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EFFECTS OF COMPOST PRODUCTS ON SEED GERMINATION OF VEGETABLES*

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Summary: *The aim of this work is determination of influence of different compost leachates and teas types on vegetables seed germination. Composts used for leachate and tea production were produced of municipal waste (MSW) and waste from tobacco industry (TW). Results achieved with MSW products were comparable to control. Compost products derived from TW showed significant phytotoxicity, which can be correlated with their chemical composition. Leachates from MSW compost lead to the lower germination index in comparison to MSW compost teas, which indicates the possibilites their application.*

Key words:Compost products, germination index, vegetables seed germination, waste

INTRODUCTION

Growth media, mainly comprised of organic matter, fertilizer and soil, is often used for horticultural plants (Boldrin et al., 2010) and vegetables (Arenas et al., 2002). One of the most important highly valuable, cost-effective and environmental friendly organic components for vegetables growth medium is peat (Herrera et al., 2009; Ingelmo et al., 1998). However, the excessive use of peat leads to the release of CO_2 counted as a greenhouse gas (Boldrin et al., 2010). Several studies have addressed the use of compost from different waste materials as an alternative to peat for growth of vegetables (Sterrett, 2001). The application of compost improves the characteristics of growth substrates (Keserović et al., 2012) and increases organic matter and nutrients content for plant growth (Darby et al., 2006). Problems of waste disposal and low content of organic matter in soils can be solved by application of composted municipal solid waste (MSW), which is suitable for agriculture due to its positive effects on soil properties (Wolkowski, 2003). Similar effects, due to high nutrients content (Chaturvedi et al., 2008) and low content of toxic elements (Okur et al., 2008), shows tobbaco waste (TW) and its composting is useful for agricultural purpose (Saithep et al., 2009).

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As a new approach, compost leachates and teas have a vital role in providing of nutrients for plant growth (Mesbahzadeh and Astaraei, 2008). For the phytotoxicity evaluation of these products, one of the suggested methods is germination index test, based on seed germination and initial growth of plants (Sanchez-Monedero et al., 2002). Because initial phases of plant growth are fundamental, the aim of this paper was to determinate the influence of different compost leachates and teas on vegetables seed germination.

MATERIAL AND METHODS

For preparation of compost products, two composts were used: (i) MSW compost from Čačak municipality (Serbia) and (ii) TW compost, obtained from tobacco waste of „Philip Morris International“ company (Niš, Serbia). In order to obtain compost, waste material was periodically turned and aerated. These 1-year-old composted materials were passed (< 7mm) and 5 hours after addition of water until the complete saturation, extraction of leachates was performed. The compost teas were prepared from the same compost materials and water (1:3, w/w). Extraction period lasted for 10 days with continuous aeration by aquarium pumps.

The electrical conductivity (EC) of compost products was measured by Conductivity Meter LF 538 (Windaus Labortechnik WTW, Germany), and pH by pH-meter CyberScan pH 510, Eutech Instruments (Singapore). Humic and fulvic acids were determined according to Jakovljevic et al. (1995). The total carbon content (C_{tot}) was determined by the dichromate oxidation method. The excess of the dichromate was determined according to Yeomans and Bremner (1989). The total nitrogen (N_{tot}) was estimated by Kjeldahl method (Bremener and Mulvaney, 1982). For determination of metal content, 1 g of air dried samples were 4-hours-shaked with 20 mL 0.5% NaEDTAextractants and after filtration samples were subjected to microwave acid (5 mL HNO_3+2 mL H_2O_2) digestion (Speedwave MWS3, Berghof, Germany) using 5 mL HNO_3 conc. (70%)+2 mL H_2O_2 (33%) and measured by ICP-OES (Spectro Genesis FEE, Germany).

The tested seeds of plants (green beans-*Phaseolus vulgaris* L., cabbage-*Brassica oleracea* L., pepper-*Capsicum annuum* L. and lettuce-*Lactuca sativa* L.) originated from Institute for vegetable crops ltd. (Smederevska Palanka, Serbia), while tomato seeds (*Solanum lycopersicum* L.) were obtained from “Superior seeds” (Velika Plana, Serbia). Ten seeds of green beans, 20 seeds of tomato and pepper, 30 seeds of cabbage and 50 seeds of lettuce) were sterilized with $H_2O_2$for 30 seconds, washed with distilled water and placed on filter paper (previously impregnated with 1 mL of compost products, separately) in each Petri dish. In control variant filter paper was impregnated with distilled water. All experiments were performed in triplicate, in darkness at the temperature of 25°C for 7 days. The germination rate was determined at the end of experiment.

The potential phytotoxicity of compost products was determined using the seed germination test. For this test, compost products were diluted with distilled water to yield 0, 25, 50, 75, and 100% extracts. According to ISO 11269-2 (1995) directions, ten seeds of lettuce and barley (*Hordeum vulgare* L.) were placed in Petri dishes on filter paper previously treated with 5 mL of adequate treatment extract, while in control with 5 mL of distilled water, with three replicate per treatment. Seeds were germinated at 25ºC in darkness, and after 5 days the number of germinated seeds was counted and root length was measured in each Petri dish.

The germination index (GI) was determined according to the following formula: (GxLx100%)/(Gic x Lc) where G and L are respectively the percentage of germination and mean root length of treatments, while GIc and Lc are respectively the mean germination rate and root length of control plates.

The data was subjected to ANOVA using MSTAT-C statistical computer package (Michigan State University, East Lansing, MI,USA). The LSD test (p = 0.05) was used for treatment means comparison.

RESULTS

Chemical analysis showed high pH values of compost products (Table 1) and low EC values. The values of chemical parameters of TW products were higher than in MSW products.

Table 1. Chemical properties of compost leachates and teas

	leachates		teas	
Parameter	MSW	TW	MSW	TW
pH	7.10	7.70	7.75	7.20
Dry matter (%)	0.401	1.632	0.207	0.263
ash (%)	0.374	0.893	0.186	1.100
organic matter (%)	0.027	0.740	0.021	1.531
N_{tot} (mg/L)	22.4	426.0	10.5	704.5
C_{tot} (mg/L)	81.5	5217.0	37.0	7825.0
C_{org} in humic acids/C_{org} in fulvic acids	1.2:1	1.0:1	1.8:1	0.9:1
C/N	3.7:1	12.2:1	3.5:1	11.1:1
EC (mS/cm)	5.19	9.78	2.61	13.81
salts (mg/L)	3321.5	6259.0	1668.5	8838.0
K (mg/L)	705	2812	356.5	3750
Na (mg/L)	182	9	85	14
Ca (mg/L)	482.5	255	352	972
Mg (mg/L)	95.5	160	104	436
P (mg/L)	0.4	3.4	0.4	15.6
S (mg/L)	334	201	150.5	222.0
Fe (mg/L)	1.9	11.7	5.2	17
Mn (mg/L)	0.47	1.01	0.25	2.50
Cu (mg/L)	0.11	1.36	0.11	2.25
Zn (mg/L)	0.11	3.75	0.09	4.75
B (mg/L)	0.98	2.21	0.84	3.51
Co (mg/L)	0.005	0.099	0.005	0.127
Mo (mg/L)	0.06	0.03	0.02	0.03
Cd (mg/L)	0.002	0.043	0.004	0.057
Cr (mg/L)	0.01	0.13	0.04	0.23
Ni (mg/L)	0.05	0.20	0.07	0.25
Pb (mg/L)	0.04	0.24	0.04	0.29

The germination rate of plant seeds was affected by compost product types and its origin (Table 2). Statistically significant influence of vegetables seeds on germination rate was noticed.

Table 2. Influence of plants and compost products on germination rate (%)

Factors	Parameters	Control	MSW	TW
A Plant seeds	Green beans	93.3±2.108ab	90.0±5.164ab	88.3±4.014a
	Cabbage	91.1±1.391ab	72.2±4.439b	0.0±0.00c
	Tomato	90.0±0.00b	80.8±8.795ab	40.8±16.094b
	Pepper	55.0±3.651c	30.0±8.062c	0.8±0.833c
	Lettuce	96.7±0.843a	97.7±0.954a	0.00±0.00c
B Products	Leachates	85.2±4.258a	81.4±5.389a	20.0±9.844b
	Teas	85.2±4.259a	66.9±8.399b	32.0±10.553a
AXB	Plant seeds x leachates	93.3±3.33a	80.0±5.773b	93.3±3.33a
		91.1±2.20a	81.1±2.967b	0.0±0.00c
		90.0±0.00a	100.0±0.00a	5.0±2.887c
		55.0±5.773b	46.7±6.009d	1.7±1.67c
		96.7±1.33a	99.3±0.667a	0.0±0.00c
	Plant seeds x compost teas	93.3±3.33a	100.0±0.00a	83.3±6.67b
		91.1±2.20a	63.4±3.33c	0.00±0.0c
		90.0±0.0a	61.7±4.409c	76.7±1.66b
		55.0±5.773b	13.3±3.33e	0.0±0.00c
		96.7±1.33a	96.0±1.154a	0.0±0.0c
A		*	*	*
B		NS	*	*
AXB		NS	*	*

Values within each column labeled with the same letter are insignificantly different at the $p \leq 0.05$ by LSD test

In general, the compost products showed lower seeds' germination rate compared to the control (Table 2). The germination rate using MSW leachate was highest at lettuce and lowest at pepper, while both TW products led to the lowest germination rate at cabbage, pepper and lettuce seeds. However, these TW products induced the highest germination rate at green beans and tomato seeds. MSW leachate has significant influence on pepper, cabbage and lettuce seed germination compared to MSW compost tea, especially at tomato seed.

As can be seen froma table 3, in most of treatments using the TW products, germination index was 0. On the other hand, only 100% and 75% dillution of MSW products had GI values close to 50.

Table 3. Germination index of lettuce and barley seeds treated with leachates and teas

Plants	Compost products' dillution	Leachates		Teas	
		Germination index (%)			
		MSW	TW	MSW	TW
Lettuce	100	25.4	0	52.8	0
	75	30.7	0	58.3	0
	50	52.1	0	68.7	0
	25	73.4	0	132.1	0
Barley	100	44,0	0	95.3	0
	75	58,0	0	83.4	0
	50	86,0	0	93.2	0
	25	98,0	2,8	92.0	37.7

DISCUSSION

Different types of waste are diposed off in landfills (Chatterjee et al., 2013). As showed previously, more than 50% of wastes are potentially biodegradable (Engineering Solutions and Design, Inc., 2004). By composting as a promised activity, waste is turned into a soil conditioner and can be used in agricultural production (Hart and Pluimers, 1996).

Lower EC values comparing to previous research (Mokhtarani et al., 2012) were obtained. Also, the concentrations of K, Mg, Zn and Cu in TW products resulted in higher EC, which has been also confirmed (Pant et al., 2012). Heavy metal content of the products was lower than proposed values (Jones-Lee and Lee, 1993), thus avoiding possible metals precipitation at high pH values (Esakku et al., 2003).

Germination rate of examinated seeds in control treatment was higher compared to compost products treatments. These results are similar with the findings of Ingelmo et al. (1998) who studied different organic amendments added to soil.

The lowest germination rate at cabbage, pepper and lettuce seeds on tobacco products can be correlated with salinity of these products, which inhibit the seed germination (Marchiol et al., 1999). The similar influence of TW on tomato seeds was obtained in previous research (Okur et al., 2008). On the other side, results of some other authors confirm the negative influence of TW treatment on some properties of tomato (Chaturvedi et al., 2008).

Germination index (GI) of selected plants (lettuce and barley) has been determined because of their high sensitivity to salt concentrations and phytotoxic substances (Dolgen et al., 2004). According to criteria proposed by Zucconi et al. (1981), used leachates showed rather high phytotoxicity (Table 3). The tea production where aeration system used had less phytotoxicity compared with nonaerated production processes, which is confirmed in previous research (Carballo et al., 2009).

CONCLUSION

Our results suggest that influence of MSW compost tea and leachate on germination of vegetables seeds' germination that their phytotoxicity is excluded as a barier to their application. Probably, the increased salinity appear to be major factor of limiting use of TW compost products. Further investigation will be directed to the possible application of these products as soil amendments with the aim of improvement the agricultural production.

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UTICAJ PROIZVODA KOMPOSTA NA KLIJANJE SEMENA POVRĆA

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Izvod: Cilj ovog rada je određivanje uticaja različitih kompostnih čajeva i ekstrakata na klijanje semena povrća. Kompost korišćen za dobijanje ekstrakata i čajeva potiče od komunalnog otpada (MSW) i otpada iz duvanske industrije (TW). Rezultati postignuti sa komposnim produktima MSW su uporedivi sa kontrolom. Kompostni produkti dobijeni od TW pokazuju značajnu fitotoksičnost koja se može dovesti u vezu sa njihovim hemijskim sastavom. Ekstrakti od MSW komposta doveli su do nižeg germinacionog indeksa u poređenju sa čajevima, što ukazuje na mogućnosti njihove primene.

Ključne reči: kompostni proizvodi, germinacioni indeks, klijanje semena povrća, otpad

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