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ORIGINAL PAPER

THE EFFECTS OF SOME AGRICULTURAL WASTES COMPOSTS (PRUNNING WASTE-SPENT MUSHROOM COMPOST) ON LETTUCE GROWTH *(LACTUCA SATIVA L.)*

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Abstract

Agricultural wastes are valuable organic materials in terms of their nutrient content. These materials are often used in non-agricultural areas. Composting in the conversion of agricultural wastes to soil is the most optimum evaluation method. In this study, composts obtained from agricultural wastes were used and these composts were consisted of different agricultural wastes such as pruning wastes-PW, spent mushroom composts-SMC and at different ratios. Five different compost mixtures were added to the pot soil (1 ton ha^{-1}) and composts effects on growth and nutrient contents of lettuce were determined. The study was carried out during two successive seasons (autumn and spring). The results showed that plant growth and yield were found higher in the compost applications than in control. Generally the highest values were obtained from M1 (80%SMC+20%PW) and M2 (70%SMC+30PW) treatments for many parameters.

Key words: Pruning wastes, spent mushroom compost, lettuce growth, yield, quality

INTRODUCTION

Agricultural wastes increase in generally intensive agricultural lands and can be cause environmental problems. These wastes have not been sufficiently evaluated as organic manure (Sönmez et al., 2017a). Whereas agricultural wastes should be used in many farming models and their negative effects can be eliminated. The best method of waste evaluation is composting and organic wastes transformed into fertilizers by microorganisms under aerobic conditions (Negro et al., 1999; Golueke, 1973). In composting process, optimum parameters are as follows; C/N: 25-35:1, humidity 40-60%, temperatures 55-65^{o}C, pH:6.5-7.5 (Erdin, 2018).

Pruning wastes are composed of pruning the fruit trees and these wastes burn as a fuel in winter season in Turkey. Although the amounts of pruning wastes are not known exactly, these wastes have a seriously potential. The pruning wastes are a major source of carbon for composting (Sönmez et al., 2017b). Benito et al. (2005) stated that prunning wastes are effective in growing media mixtures and the best mixtures were obtained from prunning wastes, peat and spent mushroom compost.

Spent mushroom compost (SMC) is important organic waste and this waste occurs after mushroom production and has important organic compounds. SMC is generally thrown randomly into storage areas. Because of the rich and valuable organic matter content, spent mushroom compost can be used in agricultural lands (Szmidt and Conway, 1995; Tüzel et al., 1992). SMC is usually used as media in floriculture and organic materials for soils.

Lettuce *(Lactuca sativa L. var. longifolia)* is the major salad crop to be cultivated and it is consumed vegetable as fresh. (Deshpande and Solunkhe, 1998). Lettuce is grown in large quantities in the world and the most important producing countries of lettuce are China and the United States. Turkey's lettuce production quantity is 478.442 tons for 2016 (FAO, 2018).

In this study, prunning wastes and spent mushroom compost at different ratios was applied to soils, and the effects of these composts were determined on lettuce quality, yield and nutrient contents.

MATERIALS AND METHODS

Pruning wastes (PW) and spent mushroom composts (SMC) were mixed at five different ratios based on dry material for composting (Table 1) and mixtures were blended with mixer for homogenization. Then, mixtures prepared were used into the reactor composting system. Waste mixtures into the reactors were formed to contain 10 kg of dry material from each. Moisture of the waste mixtures was brought to 60-65% level which is the optimum level for composting process.

Table 1. The part of the agricultural wastes in compost mixtures (%)

Mixture	Prunning waste	Spent mushroom compost
M1	80	20
M2	70	30
M3	60	40
M4	50	50
M5	40	60

Composting process was conducted in the reactor-type composting system that consisted of PVC material (127 liter reactor^{-1}). Ventilation inside the reactors was provided by radial fans and temperature was measured at three different points inside the reactors (Figure 1). Composting process was carried out under controlled conditions and composts were kept waiting for maturation phase at the end of the pre-composting process.

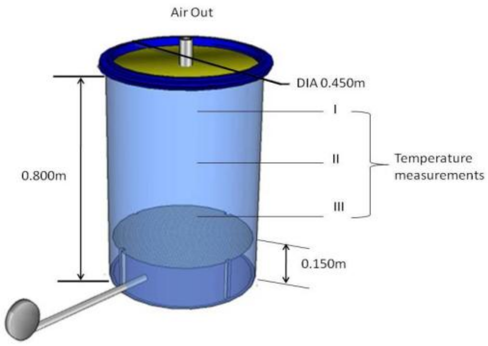

Figure 1. Properties of container composting reactor

Chemical properties of composts taken from reactors at the end of the composting process were presented in Table 2. Composts obtained from Pruning wastes (PW) and Spent mushroom composts (1 ton from each per ha^{-1}) were added to pot soil for production of lettuce (Bitez) and the pot experiment was carried out autumn (1st season) and spring (2nd season) successively. The soil was also chemically analyzed as a control and shown at Table 3.

Table 2. The analysis results of compost samples

Mixture	pH	EC dS m^{-1}	N	P	K %	Mg	Ca	Fe	Zn	Mn mg kg^{-1}	Cu
M1	7.04	3.38	1.65	1.77	1.63	0.53	3.97	5505	3394	927.6	281.0
M2	6.89	3.42	1.60	1.90	1.70	0.59	4.41	6313	2227	908.8	293.1
M3	7.17	2.98	1.50	1.69	1.58	0.53	3.97	5603	2890	816.6	258.2
M4	6.61	2.65	1.34	1.49	1.55	0.43	3.44	4588	3342	679.6	214.2
M5	6.75	2.08	1.09	1.41	1.47	0.37	3.28	3944	4212	596.2	194.6

The pot experiments (10 kg soil pot^{-1}) were established as a randomized plot design with four replications and carried out under greenhouse conditions. The cultural processes were performed during the vegetation period and experiment was completed by harvesting the plants.

Table 3. The nutrient contents of experiment soil

Parameters	Value
Total N (%)	0.07
P (mg kg^{-1})	20.2
K (mg kg^{-1})	105.7
Ca (mg kg^{-1})	2754
Mg (mg kg^{-1})	689.7
Fe (mg kg^{-1})	14.7
Zn (mg kg^{-1})	1.2
Mn (mg kg^{-1})	10.8
Cu (mg kg^{-1})	3.4

In harvested plants, head height (cm), root collar diameter (mm), leaf number (per plant), total and marketable yield and leaf color values were determined. Vitamin C (Pearson, 1970), Concentrations of K, Ca, Mg, Fe, Zn, Mn and Cu (Kacar and İnal, 2008), P (Kacar and Kovancı, 1982), N (Kacar and İnal, 2008), color values of leaves (Siomas et al., 2002; Madeira et al., 2003) were determined according to the literature.

In composts, pH (Carnes and Lossin, 1970), nitrogen (Kacar, 1972), phosphorus (Kacar and Kovancı, 1982), and K, Ca, Mg, Fe, Zn, Mn and Cu (Kacar and İnal, 2008) were determined by preferred analysis methods.

All data were subjected to analysis of variance and significance ($p < 0.05$) was detected for treatment effects, the least significant difference (Duncan) value calculated by 5% (SAS program).

RESULTS AND DISCUSSION

Plant growth and yield

The plant growth, some physical-chemical properties and yield values showed significant variation (p < 0.05–0.001) except for color values (L, Hue and Chroma), N, K concentrations and compost treatments increased with compared to control treatment. The effects of composts on some physical parameters (head height, root collar diameter, leaf number) of the lettuce are presented in Table 4.

Table 4. The effects of different composts on head height, root collar diameter, leaf number of lettuce

Combination	Head height cm		Root collar diameter mm		Leaf number per plant	
	autumn	spring	autumn	spring	autumn	spring
M1	20.0a^2	24.3a^2	20.37ab^2	25.22a^2	46.0a^2	45.3^{2}a
M2	20.5a	22.8ab	21.57a	24.59a	44.0a	42.8a
M3	19.5a	19.8bc	20.77a	19.64b	40.8ab	46.2a
M4	19.3a	19.3c	17.26b	20.19b	35.5bc	45.7a
M5	19.0a	18.8c	18.94ab	18.73bc	34.5c	45.6a
Control	12.0b	13.3d	9.17c	15.79c	26d	35.8b
Significant Level	***	***	***	***	***	**

Values are means (*n* = 4). Values in a row followed by different letters indicate significant differences (p < 0.05) between treatments according to a Duncan's multiple range test
Significance level: *** – p < 0.001

The head height values of lettuce increased with compost treatments compare to control treatment in both autumn and spring seasons. The maximum head height values were obtained from all compost treatments in autumn periods, while the maximum head height value obtained from M1 treatment in spring season. The highest values of root collar diameter were obtained from M2 and M3 treatments in autumn, M1and M2 treatments in spring season. The highest values of leaf number were obtained from M1 and M2 treatments in autumn, all compost treatments in spring season compared to control treatment. The minimum head height, root collar diameter and leaf number values were obtained from control treatment in both seasons. Increases in plant growth can be achieved by adding compost or organic material to soil (Kütük et al., 1999; Pimentel et al., 2008; Sönmez et al., 2017a).

Vitamin C values of lettuce plant were found important statistically in autumn seasons (Table 5). The maximum Vitamin C value in autumn was determined in M5 treatment. Some researchers stated that Vitamin C values of lettuce can be varied depends on different applications (Ismail and Fun, 2003; Sönmez et al., 2017a).

The effects of compost treatments on marketable-total yield of the lettuce are presented in Tables 5 and marketable-total yield of lettuce plant were found important statistically in both vegetation seasons ($p<0.001$). Marketable and total yield of lettuce increased with compost treatments compared to control. M2 compost treatment had a maximum values marketable and total yield values in autumn season while M1 compost treatment had a maximum values marketable and total yield values in spring season. Minimum yield values were obtained from control treatments all vegetation season. Some of researchers have reported that the decomposition products of organic matter contribute to soil organic matter, plant growth and yield. (Akalan, 1987; Haynes and Naidu, 1998; Polat et al., 2004; Sakara and Zhiltsov, 2007).

Table 5. Effects of different composts on Vitamin C contents, marketable yield and total yield of lettuce

Combinations	Vitamin C mg 100 g^{-1}		Marketable yield g $plant^{-1}$		Total yield g $plant^{-1}$	
	autumn	spring	autumn	spring	autumn	spring
M1	24.3b[2]	37.4	210.6ab	353.0a	252.2ab	409.9a
M2	24.7b	40.9	243.4a	260.7b	281.1a	300.4b
M3	29.9ab	44.6	204.7b	211.6c	243.8ab	248.6c
M4	27.1b	43.0	189.6b	183.8c	214.1b	215.8d
M5	36.6a	38.7	215.8ab	185.1c	242.6ab	189.1e
Control	32.0ab	35.2	145.0c	153.5d	154.0c	160.9f
Significant Level	*	ns	***	***	***	***

Values are means ($n = 4$). Values in a row followed by different letters indicate significant differences ($p < 0.05$) between treatments according to a Duncan's multiple range test
Significance level: *** – $p < 0.001$

The color values (L, Hue, Chroma) of lettuce were not found important statistically in both vegetation seasons (Table 6). There was no statistically significant difference among the compost treatments on color values of lettuce in autumn and spring seasons. All treatments were included in the same group.

Table 6. Effects of different composts on L, Hue, Chroma values (color) of lettuce

Combinations	L		Hue		Chroma	
	autumn	spring	autumn	spring	autumn	spring
M1	51.45	44.93	120.19	123.26	42.41	32.32
M2	54.84	42.63	119.58	123.83	43.42	28.62
M3	52.42	46.20	119.24	122.35	44.29	33.54
M4	50.35	44.35	121.02	123.08	40.43	33.43
M5	54.21	45.07	119.02	123.52	43.48	31.58
Control	52.85	46.44	119.17	121.93	43.92	30.62
Significant Levels	ns	ns	ns	ns	ns	ns

Values are means ($n = 4$). Values in a row followed by different letters indicate significant differences ($p < 0.05$) between treatments according to a Duncan's multiple range test
Significance levels: * – $p < 0.05$; ns – not significant

Nutrient element contents

The effects of composts on the nutrient concentrations of the lettuce plant samples are presented in Table 7 and 8. The phosphorus (spring), calcium (autumn), magnesium (spring), Fe (spring and autumn), Mn (autumn), Zn (spring), Cu (autumn) contents were found to be significant nutrient element concentrations.

Table 7. Effects of different composts on macronutrient contents of lettuce

Mixtures	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
	autumn	spring	autumn	spring	autumn	spring	autumn	spring	autumn	spring
M1	2.21	3.03	0.30	0.36a[2]	6.05	5.75	0.66ab[2]	0.76	0.32	0.26c[2]
M2	2.15	2.79	0.28	0.33a	5.20	5.34	0.62ab	0.74	0.28	0.33c
M3	1.89	2.65	0.25	0.36a	5.59	5.02	0.81a	0.95	0.33	0.48ab
M4	2.12	2.65	0.23	0.33a	5.68	5.01	0.83a	0.85	0.35	0.51a
M5	2.13	3.01	0.27	0.34a	4.74	5.46	0.64ab	0.86	0.28	0.36bc
Control	1.98	2.46	0.25	0.22b	3.70	4.28	0.49b	0.77	0.30	0.26c
Significant Levels	ns	ns	ns		ns	ns	*	ns	ns	***

Values are means (*n* = 4). Values in a row followed by different letters indicate significant differences ($p < 0.05$) between treatments according to a Duncan's multiple range test
Significance levels: * – $p < 0.05$; *** – $p < 0.001$; ns – not significant

The phosphorus concentrations of lettuce with compost treatments increased compared to control in autumn season and all compost treatments were effective. The maximum calcium concentrations of lettuce plant were determined in M3 and M4 treatments in autumn season while the maximum magnesium concentrations were determined in M4 treatment in spring season. The lowest values were obtained from control treatments. Rodrigues and Casali (1999) and Kaplan et al. (2008) stated that organic manures increase in plant nutrient contents.

The effects of composts on the micro element concentrations of lettuce plants are presented in Table 8. The maximum iron concentrations in lettuce were obtained from M5 treatments in both vegetation season and the minimum values were obtained from control treatment. The maximum Mn (autumn) and Zn (spring) concentrations of plants were determined control treatments while the maximum Cu (autumn) concentration were determined M1 treatment.

Table 8. Effects of different composts on micronutrient contents of lettuce

Mixtures	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})	
	autumn	spring	autumn	spring	autumn	spring	autumn	spring
M1	82.95c[2]	145.40c[2]	35.91ab[2]	82.46	43.12	69.58b[2]	7.59a[2]	8.13
M2	70.48c	190.98bc	38.60ab	70.69	53.19	65.49b	5.63b	7.77
M3	89.73bc	270.03abc	37.61ab	73.78	45.48	70.30b	5.20b	7.17
M4	122.58b	285.88abc	29.29b	65.40	43.94	76.82b	4.92b	6.58
M5	162.88a	358.68a	30.10b	71.65	52.17	82.03b	5.12b	7.16
Control	72.18c	340.15ab	48.77a	74.13	73.56	108.08a	5.22b	7.76
Significant Levels	***	*	*	ns	ns	**	*	ns

Values are means (*n* = 4). Values in a row followed by different letters indicate significant differences ($p < 0.05$) between treatments according to a Duncan's multiple range test
Significance levels: ** – $p < 0.01$; *** – $p < 0.001$; ns – not significant

CONCLUSION

This study was carried out to determine the effects of composts obtained from prunning wastes and spent mushroom compost on plant growth, yield and element concentrations of lettuce. The best results on lettuce growth were generally obtained from M1 *(%80PW+%20SMC)* and M2 *(%70PW+%30SMC)* applications and control application had the lowest values in many parameters. However the compost applications have increased productivity. The marketable and total yield increased with M1 and M2 compost applications compared to control. The macronutrient and micronutrient contents of lettuce increased with compost applications and composts have contributed to lettuce nutrition. Composts obtained from different organic materials, increases plant growth and the nutrient contents. For this reason composts obtained from prunning wastes and spent mushroom compost must be composted and used in agricultural lands. Thus, both environmental problems will be prevented and soil fertility will be contributed.

Composts derived from different organic materials, enhances plant growth and the nutrient contents. Therefore agricultural wastes must be composted and used in agricultural lands. By using organic waste materials, agricultural wastes will provide environmental and economic contributions.

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