Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2012, 3 (2):1094-1101
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Comparison of three techniques for estimating phytotoxicity in municipal solid waste compost

Mohammad R. Asgharipour* and Ali R. Sirousmehr

College of Agriculture, University of Zabol, Zabol, Iran

ABSTRACT

Municipal solid waste compost can provide a rich organic nutrient source and soil conditioner for agricultural and horticultural applications. To comparison three techniques of estimating phytotoxicity of municipal solid waste compost, the effect of different aqueous extracts obtained from municipal solid waste compost and different mixing ratios of sand-compost on the seed germination and early seedling growth of cress (Lepidium sativum L.), isabgol (Plantago ovata Forsk) and cumin (Cuminum cyminum L.) were studied by bioassay. The aqueous extracts of compost strongly inhibit plant germination and root growth of cress. The germination index values obtained for compost extracts were low, when compared with that of the control. Latent toxicity of compost for different plant species seemed not to be severe. However, when cress, isabgol and cumin were germinated in a sand-compost mixture (25:75 and 50:50), germination of cress was completely inhabited, with a sever reduction of the isabgol and cumin root growth. To avoid negative effects of compost on crop, routine germination bioassay should be included in education program for farmers. This showed enhance marketing and consumer acceptance of municipal solid waste composts.

Keywords: Compost, germination, bioassay, cress, Germination Index.

INTRODUCTION

Urbanization and industrialization, especially in developing countries, has accumulated huge amount of municipal wastes. High requirements of energy for municipal waste incineration and limitation that exist in the landfills, as well as many other environmental issues focused attention to waste recycling and compost application to agricultural lands [11]. In recent years, activities have been done in municipal solid waste recycling in Iran.

In the municipal solid waste recycling plant of Mashhad and similar factories in Tehran, Karaj, Isfahan and Shiraz, massive amounts of daily urban waste is converted into compost. In recent years the research on the effects of compost on physic-chemical properties of soil showed that [4, 11] addition of compost to soil increase organic matter and nutrient (micro and macronutrients) of soils, improve soil physical properties. Compost has more than 1.5% Nitrogen (N), which is a good source of N for plants. In addition to, compost supplies partial requirements of plant to phosphorus and micronutrients [15]. Studies of Bahremand et al. [2] on short and medium term effects of various organic fertilizers (sewage sludge, municipal solid waste compost and cow manure) on soil physical properties revealed that solid waste compost and sewage sludge incorporation into soil increase aggregate stability.

Demand for compost waste application on agricultural land is increasing. In comparison with chemical fertilizers, the municipal waste compost, contains relatively low amounts of mineral elements [19]. Low nutritional value of compost along with low mineralization rate of compost may cause the plants to require a large quantity of compost in order to supply their needs to nitrogen and phosphorus [9]. Heavy metals in municipal waste compost in associated with irrigation water may be permeate into the ground water or increase heavy metals content of soil and plant and will be harmful for germination, growth and yield of crops. Therefore, researchers should study the effects of municipal waste compost on germination, emergence and early stages of plant growth.

Compost maturity can be assessed using physical, chemical or biological technique [10]. Toxicity to plants (phytotoxicity henceforth) is one of the most important criteria to evaluate the suitability of compost in agricultural crops [3, 5, 21]. Phytotoxicity mainly caused by increasing the solubility of heavy metals, or toxic substances such as ammonium, ethylene oxide and organic acids [10].

Germination Index (GI) is one of the most important factors for evaluating compost. A large number of previous studies are about the crop response to compost based on assessment of its positive effects on growth and yield in an attempt to determine the appropriate amount of compost used for different crops [9, 12], and few reports are available about the negative effects of compost in the early stages of germination and growth. More studies are essential on the effects of compost, especially in plants such as cress (*Lepidium sativum* L.) or other medicinal plants which are sensitive to toxic substances [8]. The present experiment was performed to compare three techniques of evaluating phytotoxicity of municipal solid waste compost on germination and early growth of three plants of cress, isabgol (*Plantago ovata* Forsk) and cumin (*Cuminum cyminum* L.).

MATERIALS AND METHODS

Compost characterization

Compost used in this study was purchased from the compost factory in Mashhad, Iran. Table 1 shows some physicochemical characteristics of the soil and compost.

Phytotoxicity test of compost on cress developed by Zucconi
Cress was selected for this bioassay due to having a good response to toxic materials and also its rapid and easy germination [24]. For evaluation phytotoxicity of compost, samples of compost were mixed with water to 120% humidity (in terms of weight-by- weight, w/w). Aqueous extract of the mixture centrifuged for 30 min at 70 °C. Half a milliliter of solution containing 10% or 30% extract of compost (the most suitable concentration for toxicity assessment based on Zucconi et al., 1985 [24]) was added to a Petri dish containing 10 seed of cress. A no-extract control treatment, were only deionized water was added to the soils, was included to determine whether each extract caused a response.

After 24 hours storage at 27 °C in the dark, 1 ml of ethanol (50%) was added to Petri dishes to stop the germination. A seed is classified as germinated once the radicle is 4X the length of the seed coat [22]. The number of germinated seeds and the radicle length were measured and expressed as percentage of the control.

Germination Index was calculated using the following formula:

$$\text{Germination Index (GI)} = \Sigma\ (Gt/Tt),$$

where Gt is the number of seeds germinated on day t and Tt is the number of days [17].

Germination and seedling growth bioassays were conducted in a complete randomized design (CRD) with four replications and the mean values were separated on the basis of Duncan Multiple Range Test (DMRT) at a probability level of 0.05.

Assessment latent toxicity of compost
Latent toxicity of compost was estimated using the methods described by Zucconi et al. [24]. Briefly, this test consists of making a mixture of compost and water (10% W/W), incubation of mixture at 27 °C for 10 days under aerobic conditions. Then, this extract was filtered (using Whatman filter paper No. 42). Stock solution was diluted appropriately with distilled water to give the final concentrations of 10% and 30%.

Ten seeds of cress, cumin or isabgol then germinated in sterilized Petri dishes, 100 mm in diameter, on filter-paper moistened with 0.5 mL of either 10% or 30% solution. Distilled water was the control.

After 48, 72 and 96 h of wetting, seed germination percentage, GI and root length was measured. Each treatment was repeated 5 times. Data analyzed using a completely randomized design, and the mean values were separated on the basis of DMRT at a probability level of 0.05.

Sowing of seeds in a mixture of sand and compost
Another germination test was conducted on cress, cumin and isabgol using a mixture of sand and compost. Ten seeds of cress, cumin or isabgol were planted in a mixture of sand and compost. Compost and sand were mixed (volume basis) at mixing ratios of 75 to 25 and 50 to 50 compost and sand. Experimental design used in this study was a completely randomized design with six replications. Six containers filled with sand were tested as a control. The containers kept

saturated by regular watering. After 48, 72 and 96 h, the number of emerged seed were counted. Then, seedlings were harvested and GI and length of radicle and shoot was measured.

RESULTS AND DISCUSSION

Toxicity test of compost on cress

Harmful impact of compost especially low-quality compost produced from municipal solid waste on germination and early growth of crop have been widely reported [20, 21]. Decomposition in the compost continues without complete stabilization process. Decomposition of compost produces the secondary metabolites which create an unpleasant odor and can be toxic to plants and affect germination and emergence of crops [24].

The results of the germination, radicle length and GI of cress seeds after 24 h as affected by the 0.5 ml of 10% and 30% extract of compost are presented in Fig 5 a, b and c.

Germination percentage, radicle length and GI differ among different extract of compost. In this study, extract of compost produced smaller seedlings in comparison with the control. Hoekstra et al. [8] in their study on effects of cattle dung on germination and initial root growth of cress achieved similar results.

Assessment latent toxicity of compost

This bioassay was done for assessment of compost phytotoxicity. The results showed that in the cress germination completed after 48 h in distilled water. With regard to compost extract, however, 96 h was not enough for complete germination and the seeds germinated until the third day. Compost extracts significantly reduced germination of cress seed compared to the control. No statistically significant differences have been found to exist for radicle length after 48 h between the both extracts of compost and control, while after 72 and 96 h, seedling grown with compost extracts had lesser radicle length compared with that of the control. Strong correlation exists between germination and root length with degree of compost maturity [6]. Germination index has been used in many studies as a method for evaluating the quality of compost [14]. Observed inhibitory effect of compost extract on germination and growth of young seedlings is probably due to the high EC [1], and other toxic compounds such as ammonia [7], heavy metals [1], ethylene oxide [23], short-chain aliphatic acids [16] and various phenolic compounds produced during anaerobic decomposition [13, 24] in the compost.

Toxic compounds present in the compost extract had little impact on seed germination of isabgol and cumin. This could possibly be due to the lesser sensitivity of these plants than cress to substances that inhibits germination. The effect of 10% and 30% extracts of compost on radicle length only at 48 h after wetting seeds was evident. Effect of fertilizers decreased with time at 72 and 96 h. Cumin and isabgol root length was significantly different from control only in the third and fourth days. On the fourth day soaked seeds in the 30% of extract had greater radicle length in comparison with that of the control. Germination index 10% and 30% extracts for all three species were greater in comparison with that of the control (Table 1).

Lower latent phytotoxicity of compost than phytotoxicity of compost may be due to rapid decomposition of compost during the 10-day of aerobic condition. Zucconi et al. [25] argued that latent phytotoxicity of compost is associated with duration of aerobic degradation of compost.

Table 1: Physicochemical characteristic of soil and compost

Parameter	EC* (dS m^{-1})	pH	OM⁺	Total N	P	K	Na	Fe	Cu	Mn	Zn	Pb	Ni	Cd	Cr	Co
			(%)	(g kg^{-1})				(mg kg^{-1})								
Soil	2.3	7.2	0.2	0.04	1.7	0.6	1.4	21	16	22	23	2	3	0.3	1.4	3
Compost	7.7	7.5	58.3	2.67	28.9	2.7	2.49	798	139	173	634	80	19	3.6	30.4	15

* *Electrical Conductivity*
⁺ *Organic Matter*

Table 2- Effect of extract concentration on germination percentage, radicle length and Germination index of cress, cumin and isabgol

Plant	Time (h)	Extractconcentration(%)	Germination(% compared with control)	Radicle length(mm)	Germination index (%)
Cress	48	0	100 a	11.4 a	100.0 a
		10	70 b	11.5 a	70.6 b
		30	68 b	12.1 a	72.2 a
	72	0	100 a	17.4 a	100 a
		10	94 a	16.3 a	88.6 b
		30	86 b	14.2 b	70.2 c
	96	0	100 a	23.4 a	100.0 a
		10	94 a	21.3 b	85.6 b
		30	98 a	20.7 a	86.7 b
Cumin	48	0	22	0.8	100.0
		10	-	-	-
		30	-	-	-
	72	0	48 a	5.9 a	100.0 a
		10	22 b	6.6 a	51.2 b
		30	26 b	5.3 b	48.7 c
	96	0	52 a	14.9 b	100.0 a
		10	46 b	15.7 a	93.3 b
		30	50 a	14.6 b	94.2 b
Isabgol	48	0	12	2.0	100.0
		10	-	-	-
		30	-	-	-
	72	0	46 a	4.7 a	100.0 a
		10	48 a	4.1 b	91.7 b
		30	40 b	4.9 a	90.2 b
	96	0	54 a	11.4 c	100 a
		10	48 b	10.6 c	82.6 c
		30	46 b	12.6 a	94.2 b

* *Values followed by the same letter within the same columns do not differ significantly at P = 5% according to DMRT.*

They indicated two-months of aerobic decomposition completely eliminate phytotoxicity of compost.

Sanchez-Monedero et al. [18] in a similar experiment reported a positive correlation between extract concentration and decrease in germination rate. Eklind et al. [6] observed that household waste compost or chicken manure reduced the growth and germination of lettuce seeds.

Sowing of seeds in a mixture of sand and compost

In order to evaluate the direct effects of compost on the germination and development of root system, the effect of mixing ratios of sand-compost on the seed germination and early seedling growth of cress, isabgol and cumin were studied. Seeds of cress, isabgol and cumin were planted in a container containing mixtures of sand and compost. The compost in both mixing ratios completely stopped germination of cress seeds and strongly reduced germination of cumin and isabgol seed. Strong inhibitory effect of compost on germination of three species was due to high EC and high amount of sodium in municipal solid waste compost.

Table 3- Effect of different mixing ratios of sand:compost concentration on germination percentage, radicle length and Germination index of cress, cumin and isabgol

Plant	Time (h)	Mixing ratios of sand-compost(%)	Germination(% compared with control)	Radicle length(mm)	Germination index (%)
Cress	48	100:0	100 a	11.5 a	100 a
		75:25	0 b	0 b	100.8 a
		50:50	0 b	0 b	105.2 a
	72	100:0	100 a	21.1 a	100 a
		75:25	0 b	0 b	93.7 b
		50:50	0 b	0 b	81.6 c
	96	100:0	100 a	31.0 a	100 a
		75:25	0 b	0 b	85.6b
		50:50	0 b	0 b	86.7 b
Cumin	48	100:0			
		75:25	100 a	6.9 a	100
		50:50	54 b	2.4 b	-
	72	100:0	48 b	3.3 b	-
		75:25	100 a	13.2 a	100 a
		50:50	44 b	5.7 b	51.2 b
	96	100:0	54 b	4.6 b	48.7 c
		75:25	100 a	17.9 a	100 a
		50:50	76 b	6.5 b	93.3 a
Isabgol	48	100:0	55 b	8.8 b	94.2 a
		75:25			
		50:50	100 a	5.4 a	100
	72	100:0	37 b	1.0 b	-
		75:25	72 b	1.3 b	-
		50:50	100 a	10.1 a	100 a
	96	100:0	64 b	5.5 b	91.7 b
		75:25	44 b	3.7 b	90.2 b
		50:50	100 a	14.9 a	100 a

** Values followed by the same letter within the same columns do not differ significantly at P = 5% according to DMRT.*

Plant root system development in isabgol and cumin was greater at control in comparison with both mixtures of sand and compost. These findings indicate direct negative effects of compost with the seeds and young seedlings despite the low toxicity of the compost extract. Therefore, direct contact of seed and plant root system with compost should be avoided. The non-uniform germination or damage to plants in the early stages of growth has a negative impact on final yield of crop.

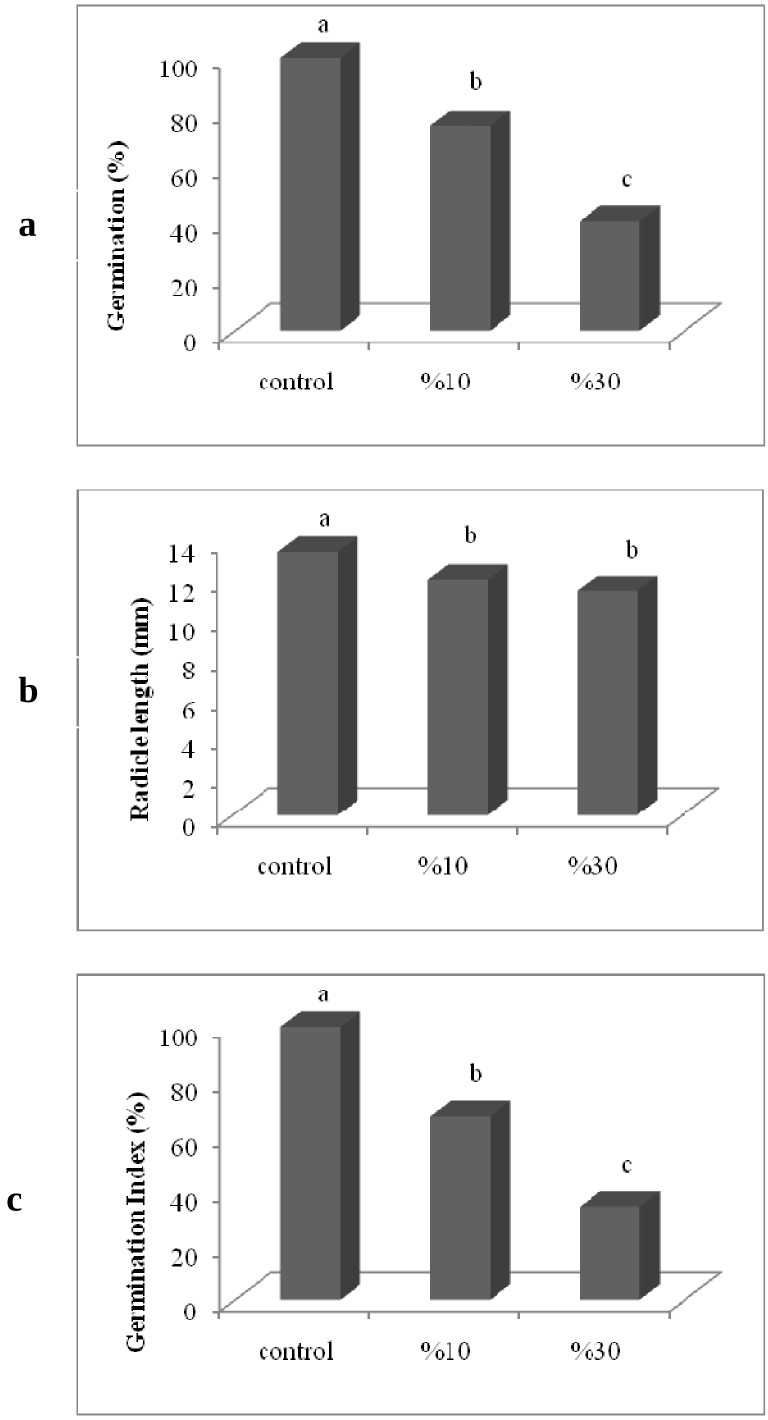

Fig. 1- Effect of extract concentration on germination percentage (a), radicle length (b) and Germination index (c) of cress, cumin and isabgol. Values followed by the same letter within the same columns do not differ significantly at p =5% according to DMRT.

CONCLUSION

The results showed that simple bioassay consists of planting seeds in the mixture of sand and compost and monitoring of early root growth can be more useful than bioassay of cress suggested by Zucconi et al. [25]. Toxicity testing of compost before application of compost by farmers with training programs can be helpful in expanding the use of these valuable products.

REFERENCES

[1] F.E. Allison; Soil Organic Matter and Its Role in Crop Production, Elsevier, Amsterdam, **1973.**
[2] M.R. Bahremand, A. Ghabool, M.A. Hadjabbasi, Y. Rezaiinezhad, *Journal of Agricultural Sciences and Natural Resources*, **2003**, 6: 1-9. (text in Persian with English abstract)
[3] L.J. Brewer, D.M. Sullivan, *Compost Science*, **2003**, 11, 96–112.
[4] F. Caravaca, D. Figuerou, M.M. Alguacil, A. Roldan, *Bioresource Technology*, **2003**, 90: 65-70.
[5] L.R. Cooperband, A.G. Stone, M.R. Fryda, *Compost Science*, **2003**, 11, 113–24.
[6] Y. Eklind, B. Ramert, M. Wivstad, *Biology and Horticulture*, **2001**, 19, 157–181.
[7] J.E. Ells, A.E. McSay, S.M. Workman, *Horticultural Science*, **1991**, 26, 380-383.
[8] N.J. Hoekstra, T. Bosker, E.A. Lantinga, *Agr. Ecosyst. Environ*, **2002**, 93, 189-196.
[9] S.B. Hornik, L.J. Sikora, S.B. Sterret, J.J. Murray, J.D. Milner, J.F. Parr, R.L. Chaney, G.B. Willson, Agriculture Information Bulletin, No. 464. USDA. US Govt. printing office, Washington DC. **1984**.
[10] E.I. Jiménez, V.P. Garcia, *Biolgical Wastes*, **1989**, 27; 115-42.
[11] A. Khoshgoftarmanesh, M. Kalbasi, *Journal of Agricultural Sciences and Natural Resources*, **2003**, 6, 141- 148. (text in Persian with English abstract)
[12] J.S. Levy, B.R. Taylor, *Bioresource Technology*, **2003**, 89, 297-305.
[13] S.P. Mathur, G. Owen, H. Dinel, M. Schnitzer, *Biology and Horticulture*, **1993**, 10, 65-85.
[14] M. Ozores-Hampton, P.J. Stoffella, T.A. Bewick, D.J. Cantliffe, T.A. Obreza, *Compost Science and Utility*, **1999**, 7, 51-57.
[15] M.D. Perez-Murcia, R. Moral, J. Moreno-Caselles, A. Perez-Espinosa, C. Paredes, *Bioresource Technology*, **2006**, 97, 123-130.
[16] F. Pinamonti, G. Zorzi, In: M. de Bertoldi, P. Sequi, B. Lemmes, (Ed.), The Science of Composting. Blackie Academic and Professional, London, **1996**, 515-527.
[17] S. Ruan, Q. Xue, K. Tylkowska, *Seed Science & Technology*, **2002**, 30, 61-67.
[18] M.A. Sanchez-Monedero, M.P. Bernal, A. Anton, P. Noguera, A. Abad, A. Roig, In: J. Cegarra (Ed.), Congreso Iberico Nacional de Fertirrigacion, 12-15 Aug. **1997**, Murcia, Spain.
[19] L.J. Sikora, N.K. Enkiri, *Sol Sáciense*, **1999**, 56: 125-137.
[20] G.L. Terman, J.M. Soileau, S.E. Allen, *Journal of Environmental Quality*, **1973**, 2: 84-90.
[21] S.M. Tiquia, N.F.Y. Tam, *Bioresource Technology*, **1998**, 65, 43-49.
[22] USEPA (US Environmental Protection Agency); Seed Germination/ Root Elongation Toxicity Test. EG-12. Office of Toxic Substance, Washington DC, **1982**.
[23] M.H. Wong, Y.H. Cheung, C.L. Cheung, *Environmental Pollution*, **1983**, 30, 109-123.
[24] F. Zucconi, A. Monaco, M. Forte, In: J.K.R. Gasser (Ed.), Composting of Agricultural and Other Wastes, Elsevier, New York, **1985**, 73-86.
[25] F. Zucconi, M. Forte, A. Monaco, M. De Bertoldi. *Bio Cycle*, **1981**, 22, 27-29.