2011 2nd International Conference on Environmental Engineering and Applications
IPCBEE vol.17 (2011) © (2011) IACSIT Press, Singapore

Impact of Selected Doses of Organic Wastes on Physico-Chemical Characteristics of the Soil and Yield of Wheat

M. Jamil Khan

Associate Professor, Department of Soil & Environmental Sciences, Faculty of Agriculture, Gomal University, Dera Ismail Khan, (KPK) Pakistan. Ph. No. 0092 300 5792248, Fax. No. 0966 750255

Abstract. Use of organic wastes / biosolids as organic fertilizer in environment friendly manner for better crop and fodder yields is also one of the good options. In the present study selected doses of sewage sludge (40 t ha^{-1}), press mud (20 t ha^{-1}) and boiler ash (50 t ha^{-1}) were applied to wheat crop in pot and field experiments. Grain and straw yield increased due to the wastes as compared to control but the highest was recorded in sewage sludge amended treatments. All other yield parameters also recorded similar response. The laboratory analysis of soils after harvest revealed that most of the physico-chemical properties of the soil were positively affected by the application of 40 t ha^{-1} of sewage sludge, 20 t ha^{-1} of pressmud and 50 t ha^{-1} of bagasse ash. After application of sewage sludge, pressmud and bagasse ash doses the dry bulk density decreased to 1.28, 1.32 and 1.30 gm cm^{-3} respectively, from 1.34 gm cm^{-3}, which ultimately increased the total porosity of the soil from 51.0 to 52.20 %. The textural class remained unchanged. The selected levels of sewage sludge and pressmud also decreased the soil pH slightly. Electrical conductivity of the treated soil increased from 0.38 dSm^{-1} upto 1.32 dSm^{-1}. The highest increase (1.32 dSm^{-1}) was recorded in the treatments receiving bagasse ash @ 50 t ha^{-1}, while it was the lowest (0.92 dSm^{-1}) in the pressmud treatment. Appreciably high contents of macro and micronutrients like, NPK, Zn, Cu, Fe and Mn were also found in the soil treated with sewage sludge, pressmud and bagasse ash. Organic matter content of the soil also increased sufficiently from 8200 mg kg^{-1} up to 9540 mg kg^{-1} with sewage sludge application which was highest as compared to that of pressmud and bagasse ash. Nitrogen content was highest (1190 mg kg^{-1}) in the sewage sludge treated soil while P was highest (290 mg kg^{-1}) in the pressmud treatment, while Iron (13 mg kg^{-1}), Manganese (22 mg kg^{-1}) and Zinc (13 mg kg^{-1}) content was recorded maximum in the bagasse ash treatments. It is therefore proved that application of organic wastes to agricultural soils would be sustainable and economical due to nutrient cycling and disposal of the waste. However, there could be some risks like that of toxic metals and pathogens.

Keywords: Organic wastes, sewage sludge, pressmud, wheat yield, calcareous soil

1. Introduction

Because of arid and semi-arid conditions dominating in Pakistan, agricultural soils are very poor in organic matter, which seldom exceeds 1% and is often less than 0.5% [1]. The organic wastes originating from urban domestic and industrial sources are often utilized as organic fertilizers for crop production, like other countries of the world to reduce their dependence on costly chemical fertilizers and for safer environment. The use of sewage sludge has become an established practice in different agricultural countries. Sewage sludge is a product of sewage treatments plants and results from removal of solids and organic matter from the sewage (municipal as well as industrial waste water). Sewage sludge is further processed through digestion, thickening, denaturing and drying for disposal. Since, sewage sludge is a good source of organic matter and plant nutrients therefore; land application of sludge for crop production provides a feasible and cost effective disposal alternative [2].

Pressmud and bagasse ash are the wastes obtained from sugar mills. In the manufacture of cane sugar, the precipitated impurities contained in the cane juice, after removed by filtration, form a cake of varying moisture content called filter cake/pressmud. The high amount of NPK contents of pressmud has made it a valuable organic resource [3]. Along with luxurious amount of organic matter, important micronutrients like Zn, Cu, Fe and Mn are also abundant in pressmud, which are deficient in calcareous soils [4].

Wheat is the most important food crop of the world. It is planted on about 7.2 million ha annually, with an average yearly production of 11.6 million tons and average yield of 1596 kg ha^{-1}. Positive crop yield responses [5] and increased bioavailability of nutrients to different crops [6] due to application of organic manures have been reported.

As different doses of sewage sludge, pressmud and bagasse ash were applied to wheat crop in a series of pot experiments and the selected doses were then applied to wheat crop in field to confirm the previous results of pot experiments and record their impact on the soil characteristics and yield of wheat crop.

2. Experimentals

The organic waste materials used for this study were sewage sludge, press mud and bagasse ash. Sewage sludge was collected from the dumping site of Jhok Dhappan Wali, DIKhan. Press mud and bagasse ash were collected from the waste disposal site of Chashma Sugar Mills (Pvt) Ltd., DIKhan. Press mud used in the investigations was collected from the waste disposal site of Chashma Sugar Mills (Pvt) Ltd; DIKhan, Pakistan. These samples were air dried and passed through 4mm sieve and then analysed for various physic-chemical characteristics.

2.1. Experiments Details

A field experiment was conducted to investigate the agronomic potential of these organic wastes on wheat at the farm area of Faculty of Agriculture, Gomal University, DIKhan, during Rabi 2002-2003. Study of heavy metal accumulation in soil and their phytoremediation by wheat crop was also an objective of the study. A composite soil sample was taken from the experimental site by mixing and homogenizing four soil samples taken from 0-30 depth by using soil auger. The soil samples were properly air dried, ground and passed through 2mm sieve. Composite samples of organic wastes were spread on plastic sheet for air drying, which were then ground and passed through a 4mm sieve. The prepared soil and organic wastes samples were stored in plastic jars for physico-chemical characterization. Experimental field was properly prepared by ploughing and planking. The experiment comprised of 5 treatments i.e., control, basal dose of NPK, sewage sludge @ 40 t ha^{-1}, press mud @ 20 t ha^{-1} and bagasse ash @ 50 t ha^{-1}. The experiment was established in Randomized Complete Block Design having 4 replications. Plot size was 2x5 m^2. Wheat variety Fakhr-e-Sarhad was sown on 20th November, 2002 using seed rate 100 kg ha^{-1}. The crop was grown to maturity and it received it received four irrigations properly timed to suit the crop requirements. Weeds were controlled manually and the crop was harvested at maturity. Various data on wheat growth and yield parameters including crop harvest index were recorded at the time of crop harvest/ after harvest.

3. Results and Discussion

3.1. Physico-chemical characteristics of soil, sewage sludge, pressmud and bagasse ash

The soil used in investigation was non saline (ECe 0.38 dSm^{-1}), non sodic (pH 8.2) but was calcareous in nature due to having 12% lime content. Organic matter and total nitrogen were low being 0.82% and 0.03%, respectively. Available P, K and micronutrients like Cu, Fe, Mn and Zn were adequate in the soil. The sewage sludge, pressmud and bagasse ash were, however, rich in organic matter contents, NPK and all micronutrients (Table 1).

Table 1. Physico-chemical characteristics of soil, sewage sludge, pressmud and bagasse ash

Characteristics	Units	Soil	Sewage sludge	Press mud	Bagasse ash
		Value		Value	
Textural Class		Sandy Clay Loam	------	------	------
Dry Bulk Density	gm cm^{-3}	1.34	------	------	------
Total Porosity	%	51.00	------	------	------
pH		8.2	8.0	7.8	9.2

E C_e	dSm^{-1}	0.38	2.39	2.2	2.4
$CaCO_3$	mg kg^{-1}	63000		------	
HCO_3^-	mg kg^{-1}	100	787	9150	1525
CO_3^{--}	mg kg^{-1}	26	Nil	------	36
Cl^-	mg kg^{-1}	93	1681	4822	1808
SO_4^{--}	mg kg^{-1}	27	158	1992	8160
Soluble Na	mg kg^{-1}	69	420	750	920
Ca^{++}+ Mg^{++}	mg kg^{-1}	94	860	5442	773
O.M	mg kg^{-1}	8200	194000	210000	Nil
Total N	mg kg^{-1}	300	16000	20000	Nil
Available P	mg kg^{-1}	7.5	70.0	13000	110
Available K	mg kg^{-1}	172	288	19500	210
Cu	mg kg^{-1}	6.5	260.0	64	55.0
Fe	mg kg^{-1}	5.4	250.0	322	267.0
Mn	mg kg^{-1}	11.0	210.0	298	194.0
Zn	mg kg^{-1}	6.2	640.0	125	65

3.2. Impact of selected doses of sewage sludge, pressmud and bagasse ash on the physic-chemical characteristics of the soil

The laboratory analysis of soils after harvest given in Table 2 revealed that most of the physico-chemical properties of the soil were positively affected by the application of 40 t ha^{-1} of sewage sludge, 20 t ha^{-1} of pressmud and 50 t ha^{-1} of bagasse ash. After application of sewage sludge, pressmud and bagasse ash doses the dry bulk density decreased to 1.28, 1.32 and 1.30 gm cm^{-3} respectively, from 1.34 gm cm^{-3}, which ultimately increased the total porosity of the soil from 51.0 to 52.20 %. The textural class remained unchanged. The selected levels of sewage sludge and pressmud also decreased the soil pH slightly, which was a positive effect of the sludge and pressmud on the environment of the calcareous soil [7]. Electrical conductivity of the treated soil increased from 0.38 dSm^{-1} up to 1.32 dSm^{-1} [8]. The highest increase (1.32 dSm^{-1}) was recorded in the treatments receiving bagasse ash @ 50 t ha^{-1}, while it was the lowest (0.92 dSm^{-1}) in the pressmud treatment. Appreciably high contents of macro and micronutrients like, NPK, Zn, Cu, Fe and Mn were also found in the soil treated with sewage sludge, pressmud and bagasse ash. Organic matter content of the soil also increased sufficiently from 8200 mg kg^{-1} up to 9540 mg kg^{-1} with sewage sludge application which was highest as compared to that of press mud and bagasse ash [9].

Table 2. Impact of selected doses of sewage sludge, pressmud and bagasse ash on the physic-chemical characteristics of the soil

S.No	Characteristics	Units	Soil treated with different doses of organic wastes			
			Control (Soil 0 wastes)	Sewage sludge 40 (t ha^{-1})	Pressmud 20 (t ha^{-1})	Bagasse ash 50 (t ha^{-1})
1	Textural Class		Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
2	Dry Bulk Density	gm cm^{-3}	1.34	1.28	1.32	1.30
3	Total Porosity	%	51.00	52.20	51.34	51.70
4	pH		8.2	8.1	8.0	8.5
5	ECe	dsm^{-1}	0.38	1.12	0.92	1.32
6	Ca++ + Mg++	mg kg^{-1}	94	156	242	258
7	Cl-	mg kg^{-1}	93	348	446	296
8	CO3	mg kg^{-1}	26	32	26	26.5
9	HCO3	mg kg^{-1}	100	262	552	412
10	SO4	mg kg^{-1}	27	53	141	207
11	Soluble Na	mg kg^{-1}	69	102	126	194
12	Available K	mg kg^{-1}	172	198	293	210

13	O. M	mg kg^{-1}	8200	9540	8610	8900
14	Total N	mg kg^{-1}	300	1190	1070	300
15	Available P	mg kg^{-1}	7.5	29	290	44
16	Fe	mg kg^{-1}	5.4	12	8	13
17	Mn	mg kg^{-1}	11.0	16	9	22
18	Cu	mg kg^{-1}	6.5	12.5	9.5	12
19	Zn	mg kg^{-1}	6.2	13	11	13

3.3. Impact of selected doses of sewage sludge, pressmud and bagasse ash on the yield and yield components of wheat.

Table 3. Impact of selected doses of sewage sludge, pressmud and bagasse ash on the yield and yield components of wheat

Treatments	Plant height (cm) *	Spike length (cm) N.S	No of Tillers m^{-2} *	No of Productive Tillers m^{-2}*	No of grains spike^{-1} *	1000-grain weight g*	Grain yield t ha^{-1} *	Straw yield t ha^{-1} *
Control	83.25 c	9.750 a	301.0 c	245.0 d	40.75 d	36.17 d	3.217 c	5.807 c
Sewage sludge 40 t ha^{-1}	104.5 a	10.50 a	416.5 a	371.0 a	56.50 a	45.92 a	6.150 a	8.700 a
Pressmud 20 t ha^{-1}	102.8 a	10.25 a	386.5 b	334.8 b	52.50 b	42.13 b	5.325 b	7.963 b
Bagasse ash 50 t ha^{-1}	91.75 b	10.00 a	383.5 b	315.0 c	49.00 c	39.95 c	5.025 b	7.635 b

* = Values followed by the same letters are not significantly different at ∝ = 0.05.

Most of the yield parameters of wheat crop like plant height, spike length, number of tillers m^{-2}, number of productive tillers m^{-2}, number of grains spike^{-1}, 1000 grains weight, grain yield and straw yield, were positively affected by the application of sewage sludge, press mud and bagasse ash respectively (Table 3). Number of researchers also reported similar results during their experiments [10].

4. Acknowledgements

The author is highly obliged and acknowledges the Higher Education Commission of Pakistan for the financial support.

5. References

[1] Zia, M.H., Anwar-ul-Haq. and M.I. Ahmed.Utilization of brackish groundwater for crops with EM- technology. *Pak. J. Agric. Sci*. 1999, **36**: 186-188.

[2] Mariangela, D and M. Francesco. Long-term effects of organic amendments on soil fertility. *A review. Agron.* Sustain. *Dev*. 2010, **30**: 401–422

[3] Rakkiyappan, P., S. Thangavelu, R. Malathi, and R. Radhamani. Effect of biocompost and enriched press mud on sugarcane yield and quality. *Sugar Techn*, 2001, **3**: 92-96.

[4] Umar, M.K., M. Qasim, M. Subhan, M. Jamil and D.A. Riazud. Response of rice to different methods of Zn application in calcareous soil. *Pak. J. Appl. Sci*. 2003, **3**: 524-529.

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

[6] Mehla, D.S., J.P. Singh, K.S. Sekhon, D. Sihag and K.K. Bhardwaj. Long-Term Effects of Inorganic and Organic Inputs on Yield and Soil Fertility in the Rice-Wheat Cropping System in India. 18th World Congress of Soil Science, July 9-15, Philadelphia, Pennsylvania, USA., 2006.

[7] Singh, Y., B. Singh, R.K. Gupta, J.K. Ladha, J.S. Bains and J. Singh. Evaluation of press mud cake as a source of nitrogen and phosphorus for rice-wheat cropping system in the Indo-Gangetic plains of India. *Biol. Fertil. Soil*. (Accepted), 2007.

[8] Bokhtiar, S.M.,M.J. Islam and S.N.A. Chowdhury. Effect of press mud along with inorganic fertilizers on sugarcane yield and fertility status of soil. *Bangl. J. Train. Dev*. 2000, **13**: 175-180.

[9] Yassen, A.A., S.M. Khaled and M.Z. Sahar. Response of Wheat to Different Rates and Ratios of Organic Residues on Yield and Chemical Composition under Two Types of Soil. *J. Amer. Sci*. 2010, **12**: 858-864.

[10] Jamil, M., M. Qasim and M.S. Zia. Utilization of pressmud as organic amendment to improve physico-chemical characteristics of calcareous soil under two legume crops. *J. Chem. Soc. Pak*. 2008, **30** (4), 577-584.