studied area might be due to alkaline soil reaction and high content of $CaCO_3$ in the soil. The range is quite large which might be due to variation in soil properties viz. pH, calcareousness, organic matter content, texture and various management and agronomic practices. The similar trend of available phosphorus were also reported by Rangaraj *et al.*, (2007) and Parthsarthi *et al.*, (2008). They found that, incorporation of organic manures increase the available phosphorus status to maximum level. The available potassium in soils was ranged from 252 to 293.90 kg ha^{-1} with an average of 272.95 kg ha^{-1}. The soils were high content in available potassium. The high content of available K in the soil could be attributed due to the dissolution and diffusion of K from internal crystal lattice of silicate clay minerals under the condition of high clay content especially of montmorillonitic clay minerals present in soil (Durgude, 1999).

The exchangeable calcium in soils ranged from 21.90 to 28.90 cmol (p+) kg^{-1} with an average of 26.29 cmol (p+) kg^{-1}. The soils was sufficient in exchangeable calcium, as the critical limit of available calcium is 20 cmol (p+) kg^{-1}.The higher amount of exchangeable Ca content found in soils under study may be due to high clay content and calcareous nature. The sufficiency of exchangeable Ca is due to no leaching of bases and moderate to high organic carbon values. Similar trend was also recorded by Barker *et al.* (1997) with the use of composts and agricultural by-products and wastes in Vertisols. The exchangeable magnesium in soils were ranged from 11.20 to 16.80 cmol (p+) kg^{-1} with an average of 13.80 cmol (p+) kg^{-1}. All the soil samples were in sufficient category, as the critical limit of exchangeable magnesium is 10 cmol (p+) kg^{1}. Sufficiency of Mg may be due to its genesis in the semiarid area. Less leaching because of low precipitation, moderate to high organic carbon and calcareousness of soil responsible for availability of magnesium in soil. The similar results were observed by Dhamak *et al*. (2014) in vertisol.

Table 3. Soil Available macro nutrient status of organic farm College of Agriculture, Dhule

Particulars	Soil available macro nutrients					
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca [cmol(p+)kg^{-1}]	Mg [cmol(p+)kg^{-1}]	S (mg kg^{-1})
Mean	249.94	18.30	272.95	26.29	13.80	18.38
Range	137-299	12-23.72	252-293.90	21.90-28.90	11.20-16.80	13.19-26.32
Critical limit	-	-	-	20	10	10
Sufficient	-	-	-	65	65	65

The available sulphur in soils ranged from 13.19 to 26.32 mg kg-1with an average of 18.38 mg kg^{-1}. All the soil samples were in sufficient range for available sulphur. The sufficiency of available sulphur is directly proportional to the organic matter content of the soil. Similar results were found by Jat and Yadav (2006) in soils of Entisols of Jaipur District, Rajasthan. Sufficiency might be due to moderate to high content of organic carbon and fine texture of soils. The moderate to high in available S content in soil may be because of accumulation of SO_4^- in surface layer. At high pH and calcareousness, sulphur availability is greater in the soil.

Fe, Mn, Zn and Cu

The available iron (Table 4) in soils ranged from 4.65 to 17.51 mg kg^{-1} with an average of 7.59 mg kg^{-1}. The data indicated that 100 per cent soil samples of organic farm, College of Agriculture, Dhule were sufficient in iron content. The similar trend in Fe was reported by Abebe (2001) in their investigation on the effect of manure on some physico-chemical properties of calcareous soil. The availability of Fe is due to organic matter content. As the pH is low and NPK availability is low or adequate, the Fe content is higher in soil (Singh and Rathore, 2013).The available manganese in soils was ranged from 2.99 to 7.58 mg kg^{-1} with an average of 5.04 mg kg^{-1}. However, the data recorded clearly indicated that the, organic farm soils are sufficient in manganese content. The sufficiency of available Mn might be due to high organic matter content under optimum soil reaction. Similar observations were also reported by Meenakshi *et al*. (2005) with spatial distribution of micronutrients in soils of Patiala district. The available zinc in soils ranged from 0.57 to 1.78 mg $kg^{-1}$with an average of 1.01 mg kg^{-1}. The results showed that, 95.38 per cent soils were sufficient and 4.62 per cent soils were deficient in Zinc. The deficiency of available zinc might be due to low organic matter content in soil, which acts as natural chelating agent, washout of the upper soil surface and excess of pH in soil. The similar observations were also reported by Kumar *et al*., (2014) in soils of vertisol of Kabeerdham district of Chattisgargh. Data indicated that the majority of soils were deficient in Zn status, it might be due to alkaline soil reaction. The available copper in soils was varied from 2.65 to 4.82 mg $kg^{-1}$with average value of 3.30 mg kg^{-1}. Data indicated that 100 per cent soil samples of organic farm, College of Agriculture, Dhule were sufficient in copper content. Similar results were observed by Venkatesh *et al*., (2003) in soils of various land use systems of Meghalaya. The sufficiency of Cu in soils might be due to interactive effect of soil properties like pH, EC and OC which have dominant role in the availability of Cu.

Table 4. Soil available micronutrients status of organic farm, College of Agriculture, Dhule

Particular	Available micronutrients (mg kg^{-1})			
	Fe	Mn	Zn	Cu
Mean	7.59	5.04	1.01	3.30
Range	4.65-17.51	2.99-7.58	0.57-1.78	2.65-4.82
Critical limit	4.5	2.0	0.6	0.2
Sufficient	65	65	62	65
Deficient	0	0	3	0

Microbial population

The data in relation to microbial population are presented in Table 5. The fungal population in soils was varied from 21 to 31 x 10^4 cfu g^{-1} soil and with an average of 25.21 x 10^4 cfu g^{-1}soil. Beneficial effects of FYM and vermicompost on fungal population was noticed by Kumar *et al*. (2010). This data was closely confirmative with the results reported by Nakhro and

Dkhar (2010) who stated that, the fungi population increased due to addition of organic amendments that might have large impact on population and activity of fungal population. The bacterial population in soils varied from 36 to 61 x 10^7 cfu g^{-1}soil and with an average of 47.12 x 10^7 cfu g^{-1}soil. Parham *et al*. (2003) reported that the farm yard manure application promoted the growth of bacteria in soil. The addition of organic carbon through organic manures under organic farming significantly increased the bacterial population was noticed by Fraster *et al*., (1994).The actinomycetes population in soils was varied from 29 to 39 x 10^6 cfu g^{-1}soil and with an average of 33.78 x 10^6 cfu g^{-1}soil. The results are in agreement with the findings of Krishnakumaran *et al*. (2005).

Table 5. Soil microbial population in organic farm, College of Agriculture, Dhule

Particular	Soil microbial population		
	Fungi (x 10^4cfu g^{-1}soil)	Bacterial (x 10^7cfu g^{-1}soil)	Actinomycetes (x 10^6cfu g^{-1}soil)
Range	21-31	36–61	29-39
Mean	25.21	47.12	33.87

Morphological characteristics of organic soil pedon

The data on soil morphological characteristics is summarized in Table 6. One representative profile sample was taken from organic farm for morphology study. It was revealed that the morphological characteristics of organic farm, College of Agriculture, Dhule were greatly influenced by topographic situation. All the soil series occurred on basaltic parent rock and belonged to brown to very dark gray soil colour groups. The soils on the top were black (10 YR 2/1) whereas, soils occurring on the slope and depressions were dark whitish colour (10 YR 2/2). However, there was no colour change of surface as well as subsurface horizon of organic farm. Among the soil series observed on organic farm, it showed dark brown colour which might be due to high iron and calcium carbonate contents. The black colour of (P1) might be due to clay humus complex in the predominantly montmorillonite soils. Whereas, decrease in organic matter and increase in calcareousness of soils was mainly responsible for dark brown colour in deeper horizon of series. Similar observations were recorded by Subbiah and Manickam (1992).The soil depth in organic farm, College of Agriculture, Dhule was 0 to 32 cm (organic and mineral matter), 32 to 73 cm (leaching light colour mineral material) and 73 to 110 cm (accumulation of $CaCO_3$, clay and colloidal particles).

Table 6. Morphological characteristics of soil pedons of organic farm College of Agriculture, Dhule

Block	Pedon No.	Horizon No.	Depth (cm)	Colour	Other special features
A	P1	Ap	0-32	10YR 2/1	Intersecting slickensides,1-2 cm wide cracks upto100 cm depth during dryperiod, shiny pressure faces.
		Bw	32-73	10YR 2/1	
		Bc	73-110	10YR 2/2	
		C	Weathered parent material		

Conclusion

Before start of the organic farming at College of Agriculture, Dhule, the soil available N and P were found in low category while, available K was in moderately high category. The soil was deficient in available sulphur and zinc content. However, availability of these nutrients were increased under organic farming. Soils of organic farming were found neutral to slightly alkaline and non-saline in nature while, moderate to moderately high in organic carbon and low to moderately high in calcium carbonate content. The available N, P and K content in organic soils were found very low to moderate, low to moderately high categories and high category, respectively. Exchangeable Ca and Mg, available S, available Fe, Mn and Cu contents were found sufficient in these soils. However, 4.62 per cent soils were deficient in Zn in least soil sample. The soil microbial population viz., fungi, bacteria and actinomycetes were found enhanced under organic soils. Holistic survey and precise use of analytical techniques in this investigation have enabled the investigator to come out with organic farm. The use of GPS-GIS based technique for soil sampling is new land mark, which will enable the further researchers and university officials to monitor the changes in organic soil fertility status for years to come. However, in future there is need to maintain this fertility status of organic soil for sustainable agriculture.

References

Abebe, G. 2001. Effect of manure on some physico-chemical properties of calcareous soil, yield and quality of cowpea [Vigna unguiculata (L.) Walp. Under greenhouse conditions. M.Sc. thesis, submitted to University of Jordan, Amman, Jordan. pp. 234-241.

Allison, L. E. and Moodie, C. D. 1965. Carbonate in methods of soil analysis. Chemical and microbiological properties. Part-II, Black C.A. (Ed.). America. Soc. Agron. Inc. Madison, Wisconsin, USA. pp. 1387-1388.

Babalad, H. B., Kamble, A. S., Bhat, S. N., Patil, R. K., Math, K. K., Geeta Shiranali and Palakappa, M. G. 2009. Sustanable groundnut production through organic approach. J. Oilseeds Res. (26):365-367.

Barker, A. V. 1997. Composition and use of composts. In JE Rechcigl and HC MacKinnon (eds.) Agricultural use of by-products and wastes. ACS Symposium Series 668. ACS, Washington DC, USA, pp. 140-162.

Dhamak, A. L., Meshram, N. A. and Waikar, S. L. 2014. Identification of major soil nutritional constraints in vertisol, inceptisol and entisol from Ambajogai tahsil of Beed district. J. Res.

Agric. and Ani. Sci., 2(10): 35-39.

Dhingra, O. D. and Sinclair. J. B. 1993. Basic Plant Pathology Methods, CBS Pub, New Delhi.

Durgude, A. G. 1999. Morphology, characterization, classification and mapping of salt affected soils of Central Campus, Research Farms, Mahatma Phule Krishi Vidyapeeth, Rahuri. Ph.D. Thesis submitted to MPKV, Rahuri (M.S.) India.

Fraster, P. M., Haynes, R. J. and Williams. P. H. 1994. Effect of pasture improvement and intensive cultivation on microbial biomass enzyme activities and composition and size of earthworm population. Biol. Fert. Soil. (17): 185-190.

Hoffman, W. M. and Shapiro, H. 1954. Some observation on the Versenate Method for calcium and magnesium in agril. Liming material. J. Assoc. off. Agric. Chem., 37: 966-971.

Ibanez Asensio S, Marqués Mateu A, Moreno Ramón H, and Balasch S. 2013. Statistical relationships between soil colour and soil attributes in semiarid areas. Biosyst. Eng. (116): 120–129.

Jackson, M. L. 1973. Soil Chemical Analysis, Prentice Hall of India. Pvt. Ltd. New Delhi. pp. 498.

Jat, J. R. and Yadav, B. L. 2006. Different forms of sulphur and their relationship with properties of Entisols of Jaipur District (Rajasthan) Under Mustard cultivation. J. Indian Soc. Soil Sci. 54(2): 208-212.

Kumar, R., Srivastav, S., Srivastav, M. and Sinha, A. 2010. Effect of organic amendments on soil microflora. Asian J. Plant Pathology. 4(2): 73-81.

Kumar, P., Kumar, A., Dhyani, B. P., Kumar, P., Shahi, U. P., Singh, S. P., Kumar, R., Kumar, Y., Kumar, A. and Raizada, S. 2014. Soil fertility status in vertisoil of Kabeerdham district of Chattisgargh, India. Afr. J. Agric. Res., 8(14): 1209-1217.

Krishnakumaran, S., Saravanan, A., Natarajan, S. K., Veerabadran, V. and Mali, S. 2005. Microbial population and enzymatic activity as influenced by organic farming. J. Agril. Biol. Sci. 1(1): 85-88.

Lakum, Y. C., Patel, S. H. and Mehta, P. V. 2011. Reducing fertilizer requirement with the use of biofertilizer in summer pearl millet. Asian Soil. Sci. 3(1): 63-70.

Lindsay, W. L. and Norvell, W. A. 1978. Development of DTPA soil test of Zn, Fe, Mn and Cu. Soil Sci. Soc. America. J. (42): 421-428.

Meenakshi, Tur. N. S., Nayyarl, V. K., Sharma, P. K. and Sood, A. K., 2005. Spatial distribution of micronutrients in soils of Patiala district - A GIS approach. J. Indian Soc. Soil Sci. 53(3): 324-329.

Nakhro, N. and Dkhar, M. S. 2010. Impact of organic and inorganic fertilizer on microbial populations and biomass carbon in paddy field soil. J. Agron. 9 (3): 102-110.

Nelson, D. W. and Sommer, L. E. 1982. Total carbon and organic matter. Methods of soil analysis part-II. Page, A.L. (Ed.). Agron. Mono. No. 9 American. Soc. Agron. Madison, Wisconsin. pp. 203-211.

Okur, N., Altindisli, A. and Cengel, M. 2009. Microbial biomass and enzyme activity in vineyard soils under organic and conventional farming systems. Turk J. Agric. (33):413-423.

Parham, J. A., Deng, S. P., Da, H. N. and Raun, W. R. 2003. Long term cattle manure application in soil: Effect on soil microbial population and community strength. Biol. fert. Soil, 38:209-215.

Parthsarthi, K., Balamurugan, M. and Ranganathan, L. 2008. Influence of vermicompost on the physiochemical properties along with yield of Bajra crop. Iranian J. of Environ. Health, Sci. and Engin. 5(1): 51-58.

Patil, P. V., Chalwade, P. B., Solanke, A. S and Kulkarni, V. K. 2003. Effect of fly ash and FYM on physic-chemical properties of vertisols. J. of Soils and Crops 13(1): 59-64.

Patil, S. S., Patil, V. C. and Al-Gaadi, K. A. 2011. Spatial variability in fertility status of surface soils of Karlawad village in Navalgund taluka of Dharwad district of Karnataka, India. World Appl. Sci. J. 14(7): 1020-1024.

Philipps, L. 2003. Soil management on organic farms, Soil Association, Bristol. pp. 204.

Rangaraj, T., Somasundaram, E., Mohamed, A. M., Thirumurugan, V., Ramesh, S., Ravi, S. 2007. Effect of Agro-industrial wastes on soil properties and yield of irrigated finger millet (Eleusinecoracana L. Gaertn) in coastal soil. Res. J. Agric. Biol. Sci. 3(3): 153-156.

Singh, D. P and Rathore, M. S. 2013. Available nutrients status and their relationship with soil properties of Aravalli mountain ranges and Malwa Plateau of Pratapgarh, Rajasthan, India. African. J. Agri. Res. 8(41):5096-5103.

Subbarao, A. K., Sammi Reddy and Ramesh, P. 2007. Protecting soil health under conventional agriculture and organic farming. Green Farming 1(1): 1-9.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. (25): 259-260.

Subbiah. G. V. and Manickam, T. S. 1992. Genesis and morphology of Vertisols developed on different parent materials. J. Indian Soc. Soil Sci. 40: 150-155.

Soil Survey Staff. 1975. Soil Taxonomy- A basic system of soil classification for making and interpreting soil survey USDA, Washington D.C.

Venkatesh, M. S., Majumdar, B., Kailash Kumar and Patiram 2003. Status of micronutrient cations under various land use systems of Meghalaya. J. Indian Soc. Soil Sci. 51(1): 60-64.

Waikar, S. L., Malewar, G. U. and More, S. D. 2004. Elemental composition of humic and fulvic acid in soils of Marathwada region of Maharashtra. J. Maharashtra Agric. Univ. 29(2): 127-129.

Watanabe, F. S. and Olsen, S. R. 1965. Test of Ascorbic acid Methods for phosphorus in water and sodium bicarbonate extract of soil. Proc. Soil Sci. Am. (21): 677-678.

William, C. H. and Steinberg, A. 1959. Soil sulphur fraction as chemical indices of available sulphur in some Australian soil. Aus. J. Agric. Res. (10): 340-352.