American-Eurasian J. Agric. & Environ. Sci., 8 (1): 55-59, 2010
ISSN 1818-6769

Fertilization of Soybean Plants with Municipal Solid Waste Compost Under Leaching and Non-Leaching Conditions

[1]Mohammadreza Mahmoodabadi, [2]Zohre Amirabadi, [2]Sevda Amini and [3]Kobra Khazaeipoul

[1]Department of Animal Science, College of Agriculture, Birjand University, Birjand, Iran
[2]Department of Soil Science, College of Agriculture, Guilan University, Rasht, Iran
[3]Department of Soil Science, College of Agriculture, Guilan University, Rasht, Iran

Abstract: Organic materials have many positive effects on physical, chemical and biological characteristics of soils. So it has important function in improving the soil fertility. The main purpose of this greenhouse study was to evaluate the impact of Municipal Solid Waste Compost (MSWC) and leaching of MSWC on growth, chemical composition and some physico-chemical properties of soil after soybean *var. A3237* harvesting. Treatments are consisted of four levels of MSWC (0, 1, 2 and 4% based on dry weight). Leaching of MSWC with 1:10 compost-water ratio was done because of reducing its salinity. The results have shown that MSWC increased dry weight of shoot. The maximum dry weight of soybean obtained by application of 2% of MSWC. The application of MSWC increased Electrical Conductivity (EC_e) and the concentration of potassium in saturation paste. Increasing soil salinity significantly decreased dry weight of root at 4% treatment compared with 2% treatments. The results of this experiment demonstrate the importance of MSWC on soybean growth.

Key words: Soybean · MSWC · Leaching · Growth parameters

INTRODUCTION

Most agricultural soils in Iran are generally low in organic matter (OM), usually less than 1% and, thus have poor physical conditions. Therefore, increasing OM in these soils is of prime concern. More than 7.2 million tons of municipal waste is generated in Iran annually. With this amounts of waste, 2.5 million tones compost is available in Iran annually and causes an increase in OM levels of agricultural soils in Iran.

Field studies with these materials applied as soil amendments have shown that the MSWC can be useful in agricultural crop production, such as by lowering bulk density and increasing water holding capacity and by supplying essential nutrients to a limited extent [1].

The major drawbacks encountered with long term use of organic fertilizers to soils are the pollution of ground and surface waters due to the leaching and runoff of nutrients, accumulation of excessive soluble salts and the buildup of certain trace elements. Thus, the main aim of this study was to investigate about MSWC effects on vegetative and reproductive growth of soybean plants and also leaching and non-leaching effects of MSWC on plant and soil characteristics.

MATERIALS AND METHODS

The experiment was carried out in greenhouse of soil science department, Shiraz University from April 1, 2006 to July, 2006 using surface layer (0-30 cm) of local soil called Ramjerdi. The classification of this soil was done regarding to method of Soil Survey Staff [2] [Fine, mixed, mesic, Fluventic Haploxerepts]. The mentioned soil and some rates of MSWC were dried, passed via 2-mm sieve and used to determine physic-chemical characteristics (Table 1) [3]. Soil texture and organic matter were assessed by hydrometer and Walkley - Black methods, respectively. The electrical conductivity (ECe) and pH in saturated paste were evaluated by EC-meter (Lovibond, con200) and pH meter (Ecoscan), respectively. Cation exchange capacity (CEC) and equal calcium carbonate were determined using sodium acetate and neutralizing with HCl methods, respectively. Total nitrogen, available phosphorus and extractable potassium were assessed using kjeldal, yellow ammonium-molybdate methods [4] and flame photometer (Corning 405), respectively. Micronutrients were extracted using DTPA (Diethylen Triamene Penta Acetate) and their concentration were determined with atomic absorption spectrophotometer

Correspoding Autor: Mohammadreza Mahmoodabadi, Agricultural and Natural Resources Research Center Southern Khorasan, Birjand, Iran Tel: +98-915-3635067

Table1: Some physical and chemical characteristics of soils prior to use in the experiment

	Clay	Silt	OM	Moisture (FC)		EC	CEC
Soil characteristics	%		dS/m	Cmolc/kg	pH		
value	48	23	0.23	20	7.5	0.27	11

Table2: Analytical characteristics of MSWC

	Quantity	
Characteristic	Without leaching	With leaching
pH (1:5 MSWC: water)	7.9	8.1
Total N (%)	1.52	1.39
Total P (mg/kg)	4810	3250
Total Fe (mg/kg)	1720	1611
Total Mn (mg/kg)	978	928
Total Zn (mg/kg)	685	647
Total Cu (mg/kg)	301	282
Total Pb (mg/kg)	232	143
Total Cd (mg/kg)	24	12
EC_e (dS/m) (1:5 MSWC: water)	7.2	2.7

(Shimadzo AA-670; Shimadzu Corporation, Japan) [5] (Tables 1 and 2). Chlorine (Cl) was determined by titration method [5].

Regarding to high salinity level of MSWC, the leaching was done with 1:10 ratio of compost: distilled water. Based on soil analysis, 50 mg N/Kg soil as $CO(NH_2)_2$ (1/2 before planting and 1/2 one month after planting), 25 mg phosphorus/kg soil as KH_2PO_4, 5 mg Iron Kg/soil as Fe EDDHA, 5 mg zinc/kg soil as $ZnSO_4.2H_2O$, 5 mg manganese/kg soil as $MnSO_4$ and 2.5 mg copper/kg soil as $CuSO_4$ were added up to the mentioned soil to provide pot mixture. Treatment included:

- Pot mixture + 0 percent of MSWC
- Pot mixture + 1 percent of MSWC without leaching
- Pot mixture + 1 percent of MSWC with leaching
- Pot mixture + 2 percent of MSWC without leaching
- Pot mixture + 2 percent of MSWC with leaching
- Pot mixture + 4 percent of MSWC without leaching
- Pot mixture + 4 percent of MSWC with leaching

MSWC was used based on dry weight in leached and non-leached status. After preparation of required treatments and filling the 3-Kg pots, six seeds of soybean var. A3237 were sown in 1.5-2 cm depth in each pot and thinned to three per pot ten days after. Under greenhouse condition, aid temperature ranged between 13±2°C (night) and 20±2°C (day). Plants were irrigated with distilled water to keep soil moisture near the field capacity (FC). RH and light intensity were maintained in 55±5%. and >800μmol $m^{-2}.s^{-1}$, respectively. Both root and shoot parts of plants were harvested separately after sixteen weeks of emergence. Then, the plant parts rinsed with distilled water to remove soil fractions of parts and consequently dried at 65°C and weighted. Total nitrogen of both shoot and root was determined using micro-kjeldal method. For analysis of iron, manganese, zinc and copper plant parts were ground and dry-ashed at 550°C and used by atomic absorption spectrophotometer (Shimadzo AA-670; Shimadzu Corporation, Japan) [5]. Soil samples of each treatment were used to study the modification of chemical characteristics after experiment. Total nitrogen, $NaHCO_3$-extractable Phosphorus (Olsen method), DTPA-extractable iron, manganese and copper also analyzed. Electrical conductivity (EC_e) and Potassium was determined in saturated paste. The experiment was arranged in Completely Randomized Design (CRD) with 7 treatments and three replications in each that each replicate consisted of 5 pots. Mean were compared using least significant difference (LSD) at 5% level.

RESULTS AND DISCUSSION

Chemical analysis of MSWC (Table 2) shows that ECe of MSWC was relatively high (7.2 dS/m) and after leaching, decrease to 2.7 dS/m. On the whole, application of MSWC increased mean's Shoot Dry Matter of soybean (SDM), but not significantly.

Table3: Effects of MSWC application and leaching on the seed yield, shoot and root dry weight and N and P concentrations of the soybean plant parts

Treatment	Shoot dry weight (g/pot)	Root dry weight (g/pot)	Seed yield (g/pot)	N (%) Shoot	N (%) Seed	P (g/kg) Shoot	P (g/kg) Seed
a	3.88abcd	0.88c	1.62b	1.27b	4.68a	1.23b	8.95b
b	4.75ab	1.47abc	2.39a	1.79ab	5.70a	2.88b	12.21ab
c	4.58abc	1.12bc	2.41a	1.67ab	4.86a	1.49b	10.66ab
d	3.29bcd	1.37abc	2.31ab	2.19a	5.09a	9.36a	12.91a
e	3.07cd	1.89a	2.46a	1.71ab	5.02a	2.09b	10.01ab
f	5.10a	0.91ab	2.69a	1.67ab	5.85a	5.94ab	11.65ab
g	2.49d	1.05bc	2.33ab	1.63b	5.19a	3.39b	11.08ab

Within each column, same letter indicates no significant difference between treatments at 5% levels

Table 4: Effects of MSWC application and leaching on K, Na and Cl concentrations of the soybean top

	K		Na		Cl	
Treatment	Shoot	Soil	Shoot	Soil	Shoot	Soil
	%	meq/l	mg/g	meq/l	mg/g	meq/l
a	0.86e	0.57d	1.03d	3.39c	4.50c	1.40b
b	1.70bc	1.44c	1.26c	7.76abc	6.25c	2.54b
c	1.04de	1.47c	0.81e	5.43bc	5.84c	1.70b
d	1.81b	2.84b	1.73b	8.63ab	9.46ab	2.66b
e	1.29cde	3.35b	0.86e	6.35abc	7.78b	2.41b
f	2.72a	4.70a	2.31a	10.76a	11.22a	5.29a
g	1.47bcd	4.46a	0.84e	6.61abc	9.79ab	1.58b

Within each column, same letter indicates no significant difference between treatments at 5% levels.

Table 5: Effects of MSWC application and leaching on the micronutrients concentrations of the soybean shoot, root and seed

	Fe			Cu			Zn			Mn		
Treatment	Shoot	Root	Seed	Shoot	Root	Seed	Shoot	Root	Seed	Shoot	Root	Seed
a	58.07b	542c	60.8c	11.55a	126.3b	12.02b	10.5b	171.7d	47.7b	99.02a	73.6c	8.75c
b	171.3a	875.4a	97.6a	21.77a	181.3ab	26.18a	15.3a	301.5bcd	89.6a	141.7a	221.4b	67.1ab
c	151.6a	594.4bc	89ab	14.91a	138.5b	19.38ab	11.4b	335.9abcd	81.5a	116.7a	181.5b	60.6b
d	155.2a	823.1ab	85.4ab	24.08a	136.8b	24.94a	15.5a	411.3abc	95.7a	106.9a	227.5b	69.6ab
e	171.7a	651.6abc	83.9ab	12.32a	225.7ab	18.82ab	12.4ab	468ab	77.6a	117.6a	166.2b	54.9b
f	201.5a	866.7a	75.9bc	25.13a	275.2a	21.5a	13.2ab	235.8cd	87.9a	128.3a	334.5a	82.9a
g	174.2a	583.8bc	91.4ab	18.55a	144.3b	21.4a	11.4b	542.2a	85.6a	112.6a	324.6a	65.8ab

Data expressed as mg/kg D. W. Within each column, same letter indicates no significant difference between treatments at 5% levels

The highest SDM was obtained on 4% MSWC pots. The higher plant growth could be the result of additional nitrogen available in the MSWC, or it could be the result of other nutrients and unknown growth factors in the MSWC.

Despite the moderate sensitivity of soybean to soil salinity, the apparently high tolerance of this cultivar to salt stress in the present study might suggest that the adverse effects of soil salinity (salinity threshold of soybean=5.0 dS/m) were probably alleviated by the constant water logging. Papadopoulos and Rendig [6] reported that, even at a high salinity level, plant growth could still be maintained if enough moisture was supplied to crops.

Phosphorus concentration, also, increased due to MSWC application (Table 3). The highest amounts of P were obtained at 2% (d) treatments in Shoot (9.36 g/kg) and seed (9.36 g/kg), respectively. More application of MSWC reduced P concentration. This is the same with the results of Wang *et al*. [7]. They believe that increased salinity caused by higher rates of organic fertilizer limited the growth and development of plant root system, thus P concentration in the seedling tissue decreased.

Application of MSWC increased the concentration of Fe in shoot from 58.07 mg/kg in control plot to 201.5 mg/kg at 4% treatment (Table 5). Hegde [8] also reported a significant increase in Fe availability and this was due to organic matter application. Zn concentration showed the same trend as Fe and the highest amount of this micronutrient was observed at the highest rate of MSWC application (Table 5). This finding is in agreement with that reported in wheat [9, 10].

In the present work, Na and Cl concentrations increased sharply with an increase in MSWC rates (Table 4). The increase in shoot Na, Cl and K concentrations at the highest rate of MSWC application were more than 2.24, 2.49 and 3.16 times that of the control (Table 4).

Table 6: Effects of MSWC and leaching on Soil micronutrients concentration

Treatment	Fe	Cu	Zn	Mn
A	4.7b	4.56c	1.46b	2.31c
B	8.9ab	6.36bc	4.35ab	3.42bc
C	8.02b	5.72bc	3.49ab	3.57bc
D	9.16ab	7.12bc	3.58ab	3.36bc
E	7.52b	6.56bc	3.13ab	3.66bc
F	13.8a	9.96a	6.10a	6.44a
G	13.7a	7.28b	4.14ab	4.29b

Data expressed as mg/kg soil Within each column, same letter indicates no significant difference between treatments at 5% levels

Table 7: Effects of MSWC and leaching on OM and EC content and P concentrations in Soil

Treatment	OM	EC	P
a	0.85d	0.82c	16.3b
b	0.98cd	2b	38.4a
c	1.14bcd	1.58b	36.7a
d	1.47ab	1.86b	37.3a
e	1.33bc	1.72b	36.5a
f	1.87a	3.2a	40.2a
g	1.79a	1.4bc	39.6a

Data expressed as mg/kg soil Within each column, same letter indicates no significant difference between

Effects of MSWC on Post Harvest Soil Properties: There was a significant increment in Electrical Conductivity (EC_e) as the level of MSWC increased, that in 4% compost pots 2.2 times was higher than control. Ismail *et al*. [11] reported that EC_e values increased in calcareous soil treated with organic fertilizer. Pratt [12] by the application of 40-150 ton ha^{-1} bovine manure found existence of positive correlation between manure application and EC_e. Many another researchers also showed an increase in EC_e which accompanied by compost and manure application [13].

Mean's comparison in Table 6 shows that the concentration of available P in soil was significantly increased by application of MSWC, basically. Many workers reported that the application of manure remarkably increased available P [14, 15].

Increasing doses of MSWC increased K in saturation paste from 0.57 meq l^{-1} to 4.70 meq l^{-1} at 4% treatment (f), by 8.25 times higher than the control pots (Table 4). McAndrews *et al*. [16] found greater potassium concentrations in soybeans that were grown in manure amended plots. Whalen *et al*. [15] showed that organic fertilization increased potassium which was approximately 3-4 times higher than the control. Gupta *et al*. [17] reported that available phosphorus and potassium concentrations in soil increased due to farmyard manure application. Supply of MSWC to soil led to an increase in extractable Cu, Fe, Zn and Mn concentrations of soil (Table 7). Saha *et al*. [18] reported that Negative effect of $CaCO_3$ on extractable Cu in acidic soils could be deducted by addition of organic fertilizer. Zhou and Wang [19] showed that soluble organic matter increased Cu extractability, especially in calcareous soils. Bevacqua and Mellano [13] noted that extractable Zn concentration increased from 3.6 mg kg^{-1} in control to 4.9 and 7.2 mg kg^{-1} in control pot, when 37 and 74 ton ha^{-1} compost were applied, respectively.

In our study Fe, Cu, Zn and Mn concentrations increased from 4.7, 4.5, 1.4 and 2.3 mg kg^{-1} in check pots to 13.8, 9.9, 4.1 and 6.4 mg kg^{-1} in 4% treatment (f). The ratios of extractable Fe, Cu, Zn and Mn concentrations in without leaching treatments (f) to with leaching treatments (g) were 1, 1.36, 1.48 and 1.5, respectively (Table 6).

The major obstacle for long-term use of MSWC is its induced salinity in the soil after harvesting the plants. Improper and/or long-term, addition of organic fertilizers might lead to the accumulation of soluble salts in the soil and, thus, compost leaching is recommended as a way to preventing the accumulation of the excess salts beneath the root zone. Land application of MSWC, however, offers the most practical means for managing the large amounts of these biosolids produced. For this reason, the proper management of MSWC and periodic monitoring of soil fertility and productivity parameters and environment quality are needed to ensure successful, safe and long term use of these materials on agricultural lands.

The highest shoot and root dry matter were produced with fertilized soil by MSWC at 4% level.

The high tolerance of this crop to salinity in our greenhouse studies may be due to the fact that the salinity effects might have been alleviated by the constant and adequate supply of water in the controlled environment [10]. Papadopoulos and Rendig [6] reported that plant growth can still occur if enough moisture is supplied, even at high salinity level.

The concentration of N in the soybean plant increased significantly as the level of MSWC by 71% at 2% treatment (d) in shoot and 25% at 4% treatment (f) in soybean seed. Increasing in N concentration suggests that MSWC is good N source for soybean plant. The results of this experiment demonstrate the importance of MSWC on soybean growth. Due to MSWC increased most of nutrient elements, so it recommended for Soybean plants because of its positive effects on nutrient concentration and plant growth.

REFRENCES

1. McCornnell, D.B., A. Shiralipour and W. Smith, 1993. Compost application improves soil properties. Biocycle., 34(4): 61-63.
2. Soil Survey Staff. 2006. Keys to soil taxonomy. 10th Ed., U. S. Govern, Print. Office, Washington, DC.
3. Sparks, D.L., 1996. Methods of soil analysis. Part 3, 3rd Ed., American Society of Agronomy: Madison, WI.
4. **Missing**
5. **Missing**
6. Papadopoulos, I. and V.V. Rendig, 1983. Tomato plant response to soil salinity. Agron. J., 75: 696-700.
7. Wang, S.H.I., V.L. Lohr and Coffey D.L Coffey, 1984. Spent mushrum compost as a soil amendment for vegetables. J. Am. Soc. Hort. Sci., 109: 698-702.
8. Hegde, D.M., 1996. Long-term sustainability of productivity in an irrigated sorghum-wheat system through integrated nutrient supply. Field. Crop. Res., 48: 167-175.
9. Cabral, F., E. Vasconcelos and M.D.S. Cordovil, 1998. Effect of solid phase from pig slurry on iron, copper, zinc and manganese content of soil and wheat plants. J. Plant Nutr., 21: 1955-1966.
10. **Missing**
11. Ismail, A.S., A.S. El-Sebaay, S.A. Saleh and A.F. Abdel-Wahab, 1996. Effect of application of mineral and organic amendments on nodulation, cowpea growth and certain chemical properties of calcareous soils. Proceedings of the sixth conference of Agricultural Development Res., 17-19 December.
12. Pratt, P.F., 1984. Salinity, sodium and potassium in an irrigated soil treated with bovine manure. Soil Sci. Soc. Am. J., 48: 823-828.
13. Bevacqua, R.F. and V.J. Mellano, 1994. Cumulative effects of sludge compost on crop yield and soil properties. Commun. Soil Sci. Plant Anal., 25: 395-406.
14. Whalen, J.K. and C. Chang, 2001. Phosphorus accumulation in cultivated soils from long term annual applications of cattle feedlot manure. J. Environ. Qual., 30: 229-237.
15. Whalen, J.T., C. Chang, G.W. Clayton and J.P. Carefoot, 2000. Cattle manure amendments can increase the pH of acid soils. Soil Sci. Soc. Am. J., 64: 962-966.
16. McAndrews, G.M., M. Liebman, C.A. Cambardella, and T.L. Richard, 2006. Residual effects of composted and fresh solid swine (*Sus scrofa* L.) manure on soybean [*Glycine max* (L.) Merr.] growth and yield. Agron. J., 98: 873-882.
17. Gupta, A.P., R.P. Narwal and R.S. Antil, 2002. Nitrogen and phosphorus responses to wheat under FYM application. 17th wcss, paper no. 927: 14-21 august 2002, Thailand.
18. Saha, J.K., T. Adhikari and B. Mandal, 1999. Effect of lime and organic matter on distribution of zinc, copper, iron and manganese in acid soils. Commun. Soil Sci. Plant Anal., 30: 1819-1829.
19. Zhou, L.X. and J.W.C. Wang, 2001. Effect of dissolved organic matter from sludge and sludge compost on soil copper sorption. J. Environ. Qual., 30: 878-883.

00\. Cario. *Annals of Agricultural Science Cario*. 1996. Special Issue, 23-39: 17 ref.

00\. Maftoun, M., F. Moshiri, N. Karimian and M. Ronaghi, 2004. Effects of two organic wastes in combination with phosphorus on growth and chemical composition of spinach and soil properties. J. Plant Nutr., 27(9): 1635-1651.