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Managing Organic Manures for Carbon Sequestration to Improve Soil Health and Sustained Vegetable Yield

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Abstract

Soil fertility and soil health are deteriorated owing to indiscriminate use of mineral sources with no organic inputs. However, large volumes of animal manure are available which can be used for nutrient cycling and soil health. A pot experiment was conducted designed in Complete Randomized Design with eight treatments including control and three rates 2.5, 5 and 7 tons $ha^{-1}$of poultry and goat manure, each and balanced rate of mineral fertilizers, respectively. It was revealed that both manures applied affected soil organic carbon, Nitrogen, Phosphorus and Potash NPK (75:60:30 kg ha^{-1}), plant height, fresh & dry weight of spinach yield ($P< 0.01$). The highest values for organic carbon nitrogen, phosphorus and potash contents were obtained when poultry manure was applied at 7 tons ha^{-1}. Manure of poultry at the rate of 7 tons ha^{-1} significantly influenced organic carbon 1.11%, N 0.055 %, P 6.89 mg kg^{-1}, K 64.06 mg kg^{-1}, plant height 37.42 cm, fresh & dry weight 43.31 g and 7.95 g, respectively. In comparison, control treatment resulted in minimum, organic carbon 0.23%, N 0.011 %, P 1.42 mg kg^{-1}, K 35.23 % and yielded 2.18 g plant dry weight. Comparison of the responses from manures revealed the trend was; Poultry manure > NPK > goat manure. This was largely attributed to differences in organic carbon, N, P, and C/N ratios of the amendments. It is concluded that goat and poultry manure could be applied for soil carbon sequestration sustained crop production and maintain soil fertility & soil health.

Keywords: Organic manures management, Carbon sequestration, Soil quality & health.

Introduction

Judicious use of agri-inputs like fertilizers ensures sustainable crop production. The non-judicious and indiscriminate use of chemical fertilizers leads to soil pollution, declining soil fertility and soil health. Besides, high cost of chemical fertilizers and market unavailability also deters growers to apply fertilizers in proper ratio. Reduced and non-judicious use of inorganic fertilizers has resulted in low soil fertility, poor soil health and marginalized crop yields. Soil fertility and carbon depletion is common phenomenon in arable fields of tropical and subtropical arid climate [1, 2]. In Sindh, abundant organic manures like cattle, goat, farm yard and poultry manure are locally available but are not properly exploited and utilized. The boost in poultry production and massive goat breeding has led to abundance of its waste which is not properly managed. Inappropriate disposing off and discarding of these materials cause wastage of organic carbon through CO_2 emission

which results in environmental implications [1, 2]. However, these resources could be used for restoration of soil fertility, sustained crop production & improve soil health [3, 4, 5]. Various researchers revealed that poultry manure can effectively increase soil fertility, affect soil parameters and increase yield of vegetable crops [3, 4, 6]. The other scientists have shown that goat manure is best source of fertilizer mineral nutrients for vegetable yields [4, 7].

Animal manure is effective in maintenance of organic carbon, and enhance physico-chemical and biological properties of soil and increase crop yield [8]. It was reported that organic manures could be applied to arable fields to increase vegetable production [9]. Wise utilization of livestock and poultry manure can reduce the grave issue of deteriorating soil fertility and soil health and improve crop productivity. This is largely due to lack of scientific basis for advising farmers on aspects such as appropriate rates and methods of application [5]. Furthermore, if management techniques made, then disposing off costs can be omitted and added economic value could be achieved for sound management of organic resources [10] by using as substitute to the expensive and hazardous chemical fertilizers [11].

Irrespective of enormous manure production potential, very little amount of the available goat and poultry manure is being utilized for crop production [5]. In organic sources manure of poultry is richest sources of nitrogen and organic carbon and other important macro and micro nutrients [12]. That is why there is dire need to utilize livestock and poultry manure for maintaining soil health, improve soil fertility and crop yield. Better utilization of goat manure and poultry manure therefore needs to be understood nutrient cycling, crop yield and increase soil fertility with various rates applied. Research work is also needed on rates of manure with different rate under same soil environments. This is necessary for making recommendations with appropriate rates for the application of goat and poultry manure. This research trail was therefore conducted to compare the efficacy of poultry manure, goat manure and recommended NPK rates on soil carbon, N, P, K, growth parameters and spinach yield, soil fertility and soil health after initial application of the manures.

Materials and Methods

Soil sampling and manure collection

The present study was carried out at the, in greenhouse of research area of Department of Soil Science, Sindh Agriculture University (SAU) Tandojam (25.4281°N, 68.5307°E) during 2016-17 growing season. Soil for experiment (plough layer) was sampled from the field near to greenhouse which was used for further laboratory analysis. The manures of goat and poultry taken from Faculty of Animal Husbandry and Veterinary Sciences, SAU, Tandojam. The soil samples 5 kg were subjected to be dried in air, ground and processed to sieve through 3 mm sieve. The manure of goat & poultry collected was also processed dried and sieved in the same manner. The 5 kg soil was placed in plastic containers (length 26 cm, dia 21.5 cm) having bottom holes for drainage. The soils analyzed were poor in organic matter & low in soil fertility. The test crop was spinach. Along with that there were three doses (2.5, 5 & 7 tones ha^{-1}) of the poultry and goat manure for each, respectively. The pots were arranged on a wooden bench in a Complete Randomized Design (CRD) with replicated thrice for all treatments. T_1 = Control, T_2 = Poultry manure (2.5 t ha^{-1}), T_3 = Poultry manure (5 t ha^{-1}), T_4 = Poultry manure (7 t ha^{-1}), T_5 = Goat manure (2.5 t ha^{-1}), T_6 = Goat manure (5 t ha^{-1}), T_7 = Goat manure (7 t ha^{-1}), T_8 = NPK (75:60:30 kg ha^{-1}). The seeds of spinach vegetable were grown in experimental pots by hands dipping manually followed by soil stirring slightly. Spinach seeds were rinsed with sand at ratio of 2:50, thoroughly. The distilled water was added to keep moisture to approximately at field capacity for all treatments. Manually, thinning was carried out to have about 10 plants per pot one week after germination. Agronomic observations included growth traits, fresh, dry weight of leaves and crop yield.

Soil analysis

The soil for research trail samples was obtained from the experimental pots before crop

sowing and after harvesting to analyze. The texture of soil samples was measured by method of Bouyoucos hydrometer [13]. The EC was in (1:5 soil: water saturated paste) [14]. Soil pH (1: 5 extract of soil: water) was determined by method [15]. For the determination of P and K in the soil, the extraction of soil was done by AB-DTPA solution [16]. Soil organic matter (%) was measured according to method reported earlier [17].

Table 1. **Physico-chemical properties of the experimental soil before sowing of crop.**

S. No.	Properties	Values
1	Soil Textural class	Silty clay loam
2.	EC (dS m^{-1})	2.08
3.	pH (1:2) (w/w)	7.9
4.	Organic matter (w/w)	0.95
5.	Total carbon **(**w/w)	1.90
6.	Nitrogen (w/w)	0.04
7.	Phosphorus (mg kg^{-1}) (w/w)	5.70
8.	Potassium (mg kg^{-1}) (w/w)	48.02

Statistical analysis

The experimental data achieved was analyzed statistically using Statistix 8.1. The LSD test was applied to compare treatments superiority, where necessary (Statistix, 2006).

Results and Discussion

Physico-chemical properties of soil influenced by treatments

In the present study, it was found that poultry and goat manure additions had significant effect on available soil organic matter (OM) organic carbon (OC), N, P and K (Table 1). It was observed that both type and rate of the goat and poultry manure applied significantly ($P<0.01$) affected of soil properties and had interaction suggesting variation in the different rates of application. The SOM, OC, N, P and K increased significantly ($P> 0.05$) with increasing rate of manure application for both manure types. The differences in OC (%) due to organic manures were statistically significant ($P> 0.05$). The maximum 1.96% OM % was recorded at the higher rate applied manure of poultry 7 tons ha^{-1}. Lower values of OM % 0.35 % were found in control pots, where the crop was left untreated. Both manures improved OC % with increasing rates because they contain a lot of the organic matter. Generally, organic manure is known to have liming effect on the soil properties [18, 4]. The highest value of OC of maximum 1.96 % was recorded at the rate of seven tones / ha manure followed by the balanced rate of mineral fertilizer kg ha^{-1}, goat manure. The crop at goat manure 5 tons ha^{-1}, poultry manure 2.5 tons ha^{-1} and goat manure 2.5 tons ha^{-1} resulted in reduced OC up to 1.90 %. Similar results are found in a research work carried out by other researchers [2, 7].

The differences in soil N (%) due to organic manures were statistically significant ($P > 0.05$) (Table 2). The maximum soil N 0.55 (%) was obtained at chicken manure used seven tons ha^{-1} goat and chicken feaces. The minimum soil N 0.017 (%) was recorded in control pots, with no manure added in soil. Irrespective of rates soil with poultry faeces had higher value of OC and N than the soils applied with goat manure. Comparative analysis of different manures showed that poultry manure had higher C and N than cow dung [19]. The manure of poultry applied at the rate of seven tons ha^{-1} yielded maximum soil N contents and P analyzed. This reasonably significant increase in soil N and available may have been brought due to enhanced population of and activities of soil microbes and nutrient cycling owing to the application of both manure as goat and poultry. The better effect on f chicken manure on soil physico-chemical properties compared with manure of goat could be adduced to lower CN and CP ratios recorded for chicken manure for previous studies [5]. The differences in soil K mg kg^{-1} content due to organic manures were statistically significant ($P> 0.05$). The similar trend was observed for soil K at manure applied seven tons ha^{-1} followed by recommended dose of inorganic fertilizers and goat manure added to soil. However, the minimum soil K of 35.23 mg kg^{-1} was determined in pots of control treatments, where the soil was not added K. Both P & K increased significantly with the increasing rates of poultry and goat manure and similar results are found by [5, 7].

Table 2. Effect of organic manures on Electrical conductivity (EC), pH, Organic matter (O.M), total carbon (T.C), N, P, and K contents in Soil.

Treatments	EC dSm^{-1}	pH	OM %	OC (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})
T_1 = Control	1.29 $_{BC}$	7.63 $_{AB}$	0.35 $_{G}$	1.50 $_{D}$	0.017 $_{F}$	1.42 $_{G}$	35.23 $_{G}$
T_2 = P M (2.5 t ha^{-1})	1.24 $_{BC}$	7.43 $_{CDE}$	0.54 $_{E}$	1.87 $_{C}$	0.027 $_{D}$	2.2$_{FG}$	43.86 $_{EF}$
T_3 = P M (5 t ha^{-1})	1.27 $_{BC}$	7.43 $_{CDE}$	0.94 $_{B}$	1.92 $_{AB}$	0.047 $_{B}$	3.66 $_{D}$	48.33 $_{D}$
T_4 = P M (7 t ha^{-1})	1.40 $_{B}$	7.30 $_{E}$	1.96 $_{A}$	1.17 $_{A}$	0.055 $_{A}$	6.89 $_{A}$	64.06 $_{A}$
T_5 = G M (2.5 t ha^{-1})	0.92 $_{C}$	7.53 $_{ABC}$	1.90 $_{BC}$	1.16 $_{F}$	0.021 $_{E}$	1.71$_{FG}$	41.93$_{F}$
T_6 = G M (5 t ha^{-1})	1.22 $_{BC}$	7.50 $_{BCD}$	1.90 $_{BC}$	1.10 $_{D}$	0.033 $_{C}$	2.68 $_{E}$	45.66 $_{DE}$
T_7 = G M (7 t ha^{-1})	1.26 $_{BC}$	7.36 $_{DE}$	1.92 $_{AB}$	1.11 $_{C}$	0.043 $_{B}$	4.59 $_{C}$	53.33 $_{C}$
T_8 = NPK (75:60:30 kg ha^{-1}	1.51 $_{A}$	7.66 $_{A}$	0.99 $_{B}$	1.09$_{AB}$	0.049 $_{B}$	5.66 $_{B}$	58.00 $_{B}$
SE ±	0.1802	0.0769	0.024	0.021	1.1140	0.388	1.624
LSD 0.05	0.3866	0.1649	0.051	0.045	2.3900	0.832	3.4835

Significant difference among treatments are indicated at p<0.05: significant difference among means are indicated at p<0.01. PM poultry manure, GM goat manure, N, nitrogen, P phosphorus, K potassium, EC electrical conductivity, OM, organic matter, OC organic carbon

Effect on crop growth parameters and crop yield

Plant height (cm) influenced by manures

The differences in plant height (cm) due to organic manures were significant ($P > 0.05$) Fig. 1. Manures of poultry and goat 7 tons ha^{-1} resulted in maximum plant height 37.42 cm; followed by applied at recommended dose. Chat et al., [20] found that application of poultry and goat manure in addition to mineral nutrients responded in higher leaf growth and plant height. The minimum plant height 16.29 cm was recorded in control pots, where the soil was added no manure nor inorganic fertilizer. This shows that the plant height responded well to the increasing rates of the manures. Results are in agreement with earlier reports [6, 7].

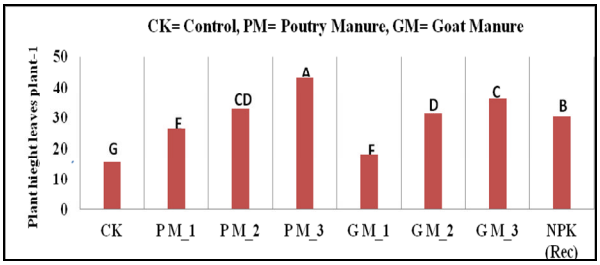

Figure 1. **Effect of organic manures on plant height of spinach**

Influenced of manures on fresh weight of spinach plant^{-1}

The differences due to manures applied in weight of fresh per plant was significant ($P< 0.05$) (Fig 2). The weight of fresh plant was highest 43.31 g when manure of poultry was applied at the dose of 7 tons ha^{-1} which was consequently followed by addition of the inorganic fertilizer with balanced recommended dose and higher rate of goat manure. It was observed that weight of leaves was significantly related to the type of manure and the dose of the manure applied. Similar results were observed by Akani and Ojenivi [4]. The research results found in this study may be in same way as stated in (Fig. 1) are similar about soil nitrogen and available phosphorous regarding elevation in fresh weight of plant and spinach growth was significantly affected by poultry and goat manure application resulting in enhanced contents of N and P in soil. However, lower weight of plant^{-1} of 15.65 g was recorded in control pots. Similarly, better response of goat in addition to mineral nutrients on the yield of spinach plants was reported by [21].

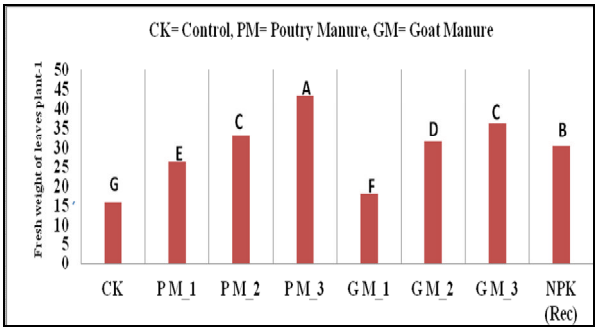

Figure 2. **Effect of organic manures on fresh weight of leaves of plant**

Influence of manures on dry weight of leaves

The differences in weight of dry leaves per plant was affected by dose and type of the animal manures and mineral nutrients were significant ($P< 0.05$) (Fig. 3). The dry weight of leaves was highest 7.95 g when manure of chicken was added to soil at the rate of 7 tons ha^{-1}. After that manure of goat at same rate and addition of mineral fertilizers at balanced recommended rate. It was observed that the influence of poultry yielded maximum production in comparison to manure of goat and mineral fertilizers applied. The trend that was observed could be illustrated as poultry manure followed by inorganic fertilizer and by manure of goat applied. These results are in complete accordance with the results found by Maerere et al., [5]. Furthermore, same research findings were found that application of recommended balance mineral fertilizer along with manure applied produced more crop yield [9].

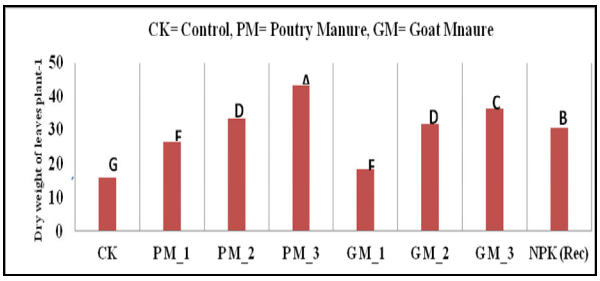

Figure 3. **Effect of organic manures on dry weight of leaves in spinach**

Conclusion

It is concluded that poultry and goat manure improved soil physico-chemical and biological properties. Crop attributes were influenced significantly by the manure poultry applied at higher rates and goat manure which increased with increasing rates of both the manures. Soil carbon was improved by the goat manure and N was increased with chicken manure. Poultry manure at rate of 7 tons ha^{-1} resulted highest nutrient contents and crop yield. Soil and crop responded significantly to the use and rates of the poultry and goat manure followed by inorganic fertilizers. Vegetable growers may apply poultry and goat manure at rate of 7 tons ha^{-1} for improving soil organic matter, physico-chemical properties and sustained vegetable crop yield.

References

1. R. Lal, *Bio. Sci. J.*, 304 (2010) 163. doi.org/10.1525/bio.2010.60.9.8
2. S. A. Abro, I. H. Shah, G. Q. Shar, A. A. Abro and A. Q. Mahar, *Pak. J. Anal. Environ. Chem*., 1 (2016) 111. doi:10.21743/pjaec/2016.06.01
3. B. S. Ewulo, *J. Anim. Vet. Adv.*, 4 (2004) 839. https://doi.org/10.1680/mpal.2010.163.1.1
4. D. I. Akani and S. O. Ojenivi, *Res. J. Agrono.*, 2 (2008) 44. http://medwelljournals.com/abstract/?doi=rjagr.2008.44.47
5. A. P. Maerere, J. J. Kimbi and D. L. M. Nonga, *Asian J. Sci. Tech.*, 1 (2011) 14. http://dx.doi.org/10.4314/ajst.v1i4.44623
6. A. A. Razzag, *Pak. J. Bio. Sci.*, 5(2002) 266. http://docsdrive.com/pdfs/ansinet/pjbs/2002/212-214.pdf
7. M. A. Awodum, I. I. Omonijo and S. O. Ojenivi, *Int. J. Soil. Sci*., 2 (2007) 14. http://agris.fao.org/agris-search/search.do?recordID=SD2008000145
8. F. N. Ikpe and J. M. Powel, *Nutri. Cycling Agroecosys*., 62 (2002) 37. https://doi.org/10.1023/A:1015199114833
9. M. Solangi, A. A. Somro, A. J. Shaikh, W. Baloch and S. A. Abro, *Pak. J. Sci*., 69 (2017) 111.
10. M. Memon, K. S. Memon, S. Mirani and G. M. Jamro, *Afri. J. Biotech.*, 11 (2012) 9343. http://dx.doi.org/10.5897/AJB12.004
11. C. Marimuthu, M. Jayaramani and S. Vivekanandan, *J. Appl. Agr. Res*., 5 (2010) 337.
12. P. M. Fearn, P. M. Lima, A. Garcia and F. J. A. Rodriques, *J. Ecol. Manag.*, 146 (2013) 115.
13. G. J. Bouyoucos, *Agrono. J.*, 54 (1962) 464. https://doi.org/10.2134/agronj1962.00021962005400050028x
14. M. I. Jackson, *Soil Chem. Anal. Adv. Course*, (1962) 141. https://www.coursehero.com/file/p5enl9kl/Jackson-ML-1969-Soil-chemical-analysis-Advanced-course-2nd-edition-Madison-WI/
15. E. O. Mclean, *Alumi in Black CA (Ed) Meth. Soil Anal.*, 2 (1982) 31.

https://doi.org/10.3758/BF03205725
16. P. N. Soltanpour and A. P. Schwab, *Comm. Soil Sci. Plant Anal.*, 3 (1977) 13. http://dx.doi.org/10.1080/00103627709366714
17. A. Walkley and I. A. Black, *J. Soil. Sci.*, 37 (1934) 29. https://doi.org/10.1097/00010694-193401000-00003
18. M. C. Manna, A. Swarup, B. Mishra and D. K. Shahi, *Soil Till. Res.*, 94 (2007) 397. https://doi.org/10.1016/j.still.2006.08.013
19. M. A. K. Smith and A. Ayenigbara, *Afri. Crop. Sci. Conf. Proc. Uganda*, 5 (2011) 1007. doi: 10.1186/s40064-015-1188-z
20. T. H. Chat, N. T. Dung, D. V. Binh and T. R. Preston, *J. Livestock Res. Rural Deve.*, 17 (2015) 20. http://www.lrrd.org/lrrd17/10/chat17109.htm
21. V. H. Nguyen and T. R. Preston., *J. Livestock Res. Rural Dev.*, 18 (2008) 20. (http://www.cipav.org./lrrd/lrrd20/7/nhan20113.htm).