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Influence of Organic Manures on Soil Physico-chemical Properties under *Morus* based Agrisilviculture System

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ABSTRACT

Background: Health of soil is important being an integral part of any production system. As agroforestry aims to maintain the sustainability in the system, therefore, soil status under any agroforestry system plays key role. This study was conducted at Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan, HP (India) under *Morus* based agroforestry system.

Methods: The present investigation was carried out during 2016 from month of July to October for quantifying the effect of application of organic manures on soil physico-chemical properties under *Morus* based agroforestry system. Five soil samples from each experimental plot were collected separately and a single representative composite sample was drawn for each plot replicated three times. The analysis of soil was carried out with standard adopted procedures.

Result: Findings of the study revealed that different organic manure combinations were having significant influence on various soil physico-chemical properties. Maximum improvement in terms of soil physico-chemical parameters was found for the application of 100% poultry manure. Further, soil properties were found to be better under the influence of tree canopy as compared to open condition suggesting key role of trees in improving soil properties.

Key words: Agroforestry, *Morus,* Organic manure, Physico-chemical, Soil.

INTRODUCTION

Healthy soil is one of the most critical resources for the health and sustainability of ecosystems, including agro-ecosystems so that they can sustain food production as well as provide ecosystem services. The term sustainability denotes the characteristics of a process that can be maintained indefinitely and sustainable use of the ecosystem refers to making use of the system without impairing its capacity for renewal or regeneration (Katyayan, 2017). Soil management is sustainable if the services provided by soil are enhanced or maintained to present level without significantly impairing soil functions. Agroforestry is a collective name for land use systems and technologies where woody perennials (tree, shrubs, palms, bamboos, *etc.*) are deliberately used on the same land management units as agriculture crops and/or animals, in some form of spatial arrangement or temporal sequence and in agroforestry system there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982). The assortment of trees on the edges of agricultural field is a farmer-friendly and compatible practice. Some major fodder trees on which hill farmers depend upon during the lean period are *Grewia optiva, Celtis australis, Dendrocalamus hamiltonii, Bauhinia variegate, Morus alba, Quercus leucotrichophora, Q. semicarpifolia, Robinia pseudocacia. Morus alba* commonly known as mulberry, is a fast growing small to medium sized tree and is mostly grown for its multiple benefits such as fodder, fruit, fuel wood, rearing of silkworms *etc*. Growing concerns about the state of global soils resulted in the proclamation of the International Year of Soils (2015) by the UN General Assembly. Indian soils are facing problem of degradation due to unscientific management and intensive land use practices (Uthappa *et al*., 2015). Serious depletion of soil fertility due to widening gap between nutrient removal and supply (Ramesh, 2008) has affected crop productivity. The use of organic manures and chemical fertilizers result in both positive as well as negative impact on plant growth and soil. On one hand, chemical fertilizers are inexpensive, have high nutrient content and readily taken by plants while on other hand, their indiscriminate utilization results in nutrient loss, soil and water resource contamination, soil acidification, soil basification and harmful effects on useful biotic communities. The organic manures with shortcomings like low nutrient content, slow decomposition and varying nutrient composition have multiple benefits including balanced nutrient supply, increased nutrient availability, enhanced microbial activity, decomposition of toxic

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elements, improved soil structure and soil water availability (Han *et al.,* 2016; Joshi *et al.,* 2016). The excessive utilization of chemical fertilizers and the negligence towards the use of organic sources of nutrients have not only caused the exhaustion of soil of its reserved nutrients but also resulted in soil health problems not conducive in increasing agricultural production. The use of inorganic fertilizers alone has not been helpful because it promotes and increases degradation of plant nutrients (Sharma and Mittra, 1991). The degradation accordingly is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields. So, use of organic manure is more suitable and economical. Manures are the organic material derive from animal, human and plant residues which contain plant nutrients in complex organic form. The organic manures play an important role in soil by contributing carbonaceous matter, which when decomposes, provides mineral nutrients to the plants acting as a base exchange material and helping in improving the physical, chemical and biological properties of soil. So, the present investigation was carried out to study the effect of application of various organic manure combinations on soil physico-chemical properties under *Morus* based agri-silviculture system.

MATERIALS AND METHODS

The present investigation was conducted at the experimental farm of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh (India) during *kharif* season of the year 2016 from month of July to October. The experimental site is located in the mid-hill zone of Himachal Pradesh at 30°N latitude and 76° 11′ E longitude, with an elevation of 1200 m above mean sea level having slope of 7-8 per cent. The area experiences a wide range of temperature within a minimum of 1°C in winter to a maximum of 37°C in summer. The annual rainfall varies from 1000-1400 mm, about 75 per cent of which is received during monsoon period (mid June-mid September). The agroforestry system for present study consisted of two functional components *viz*; mulberry (*Morus alba* L.) tree as woody perennial and okra [*Abelmoschus esculentus* (L.) Moench] as intercrop. For quantifying the effect of organic manures on soil physico-chemical properties there were total of ten treatment combinations *viz.* T_1 (recommended dose of fertilizer (RDF) + FYM), T_2 (50% vermicompost (25.33 q ha^{-1}) + 50% RDF + FYM), T_3 (75% vermicompost (38 q ha^{-1}) + 25% RDF + FYM), T_4 (100% vermicompost (50.66 q ha^{-1})+ FYM), T_5 (50% goat manure (12.66 q ha^{-1}) + 50% RDF + FYM), T_6 (75% goat manure (19 q ha^{-1})+ 25% RDF + FYM), T_7 (100% Goat manure (25.33 q ha^{-1}) + FYM), T_8 (50% poultry manure (12.54 q ha^{-1})+ 50% RDF + FYM), T_9 (75% poultry manure (18.81 q ha^{-1})+ 25% RDF + FYM) and T_{10} (100% poultry manure (25.08 q ha^{-1}) + FYM). In the above mentioned treatment combinations, recommended dose of fertilizers (RDF) applied was 76 kg ha^{-1} of nitrogen, 57 kg ha^{-1} of phosphorus and 54 kg ha^{-1} of potassium whereas FYM was applied at the rate of 10 tonnes ha^{-1} as basal dose and the doses for different organic manures were calculated on nitrogen equivalent basis. 2 m × 2.4 m size beds were prepared along both sides (North and South direction) of the tree rows with plant spacing of 60 cm × 20 cm, thereby, accomodating 36 plants in each bed. For assessing the influence of tree species on the soil physico-chemical properties, composite soil samples were collected from the area under influence of tree canopy as well as area outside tree canopy subjected to similar treatments.

Collection and preparation of soil sample

Three soil samples collected as composite sample from 0-15 cm depth of the study area were analyzed to study the soil status before sowing of intercrop. For studying the soil status after crop harvesting five soil samples from each plot from 0-15cm depth were collected separately and single representative composite sample was drawn from each plot at crop harvest (October, 2016). Thus, soil samples were collected for plots applied with different treatments each replicated three times. Collected samples were placed in cloth bag, tagged and transported to laboratory, air dried under shade and grinded using mortar and pestle, sieved through 2 mm plastic sieve. Method employed and instrument used for analysis of soil samples are depicted in Table 1.

The entire data of present study were statistically analyzed by using analysis of variance (ANOVA) for randomized block design in accordance with the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results of the present study revealed that application of different treatment combinations of organic manures influenced the various chemical properties *viz*. available nitrogen, available P, available K, organic carbon, pH, electrical conductivity and moisture content of the soil under *Morus* based agroforestry system significantly as seen from the Table 2. The physical properties *viz*. bulk density and particle density were found same under all the treatment combinations suggesting absence of any significant effect of organic manures on these parameters. Tree proximity also influenced the soil physico-chemical properties suggesting the beneficial effects of trees on soil that may be in terms of organic matter addition, binding soil into stable aggregates, absorption from deeper layers *etc*.

Available nitrogen (kg ha^{-1})

As depicted from the data presented in (Table 2) different organic manure combinations had a significant influence on soil available nitrogen content where T_{10} was found to be the best treatment giving the highest (339.89 kg ha^{-1}) available nitrogen content in soil. This was at par with treatments T_3 (336.08 kg ha^{-1}), T_4 (336.99 kg ha^{-1}), T_6 (336.88 kg ha^{-1}) and T_8 (335.07 kg ha^{-1}) and the least under T_1 (324.09 kg ha^{-1}). Sole application of organic manures on nitrogen equivalent basis resulted in significant enhancement of available N compared to recommended dose of fertilizer.

Table 1: Soil physico-chemical parameters studied along with methods employed.

Parameters	Method employed	Instrument/ apparatus used
pH	1:2 soil water suspension (Jackson, 1973)	pH meter
Electrical conductivity (EC)	1:2 soil water suspension (Jackson, 1973)	Electrical conductivity meter
Organic carbon	Rapid titration method (Walkley and Black, 1934)	-
Available nitrogen	Alkaline potassium permanganate method (Subbiah and Asija, 1956)	Kjeldhal distillation unit
Available phosphorus	Olsen *et al.,* (1954)	Spectronic 20-D+
Available potassium	Neutral 1 N ammonium acetate solution method (Merwin and Peach, 1951)	Flame photometer
Moisture content	Gravimetric method	-
Bulk density	Core sampler method	Core sampler
Particle density	Pynometric method	Pycnometer

Table 2: Effect of different organic manure combinations on soil physico-chemical properties.

Treatments \ Parameters	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})	pH	EC (dSm^{-1})	Organic carbon (%)	Moisture content (%)	Bulk density (g cm^{-3})	Particle density (g cm^{-3})
T_1	324.09^{b}	50.23^{c}	251.82^{c}	6.25^{a}	0.20^{a}	1.46^{e}	8.68^{b}	1.25^{a}	2.64^{ab}
T_2	332.47^{ab}	58.59^{ab}	252.36^{c}	6.36^{a}	0.22^{a}	1.74^{d}	9.26^{ab}	1.26^{a}	2.64^{ab}
T_3	336.08^{a}	60.97^{ab}	255.52^{bc}	6.39^{a}	0.23^{a}	1.75^{cd}	9.22^{ab}	1.26^{a}	2.64^{ab}
T_4	336.99^{a}	63.55^{ab}	263.58^{ab}	6.44^{a}	0.22^{a}	1.80^{bc}	9.19^{ab}	1.26^{a}	2.65^{a}
T_5	334.12^{ab}	56.07^{bc}	255.70^{abc}	6.33^{a}	0.21^{a}	1.75^{cd}	9.04^{ab}	1.25^{a}	2.65^{a}
T_6	336.88^{a}	59.98^{ab}	262.62^{abc}	6.35^{a}	0.22^{a}	1.76^{bcd}	9.06^{ab}	1.26^{a}	2.65^{a}
T_7	333.69^{ab}	63.92^{ab}	265.01^{ab}	6.36^{a}	0.22^{a}	1.78^{bcd}	9.05^{ab}	1.25^{a}	2.64^{ab}
T_8	335.07^{a}	62.80^{ab}	256.23^{abc}	6.32^{a}	0.22^{a}	1.81^{ab}	9.01^{ab}	1.25^{a}	2.65^{a}
T_9	334.59^{ab}	62.70^{ab}	263.64^{ab}	6.31^{a}	0.23^{a}	1.86^{a}	9.47^{ab}	1.24^{a}	2.63^{ab}
T_{10}	339.89^{a}	66.62^{a}	266.38^{a}	6.31^{a}	0.23^{a}	1.86^{a}	9.82^{a}	1.24^{a}	2.58^{b}

Values in the same column followed by different letter(s) are different at $p \leq 0.05$ using DMRT.

Ewulo *et al*., 2008 also found that poultry manure increased soil organic matter, N and P. This increase was attributed to the improvement in soil organic manure, as well as macro and micro nutrients of the soil. Tabitha *et al.* (2017) also reported better results in terms of available macronutrients under the integrated application of inorganic fertilizers with poultry manure. The lesser availability of macronutrients under application of recommended NPK through inorganic fertilizers was attributed to leaching of nutrients.

Available phosphorus (kg ha^{-1})

Different organic manure combinations had a significant influence on soil available phosphorus content where T_{10} was found to be the best giving the highest (66.62 kg ha^{-1}) available phosphorus content in soil which was statistically at par with almost all the integrated treatment combinations except T_1 and T_5 and the least results were under T_1 (50.23 kg ha^{-1}). Several findings (Soremi *et al.,* 2017; Ewulo *et al*., 2008) also reported the increase in available P in soil treated with poultry manure attributed to mineralization of the organic P in poultry manure as well as the improved soil physical properties. However, enhanced P in soil treated with organic manures was attributed to the greater availability and supply of organic manure (Adekiya *et al.,* 2020).

Available potassium (kg ha^{-1})

The data presented in Table 2 revealed that different organic manure combinations had a significant influence on soil available potassium content where T_{10} was found to be the best treatment giving the highest available potassium (266.38 kg ha^{-1}) content in soil which was statistically at par with T_7 (265.01 kg ha^{-1}), T_9 (263.64 kg ha^{-1}), T_4 (263.58 kg ha^{-1}), T_6 (262.62 kg ha^{-1}), T_8 (256.23 kg ha^{-1}) and T_5 (255.70 kg ha^{-1}) in descending order and the least under T_1 (251.82 kg ha^{-1}). Ekpe *et al.,* 2017 also found the highest value of potassium under the farming practices involving application of organic manures. Also, enhanced potassium under application of poultry manure was reported by Adekiya *et al.,* 2020, which was attributed to the low C: N ratio, lignin and higher nutrient contents in poultry manure.

Soil organic carbon (%)

Perusal of data presented in Table 2 revealed that different organic manure combinations had a significant influence on soil organic carbon content where T_{10} was found to be

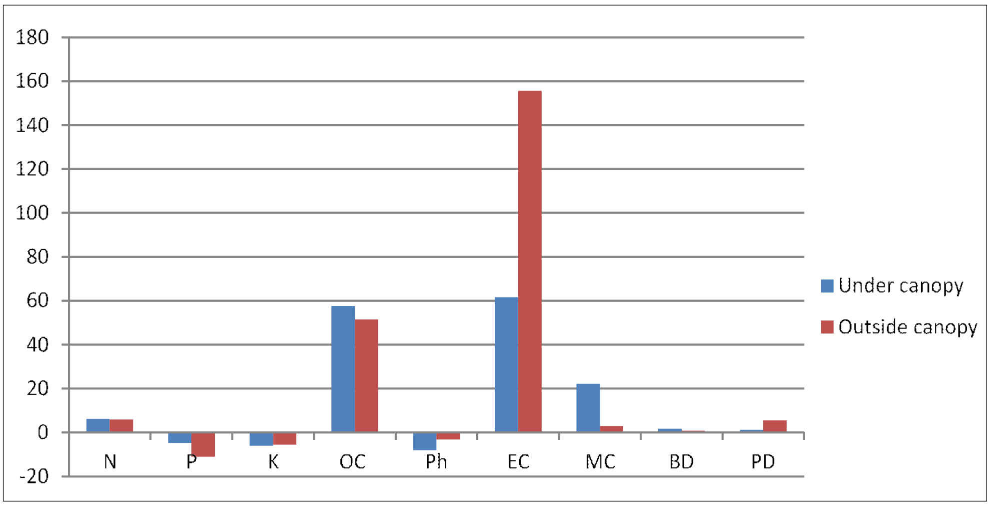

Fig 1: Per cent change in soil properties under and outside the tree canopy compared to initial status.

the best giving the highest (1.86%) organic carbon content in soil which was at par with treatment T_8 and T_9 and the least organic carbon was found under T_1 (1.46 %). Joshi *et al.,* 2016 also reported higher organic carbon under application of poultry manure and attributed the improved organic carbon to bulk posting of organic matter rich in nitrogen as well as enhanced activity of microorganisms. Increase in the amount of soil organic carbon in soils may be due to richness of organic manures in organic carbon and difference in the soil organic carbon may be due to differential utilization of the carbon during the microbial activity as found by Soremi *et al.,* 2017.

Soil pH

As revealed from the data presented in Table 2 different organic manure combinations had no significant influence on soil pH**,** however, T_4 had maximum soil pH (6.44) and minimum was observed under T_1 (6.25). As there is not much difference in the pH of the soils treated with different organic manure combinations, however, variations among pH under different treatments may be due to the pH of organic manure used in the treatment combinations as reported by Gopinath and Mina, 2011; Roy and Kashem, 2014. Further, Islam *et al.,* 2017 reported improvement in soil pH when treated with organic manures as compared with inorganic fertilizer.

Electrical conductivity (dS m^{-1})

The data revealed that different organic manure combinations had no influence on electrical conductivity of soil with T_{10} having maximum electrical conductivity (0.23 dS m^{-1}) and the minimum (0.20 dS m^{-1}) was observed under T_1. Islam *et al.* 2017; Roy and Kashem, 2014 reported improvement in soil EC when treated with organic manures as compared with inorganic fertilizer. Similarly, the findings of Rayne and Aula, 2020 suggest increase in electrical conductivity with increased application of organic manures which was attributed to increased organic matter supplying nutrients and ions that can be released in soil solution.

Soil moisture (%)

Data from Table 2 revealed that different organic manure combinations had a significant influence on soil moisture, where T_{10} had maximum soil moisture (9.82%) which was statistically at par with all treatment combinations except recommended dose of fertilizer and minimum soil moisture (8.68%) was observed under T_1. Adebola *et al.,* 2017 also found higher moisture content in soil treated with organic manure and poultry manure. Agbede *et al.,* 2017 also reported improved moisture content under application of poultry manure as compared to controlled condition as well as application of inorganic fertilizers and attributed this improvement to the increased organic matter from poultry manure which consequently resulted in improved soil structure, reduced bulk density and enhanced water infiltration and retention. Rayne and Aula, 2020 concluded that the organic matter application to the soil improves soil aggregation, water infiltration, water holding capacity thereby improving hydraulic properties of the soil.

Bulk density and Particle density

The present investigation revealed that different organic manure combinations had a non significant influence on soil bulk density, however T_2, T_3, T_4 and T_6 had maximum soil bulk density (1.26 g cm^{-3}) and minimum soil bulk density (1.24 g cm^{-3}) was observed in T_{10} and T_9. However, particle density under T_{10} seems to be significantly different from the rest of the treatment combinations. Various studies revealed that with increasing rate of manure application the bulk density of soil decreases which was attributed to the increase in the soil porosity. Also, treatment of soils with organic manures results in release of bacterial gums and polysaccharides that enhances soil aggregation and reduces bulk density (Gopinath and Mina, 2011; Udom *et al.,* 2019; Rayne and Aula, 2020; Suhaibani *et al.,* 2020).

Soil status under *Morus* based system and open condition after crop harvesting

The level of available soil nitrogen (N) increased after harvest by 5.76% at one meter from tree trunk and 5.55% in open condition while a reduction in available soil phosphorus and potassium were observed in all planting conditions. The percentage decrease observed was 5.03% and 12.41% for phosphorus (P) and 6.45% and 5.56% for potassium (K) at 1m and open conditions, respectively. There was an increase in level of organic carbon and electrical conductivity while a decrease in soil pH in all planting conditions. Moisture content of soil increased by about 20% at one meter from tree trunk and 2.89% in open condition compared to initial moisture condition at respective distances (Fig 1). Results reveal that soil properties were better under tree canopy as compared to that of open area. This suggests that if tree component is not able to enhance the soil fertility it will maintain fertility status by minimizing the losses from the system. Various studies reported beneficial influence of trees on soil physico-chemical properties that may be attributed to litter accumulation as leaves, buds, twigs, flowers etc., improved soil structure, nutrient pumping, efficient cycling, microclimate, throughfall *etc*. (Rhoades, 1997; Sharma *et al.,* 2017; Habumugisha *et al.,* 2019).

CONCLUSION

It may be inferred from the present investigation that organic manures have greater positive influence on soil physico-chemical properties compared to that of inorganic fertilizers. Among different combinations of organic manures in the study, use of 100 per cent poultry manure is most suitable for beneficial influence on the soil properties. However, other organic manures viz., 100 per cent vermin-compost, 100 per cent goat manure, were also at par with best organic manure treatment for most soil properties. The better performance of organic manures compared with inorganic fertilizers may be due to multiple benefits associated with organic manures such as nutrient composition, improved soil structure, better absorption, improved microbial processes, better soil hydrological properties, reduced nutrient losses etc. Further, soil properties under the integrated system were found to be better and improved as compared to the sole cropping suggesting considerable influence of the *Morus* tree on soil physico-chemical properties.

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REFERENCES

Adebola, A.E., Ewulo, B.S. and Arije, D.N. (2017). Effects of different animal manures on soil physical and microbial properties. Applied Tropical Agriculture. 22: 128-133.

Adekiya, A.O., Ejue, W.S., Olayanju, A., Dunsin, O., Aboyeji, C.M., Aremu, C., Adegbite, K. and Akinpelu, O. (2020). Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. Scientific Reports. 10: 16083.

Agbede, T.M., Adekiya, A.O. and Eifediyi, E.K. (2017). Impact of poultry manure and npk fertilizer on soil physical properties and growth and yield of carrot. Journal of Horticultural Research. 25: 81-88.

Ewulo, B.S., Ojeniyi, S.O. and Akanni, D.A. (2008). Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. African Journal of Agricultural Research. 3: 612-616.

Ekpe, I.I., Oti, N.N. and Asoluka, I.K. (2017). Effect of different tillage practices and fertilizer on soil physical and chemical properties in Umuokanne Ohaji-egbema Imo Southeast, Nigeria. Nigeria Agricultural Journal. 48: 224-234.

Gomez, K.A. and Gomez, A.A. (1983). Statistical Procedures for Agricultural Research. John Wiley and sons Inc., New York. pp. 657.

Gopinath, K.A. and Mina, B.L. (2011). Effect of organic manures on agronomic and economic performance of garden pea (*Pisum sativum*) and on soil properties. Indian Journal of Agricultural Sciences. 81(3): 236-239.

Habumugisha, V., Mourad, K.A. and Hashakimana, L. (2019). The effects of trees on soil chemistry. Current Environmental Engineering. 6(1): 35-44.

Han, S.H., An, J.Y., Hwang, J., Kim, S.B. and Park, B.B. (2016). The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. Forest Science and Technology. 12(3): 137-143.

Islam, M.A., Islam, S., Akter, A., Rehman, M.H. and Nandwani, D. (2017). Effect of organic and inorganic fertilizers on soil properties and the growth, yield and quality of tomato in Mymensingh, Bangladesh. Agriculture. 18: 1-7.

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

Joshi, D., Gediya, K.M., Gupta, S. and Birari, M.M. (2016). Effect of organic manures on soil and quality parameters of cowpea [*Vigna unguiculata* (L.) Walp] under middle Gujarat conditions. Agricultural Science Digest. 36(3): 216-219.

Katyayan, A. (2017). Fundamentals of agriculture. Kushal Publications and distributors. pp. 475.

Lundgren, B. and Raintree, J.B. (1982). Sustained Agroforestry. In: Agricultural Research for Development, Potentials and Challenges in Asia [B. Nestel (ed.)]. INSAR*,* The Hague. pp. 37-49.

Merwin, H.D. and Peach, P.M. (1951). Exchangeability of soil potassium in the sand, slit and clay fractions as influenced by the nature of complementary exchangeable cations. Soil Science Society. 15: 125-26.

Olsen, R., Cole, C.V., Wantable, F.S. and Dean, L.A. (1954). Estimation of available P in soil by extraction with sodium bicarbonate. US Deptt. Agricultural Circular. pp.19.

Ramesh, P. (2008). Organic Farming Research in M.P. Organic Farming in Rain-fed Agriculture: Central Institute from Dry Land Agriculture, Hyderabad. pp. 13-17.

Rayne, N. and Aula, L. (2020). Livestock manure and its impact on soil health: A review. Soil Systems. 4(64): 1-26.

Rhoades, C.C. (1997). Single tree influences on soil properties in agroforestry: lessons from natural forest and savanna ecosystem. Agroforestry Systems. 35: 71-94.

Roy, S. and Kashem, M.A. (2014). Effects of organic manures in changes of some soil properties at different incubation periods. Open Journal of Soil Science. 4: 81-86.

Sharma, A.R. and Mittra, B.N. (1991). Effect of different rates of application of organic and nitrogen fertilizers in a rice-based cropping system. Journal of Agricultural Science. 117: 313- 318.

Sharma, H., Thakur, C.L., Bhardwaj, D.R. and Prabhakar, M. (2017). Growth and yield performance of maize (*Zea mays*) and tomato (*Solanum lycopersicum*) under *Grewia optiva* Drummond based agroforestry system. Indian Journal of Ecology. 44(6): 771-776.

Soremi, A.O., Adetunji, M.T., Adejuylgbe, C.O., Bodunde, J.G. and Azeez, J.O. (2017). Effects of poultry manure on some soil chemical properties and nutrient bioavailability to soybean. International Journal of Agriculture and Ecology Research. 11: 1-10.

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

Suhaibani, N.V., Selim, M., Alderfasi, A. and Hendawy, S.E. (2020). Comparative performance of of integrated nutrient management between composted agricultural wastes, chemical fertilizers, and biofertilisers in improving soil quantitative and qualitative properties and crop yields under arid conditions. Agronomy. 10: 1-25.

Tabitha, K., Wilson, T. and Joseph, P.G.O. (2017). Effect of organic and inorganic fertilizer on the soil chemical properties of the rhizosphere in Kiambu county, Kenya. Asian Research Journal of Agriculture. 7: 1-13.

Udom, B.E., Wokocha, C.C. and Ike, O.J. (2019). Effect of organic manures on soil properties and performance of maize and aerial yam intercrop. International Journal of Agriculture and Earth Sciences. 5(1): 17-28.

Uthappa, A.R., Chavan, S.B., Handa, A.K. and Newaj, R. (2015). Trees for soil health and sustainable agriculture. Indian farming. 65: 02-05.

Walkley, A.J. and Black, I.A. (1934). Estimation of soil organic carbon by chromic acid titration method. Soil Science. 37: 28-29.