A Comparative Analysis of Soil Properties Under Organic and Inorganic *Triticum aestivum* (Wheat) Farm Soil

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Wheat (*Triticum aestivum*) is one of the important staple crop of India. Increased awareness in people about harmful effects of inorganic fertilizers on soil health turned some progressive farmers to use organic fertilizers. Present study is an attempt to scientifically analyze the effects of organic and inorganic fertilizers application on various physico-chemical, microbial and enzymatic properties of soil. Soil samples were collected from farms growing wheat crop under organic and inorganic fertilizers application. To replicate the results two farms from each category of organic and inorganic fertilizers application were selected in Cchodavadi village of Bhesan Taluka, Junagadh District, Gujarat, India. Soil samples were collected at two growth stages of crop i.e. from standing crop (pre-harvesting stage) and at post-harvest stage and analyzed for various physico-chemical, microbial and enzymatic properties following standard procedures. Results show that fungal diversity and population of phosphate solubilizers, yeast, rhizobium, azotobacter and actinomycetes were higher in organic soils than that of inorganic farm soil and further, their counts were found higher at pre-harvesting stage than post-harvesting. Similar trend was recorded for content of organic carbon and activities of phosphatase (acid and alkaline) and urease. On the other hand content of available nitrogen, phosphorus and potassium were found higher in inorganic soil compared to organic soil and here also their content were higher at pre-harvest stage than post-harvest. It can be concluded that application of organic fertilizers to soil improves its physico-chemical, microbial and enzymatic properties.

Keywords: Organic and inorganic farming, soil health, soil fertility.

Crop productivity depends on soil health whose indicators are amount of essential nutrients, soil reaction, activities of enzymes and microbial population in soil. A number of factors affect these indicators and the most closely related factor is fertilizers applied to soil. Broadly, fertilizers are of two types- organic and inorganic, based on their origin. Organic fertilizers are produced by animal wastes whereas chemical or inorganic fertilizers are produced in factories using chemicals. Organic fertilizers contains all the essential plant nutrients whereas inorganic fertilizes contains only one or two major nutrients but in highly concentrated form. Both the fertilizers have their inherent advantages and disadvantages. Organic fertilizers were used initially but gradually with time they were replaced by inorganic fertilizers but growing concern of people about harmful effects of inorganic fertilizers and pesticides farmer takes U-turn and began to use organic fertilizers again. This awareness is higher in peoples from developed countries thatswhy consumers from United States purchased more organic food[1]. Reliance on organic agriculture from food security point of view also increased[2,3].

In present study wheat farm soils from organic and inorganic fertilizers application history

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were analyzed for various physico-chemical, microbial and enzymatic properties to find out the truth behind the role of organic and inorganic fertilizers application on soil health. This work is done by first author under guidance of co-authors for her M.Sc. Dissertation.

MATERIALS AND METHODS

Study site and sample collection

Surface soil samples under *Triticum aestivum* were collected from two organic and two inorganic farms of Cchodavadi village of Bhesan Taluka, Junagadh Distict, Gujrat, India by standard method. Sample were collected two times, before harvesting (26th December, 2011) and after harvesting (15th February, 2012) of *Triticum aestivum* (Wheat). Soil samples were collected aseptically in ultraviolet treated sterile plastic bag.

Analysis of soil samples

Collected samples were analysed immediately in laboratory for microbial and enzymatic parameters and stored at 3^0C for chemical analysis. Counts of species of rhizobium, azotobactor, actinomycetes, yeast, and phosphate solubilizers and fungal diversity were studied by standard serial dilution pour plate method[4]. Phosphatase and urease activities were checked by spectrophotometry and titrametric methods[5,6]. Standard procedures followed for soil physico-chemical analysis are- soil pH and electrical conductivity[7], organic carbon[8], available nitrogen[9], available phosphorus[10], and available potassium[11]. Average results of two replicates are presented here.

RESULTS AND DISCUSSION

Microbial Analysis

The population of phosphate solubilizers, yeast, rhizobium, azotobacter and actinomycetes were higher in organic soil than that of inorganic soil (Table-1) and this increase ranged between 35.48% (population of yeast) and 235.71% (population of azotobacter). Further, the microbial count was higher at pre-harvesting stage than that of post-harvesting and ranged between 29.34% (rhizobium) and 123.81% (azotobacter) high.

Observation over five years showed that organic nutrients source have a stimulating influence on the soil microbial communities as seen by the increase in microbial population. Total bacterial, fungal and actinomycetes population were found to increase under organic farming[12].

Increase the amount of organic matter, improves water and air relationships in the soil, thus intensifying count and enzymatic activity of soil microorganisms[13,14].

Increased availability of substrates (carbon and nitrogen) required for microbial population build up could be the probable reason for this increase[15].

Soil organic carbon had a positive and significant relationship with actinomycetes count. The data revealed that, with improvement in organic carbon status of the soil, the microbial population increased[16,17].

Data presented in Table-2 clearly reflects that organic soil have more fungal species compared to inorganic soil but their diversity decreased at post-harvesting stage than that of pre-harvesting stage.

The fungal population showed positive correlation with organic carbon in all the treatment at the surface soil depth showing that the addition of the fertilizers increase the organic carbon content of the soil and thereby increase the fungal population[18]. Higher microbial diversity in organically managed soil was reported earliar[19].

Other researchers have shown that incorporation of organic amendments increase the soil microbial activity[20], microbial diversity[21] and density of bacterial species[22]. Another possible reason is manual promoted biological and microbial activities, which accelerated the breakdown of organic substance in the added manure.

Effect of fertilizers and pesticides can be either (immediate or short-term impacts) due to harm to the organisms that come in contact with the chemical or indirect due to changes caused by the chemical to the environmental and/or food source of the organisms being studied[23].

A number of studies have shown that organic farming leads to higher soil quality and soil biological activity than conventional farming[24,25,26].

Chemical Analysis

All the three major nutrients for crop i.e. nitrogen, phosphorus and potassium were found 105.01, 53.89 and 50.00% higher in inorganic soil compared to organic soil but organic carbon content follow the reverse trend and remains 68.06% higher in organic soil than inorganic soil. Among pre- and post-harvesting stages nutrients contents remain higher in pre-harvesting stage.

Increased content of available major nutrients in inorganic fertilizers receiving soil is reported earlier[27-29]. Humus portion of organic fertilizers is responsible for increased organic carbon content in soils. Immobilization and mineralization of nutrients are two important processes that take place simultaneously in soil with the addition of organic manures. A slight but consistent increase in organic carbon under tropical condition had been reported earliar[30]. The increase in soil pH was due to release of NH_3/NH_4 ions. Increase in the value of electrical conductivity due to organic amendments is reported previously by a number of workers[31-33] and it occurs because the decomposition of organic materials released acids or acid forming compounds that reacted with the sparingly soluble salts already present in the soil and either converted them into soluble salts or at least increased their solubility.

Enzymatic activity

Activities of acid phoaphatase, alkaline phosphatase and urease remains 5.85, 44.44 and 22.23% higher at pre-harvesting stage and 13.64, 60.0 and 23.96% higher at post-harvesting stage in organic soil compared to inorganic soil. Pre-harvesting stage soil reflects 5.0, 1.56 and 10.55% higher content in organic soil and 12.73, 12.5 and 12.12% higher content in inorganic soil of acid phoaphatase, alkaline phosphatase and urease. We know that enzyme activity depends on microbial number and their activities. Stimulated microbial activity is reported due to addition of organic residues and enzymes produced thereby showed higher activity than direct addition of enzymes from organic sources[34]. Higher number of microorganisms in organic soil at pre-harvesting stage results in higher enzymatic activity compared to inorganic soil and post-harvest stage. Inhibition of enzyme synthesis by microorganisms in

Table 1. Microbial population in soil (×10^3 cfu/g of dry soil)

Microorganisms	Organic soil		Inorganic soil	
	Pre-harvesting	Post-harvesting	Pre-harvesting	Post-harvesting
Phosphate solubilizers	11.9 (158.69)* (41.67)**	8.4 (147.06)*	4.6	3.4
Yeast	8.5 (80.85)* (102.38)**	4.2 (35.48)*	4.7	3.1
Rhizobium	31.3 (81.98)* (29.34)**	24.2 (112.28)*	17.2	11.4
Azotobacter	23.5 (235.71)* (123.81)**	10.5 (66.67)*	7.0	6.3
Actinomycets	6.1 (96.77)* (38.64)**	4.4 (91.30)*	3.1	2.3

*Comparison of pre-harvest value of organic soil with pre-harvest value of inorganic soil and post-harvest value of organic soil with post-harvest value of inorganic soil
**Compared to post-harvest value of organic soil

Table 2. Fungal diversity in soil

Soil	Pre Harvesting	Post Harvesting
Organic soil	*Penicillium* Neurospora Aspergillus Alterneria Curvularia Mucor	*Penicillium* Aspergillus Neurospora
Inorganic soil	*Penicillium* Aspergillus Neurospora	*Penicillium* Aspergillus

Table 3. Physico-chemical properties of soil

Physico-chemical characteristics	Organic soil Pre-harvesting	Organic soil Post-harvesting	Inorganic soil Pre-harvesting	Inorganic soil Post-harvesting
Available nitrogen(kg/ha)	275.50 (70.22)**	161.85	564.79 (105.01)* (97.76)**	285.6
Available potassium (kg/ha)	228.4 (77.88)**	128.4	342.6 (50.00)* (59.05)**	215.4
Available phosphorous (kg/ha)	193 (50.78)**	128	297 (53.89)* (15.12)**	258
Organic carbon(%)	3.21 (68.06)* (31.02)**	2.45	1.91 (41.48)**	1.35
pH	7.79	9.5	7.67	9.1
Electrical conductivity (mS/m)	28	22	28	23

**Comparison of pre-harvest value of organic soil with pre-harvest value of inorganic soil and post-harvest value of organic soil with post-harvest value of inorganic soil
**Compared to post-harvest value of same soil

Table 4. Enzymatic activity in soil

Enzymes	Organic soil Pre harvesting	Organic soil Post harvesting	Inorganic soil Pre harvesting	Inorganic soil Post harvesting
Acid phosphatase (µg of p-nitrophenol/g/hr)	262.5 (5.85)*	250 (13.64)*	248	220
Alkaline phosphatase (µg of p-nitrophenol /g/hr)	325 (44.44)*	320 (60)*	225	200
Urease (% NH_4 released)	34.26 (22)*	30.99 (23.96)*	28.03	25.00

*Comparison of pre-harvest value of organic soil with pre-harvest value of inorganic soil and post-harvest value of organic soil with post-harvest value of inorganic soil

inorganic fertilizers amended soil due to presence of inorganic ions may also be the reason of lower enzyme activities in these soils[28].

Decreased microbial count and studied physico-chemical and enzymatic properties in post-harvesting stage compared to pre-harvesting in both the soils may be due to lowered nutrients content in soil after crop uptake. Nutrients content affects microbial number and activities hence they also goes down in post-harvesting stage. Changes in chemical properties of soil by long term application of mineral fertilizers are reported earliar[35]. The continuous use of fertilizers under intensive cropping might alter the status of microorganisms such as bacteria, fungi and actinomycetes in the soil[36]. Productivity and sustainability of organic agriculture over conventional was proved by a number of workers[37-38].

CONCLUSION

On the basis of experimental results, it can be concluded organic farm soils are more healthier than that of inorganic farm soil in terms of higher microbial numbers and increased nutrients content and enzymatic activities.

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REFERENCES

1. Dimitri, C., Greene, C. *Recent growth patterns in the US organic food market*. Washington, DC: USDA Economic Research Service. 2002
2. Badgley, D., Moghtader, J., Quintero, E. Organic agriculture and the global food supply. *Renew Agar Food System*, 2006; **22**: 86-108.
3. Zanoli, R., Gambelli, D., Vitulano, S. Conceptual frame work on the assessment of the impact of organic agriculture on the economies of developing countries. Rome, Italy: *Food and Agriculture Organisation*. 2007
4. Subba Rao, N. *Soil Microbiology 4th Edition of soil Microorganisms for Plant Growth*. Oxford and IBH Publishing CO Pvt Ltd, New Delhi, 2001: 390-391.
5. Tabatabai, M. A., Bremner, J. M. *Use of p-nitrophenol phosphatase for assay of soil phosphatase activity*. Low state university, Ames, Lowa, USA, 1969.
6. Tabatabai, M. A., Bremner, J. M. *Assay of urease activity in soil*, Department of Agronomy, Lowa. State university, Ames, Lowa, U.S.A. 1972
7. Richard, L. A. *Diagnosis and improvement of saline and alkaline soil*. USDA,Handbook No.60. 1954
8. Walkley, A., Black, I. A. An examination of the Degtareff method for determine soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 1934; 37: 29-38.
9. Subbiah, B. V., Asija, G.L. A rapid procedure for the estimation of available nitrogen in soil. *Current science*, 1956; **25**(7): 159-260.
10. Olsen, S. R., Cole, C. V., Watanable, F.S., Dean, L.A. *Estimation of available phosphorus in soil by extraction with sodium bicarbonate*, Cir. U.S. Department, Agriculture, 1954; 939.
11. Hanway, J. J., Heidel, H. Soil analysis method as used in lowa state college soil testing laboratory. *Lowa state collage of Agriculture*, 1952; **57**:1-31.
12. Surekha, K., Jhansilakshmi, V., Somasekhar, N., Latha, P. C., Kumar, R. M., Shobha Rani, N., Rao, K. V., Viraktamath, B. C. Directorate of Rice Research, Hyderabad- 500 030 Andhra Pradesh. *Journal of Rice Research*, 2009; **3**:1.
13. Mandal, A., Patre, A.K., Singh, D., Swarup, A., Masto, R.E. Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages. *Bioresource Technology*, 2007; **98**(8):3585-3592.
14. Zhong, W., Gu, T., Wang, W., Zhang, B., Lin, X., Huang, Q., Shen, W. The effect of mineral fertilizer and organic manure on soil microbial community and diversity. *Plant Soil*, 2010; **326**(1-2): 511-522.
15. Bunemann, E. K., Schwenke, G. D., Van Zwieten, L. Impact of agricultural inputs on soil organisms- a review. *Australian Journal of Soil Research*, 2006; **44**: 379-406.
16. Singh, P., Nand Ram, Chandra, R. Impact of lona-term use of fertilizers and manure on the microbial population in a rice-wheat-cowpea system. Department of Soil Science, G. B. Pant University of Agriculture and Technology, Pantnagar 263145, India. *International Rice Research Notes*, 2009; 0117-4185.
17. Shuglya, Z.M., Karyagina, L.A. Effects of long-term application of FYM and mineral fertilizers on soil properties and crop yield in rotation. *Agrokhimiya*, 1982; **5**: 51-54.
18. Nakhro, N., Dkhar, M.S. Impact of Organic and Inorganic Fertilizers on Microbial Population and Biomass Carbon in padyy Field Soil. *Journal of Agronomy*, 2010; **9**: 102-110.
19. Rao, D. L. *Soil microbial diversity in chemical and organic farming*. Paper presented at “National seminar on organic farming-Current Scenario and future thrust” during April 27-27, 2005 held at ANGER Agriculture University, Hyderabad, India, 2005: 61-64.
20. Elliott, L.F., Lynch, J.M. *Biodiversity and soil resilience*. In: Greenland, D.J., Szabolc, I. (Eds.), Soil Resilience and Sustainable Land use. CAB International, Wallingford, UK, 1994: 353–364.
21. Girvan, M.S., Bullimore, J., Ball, A.S., Pretty, J.N., Osborn, A.M. Responses of active bacterial and fungal communities in soils under winter wheat to different fertilizer and pesticide regimens. *Applied and Environmental Microbiology*, 2004; **70**: 2692–2701.
22. Van Bruggen, A.H.C., Semenov, A.M. In search of biological indicators for plant health and disease suppression. *Applied Soil Ecology*, 2000; **15**: 13–24.

23. Wildermuth, G. B., Thompson, J. P., Robertson, L. N. Biological change: disease, insects and beneficial organisms. In "Sustainable crop production in the sub- tropics. *An Australian perspective*." Brisbane, Department of Primary Industries, Queensland. Ed. A. L. Clarke and P. B. Wylie. 1997: 112-130.
24. Carpenter-Boggs, L., Keeney, A. C., Reganold, J. P. Organic and Biodynamic Management: Effects on soil Biology. *Soil Science Society American Journal*, 2000; **64**:1651-1659.
25. Fliessbach, A., Mader, P., Dubois, D., Gunst, L.G. Results from a 21 year old field trial. Organic farming enhances soil fertility and biodiversity. *FiBL- Dossier*, No 2000; 1:15.
26. Shannon, D., Sen, A. M., Johnson, D. B. A Comparative study of the microbiology of soils managed under organic and conventional regimes. *Soil Use Management*, 2002; **18**:274-283.
27. Suri, V. K., Puri, U.K. Effect of phosphorus application with and without farmyard manure on rain fed maize (*Zea mays*)-wheat (*Triticum aestivum*) maize sequence. *Indian Journal Agriculture Science*, 1997; **67**:13-15.
28. Okur, N., Altindisl A., Cengel, M., Gocmez, S., Kayikcioglu, H. Microbial biomass and enzyme activity in vineyard soil under organic and conventional farming systems. Department of Soil Science, Faculty of Agriculture, Ege University, Bornova, Izmir-Turkey. *Turk Journal of Agriculture and Forestry*, 2008; **33**: 413-423.
29. Dobermann, A., Frairhurst, T. H. Rice*: Nutrient Disorders and Nutrient Management*. 1st Edn., PPIC and IRRI, Philippines, Singapore, ISBN: 981-04-2742-5: 2000: 191.
30. Sundara Rao, W. V. B., Krishnan, A. The effect of manuring and rotation on the soil fertilizer status and composition of barley crop in the permanent manurial series (A) at Pusa Bihar. *The Indian Society of Agronomy*, 1963; **8**(1): 345-357.
31. Sarwar, G., Hussain, N., Mujeeb, F., Schmeisky, H., Hassan, G. Biocompost application for the improvement of soil characteristics and dry matter yield of *Lolium perenne* (Grass). *Asian Journal of Plant Science*, 2003; **2**(2): 237-241.
32. Niklasch, H., Joergensen, R.G. Decomposition of peat, biogenic municipal waste compost, and shrub/grass compost added in different rates to a silt loam. *Journal of Plant Nutrition Soil Science*, 2001; **164**: 365-369.
33. Selvakumari, G., Baskar, M., Jayanthi, D., Mathan, K. K. Effect of integration of Flyash with fertilizers and organic manures on nutrient availability, yield and nutrient uptake of rice in alfisols. *Journal of Indian Society Soil Science*, 2000; **48**(2): 268-278.
34. Martens, D. A., Johanson, J.B., Frankenberger, W.T. J. Production and persistence of soil enzymes with respected additions of organic residues. *Soil Science*, 1992; **153**: 53-61.
35. Sharma, S.P., Subehia, S.K. Effect of 25 years fertilizer use on maize-wheat yield and soil health in an acidic soil. *Experimental Agriculture*, 2003; **39**: 55-64.
36. Campbell, C.A., Biederrbeck, U.O., Ukrainetz, H., Curtin, D., Bouyman, T. Effects of long-term use of urea and anhydrous ammonia on crop yield and soil characteristics. In: *Proceedings of the 15th World Congress of Soil Science*, Mexico, 1994; **5**(A): 704-713.
37. Reganold, J.P., Palmer, A.S., Lockhart, J.C., Macgregor, A.N. Soil quality and financial performance of biodynamic and conventional farms in New Zealand. *Science*, 1993; **260**(5106): 344–349.
38. Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P., Niggli, U. Soil fertility and biodiversity in organic farming. *Science*, 2002; **296**(5573): 1694–1697.