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THE EFFECTS OF AGRICULTURAL WASTE COMPOSTS (BANANA PLANT WASTES-GREENHOUSE WASTES-SPENT MUSHROOM COMPOSTS) ON MINERAL COMPOSITION AND QUALITY PARAMETERS OF LETTUCE (LACTUCA SATIVA L.)

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ABSTRACT

Agricultural waste is generally disposed of without being utilized on agricultural land. It is estimated that such waste is of large volume with different types and amounts linked to production regions. Both environmental pollution and rich nutrient contents need to be converted into fertilizer. The aim of this research was to determine the effects of organic fertilizer prepared from the composting of banana plant waste, greenhouse waste and spent mushroom compost on the development, morphology and productivity of lettuce. The composts used consisted of different agricultural waste; banana plant waste (BPW), greenhouse plant waste (GPW), and spent mushroom compost (SMC). In these experiments, compost was used at 5 different levels for each 1 ton ha^{-1} of pot soil and the effects on growth and mineral nutrient contents of lettuce plants were investigated during two successive seasons (autumn and spring). The results showed that the compost treatments had positive effects on lettuce growth parameters and treatments of M3 (50%BPW+40%GPW+10%SMC) and M4 (40% BPW+50%GPW+10%SMC) in the lettuce yield values came to the forefront in both seasons compared to the control group. M1 (70%BPW+20% GPW+10%SMC) application was determined to be the best practice in mineral nutrition of lettuce.

KEYWORDS:
Banana plant waste, Greenhouse plant waste, Spent mushroom compost, Lettuce growth, Yield

INTRODUCTION

Lettuce is grown in large quantities throughout the world and the most important countries producing lettuce are China and the United States. In 2016, the lettuce production in Turkey was 478.442 tons and production area was 22.431 ha [1]. Lettuce (Lactuca sativa L. var. longifolia) is the major salad crop to be cultivated and commercialized internationally [2]. As an edible vegetable, lettuce is widely produced and consumed in Turkey. Lettuce is a salad that can be grown in open and covered conditions all year round, and is consumed as fresh greens [3].

Fertilization is the most important application that increases productivity in agriculture. Organic manures are used in conventional agriculture for the protection of soil properties and these materials consist of plant and animal wastes. Agricultural waste has generally been considered as a source of pollution and has not been sufficiently evaluated as a by-product of agricultural activity which could produce organic fertilizers by composting [4]. Agricultural wastes should be utilized in useful ways through composting which is the best transformation system for agricultural wastes. Composting is the method in which organic waste is decomposed by microorganisms under aerobic conditions [5, 6, 7]. During this process, micro-organisms break down and transform the organic matter and expose thermal energy. The optimum parameters for composting are as follows; C/N:25-35:1, humidity 40-70%, temperatures below 70ºC and preferably 55-65 ºC and pH around 6.5-7.5 [8, 9].

The disposal of agricultural waste is inevitable because increasing urbanization and populations have increased the generation of waste throughout the world [10]. It has become an important environmental problem and solutions to these problems can be expensive. In recent years in particular, the amount of agricultural waste has escalated significantly. Doran et al. [11] determined that banana plant waste could be used in agricultural areas after being composted and in this way, the mineral content of the plant increased. Elnour et al. [12] emphasized that the application of compost obtained from banana waste resulted in a significant increase in crop production and reduced the negative effect of off-season sowing. However, it is also important to

increase the adoption of compost technology on a large scale, which leads to zero waste.

Mushroom compost cannot be used for a second time in the cultivation of mushrooms because it has lost its properties. Therefore, it is discarded randomly at the periphery of agricultural areas. However, several researchers have indicated that because of the valuable organic matter content, spent mushroom compost can be used in many different ways [13, 14, 15].

The aim of this research was to determine the effects of agricultural waste on lettuce production. Therefore, greenhouse plant waste combined with used banana plant waste and spent mushroom compost at different ratios was added to experiment soils, and the effects of these materials were determined on lettuce yield, quality and nutrient contents.

MATERIALS AND METHODS

Banana plantation waste (BPW), greenhouse tomato plant waste (GPW) and spent mushroom compost (SMC) were mixed at five different ratios based on dry material for composting with a reactor-type composting system (Table 1). Organic materials used in the experiments were ground in a hammer mill prior to the composting process so as to obtain fine grains of these materials. Then, different mixtures were prepared and added into the composting system. The mixtures to be placed into the composting reactors were formed to contain 10 kg of dry material each. The humidity of the mixtures was brought to 60-70 % level which is the optimum level for the composting process and the materials were mixed until a homogenous mixture was obtained.

The composting process was carried out in compost reactors consisting of PVC (polyvinyl chloride) material covered with glass wool against heat loss. Each reactor had a volume of 127 liters and temperature-ventilation measurements that are taken at different points were recorded inside the reactors (Figure 1). Ventilation inside the reactors was measured by radial fans.

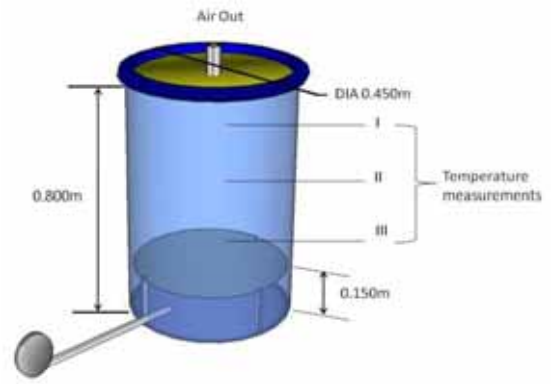


FIGURE 1
Properties of container composting reactor

The pre-composting experiments were performed within a 21-day period. In order to determine the optimum mixture ratio, the process temperatures and levels of dry organic materials were taken into consideration. Process temperatures were measured every 15 minutes. Management of the composting system was controlled by a PLC-based process control device [16]. The composting phase was conducted under controlled conditions and composts were kept in the maturation phase after the pre-composting process (Figure 2).

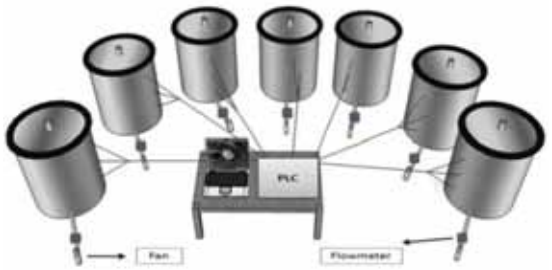


FIGURE 2
The principle of the reactor composting system

The chemical contents of the composts obtained from different agricultural wastes at the end of the composting process are presented in Table 2. Five different composts were added to pot soil (10 kg soil pot^{-1}) taking into account humidity content, so that 1 ton is ha^{-1} for the production of lettuce and the pot experiment was carried out in autumn (1st season) and spring (2nd season) successively. The soil used as a control in the experiment was chemically analyzed and is shown in Table 3.

TABLE 1
The ratios of agricultural waste in the compost mixtures (%)

Mixture No	Banana Plantation Waste	Greenhouse Plant Waste	Spent Mushroom Compost
M1	70	20	10
M2	60	30	10
M3	50	40	10
M4	40	50	10
M5	75	20	5

TABLE 2
The chemical characteristics of the compost samples used in the experiments

No	pH	EC	N	P	K	Mg	Ca	Fe	Zn	Mn	Cu
		dS m^{-1}			%				mg kg^{-1}		
M1	9.13	12.22	1.76	1.19	3.05	0.64	3.61	3387	7202	722.5	139.9
M2	8.53	12.41	1.82	1.45	3.16	0.76	4.36	4665	6840	951.7	165.0
M3	8.53	13.76	1.92	1.67	3.29	0.76	5.03	5444	6185	1046.0	176.8
M4	8.77	13.58	1.87	1.49	3.26	0.64	4.17	4844	7446	958.3	161.1
M5	8.76	12.57	1.88	1.42	3.10	0.90	5.78	4793	7153	980.2	152.2

TABLE 3
The evaluate of mineral compounds in the soil

Parameters	Value
Total N (%)	0.069
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

The pot experiments were conducted under greenhouse conditions as a randomized plot design with four replications. Normal cultivating processes were carried out during the vegetation period and the plants were harvested at the end of the experiment.

Head height (cm), head diameter (mm), leaf number (per plant), total and marketable yield and leaf color values were measured on the harvested lettuce plants. The wet weights of the harvested plants were determined, then the plants were washed with water and dried in an oven at 65 °C with constant weight. The dry weights were then determined and Vitamin C [17], K, Ca, Mg, Fe, Zn, Mn and Cu [18], phosphorus [19] and N [18] were determined by preferred analysis methods. L, Hue and Chroma values were measured and calculated [20, 21].

In all the compost samples, organic matter content [22], organic carbon [23], pH [24], nitrogen [25], phosphorus [26], and K, Ca, Mg, Fe, Zn, Mn and Cu [18] were determined.

All data were subjected to analysis of variance and to detect significance ($p<0.05$) of treatment effects, Duncan's Multiple Range Test was used with SAS software.

RESULTS AND DISCUSSION

The effects of the different composts obtained from agricultural waste on the height, diameter, and leaf number of the lettuce are presented in Tables 4 and 5. Generally, the effects of the compost treatments on lettuce growth were found to be statistically significant except for leaf number (2nd period).

The head height values of lettuce were determined to increase with compost treatments compared to the control in both seasons ($p<0.001$). The maximum head height, head diameter and leaf number values (except for 2nd season) were recorded in almost all the compost applications in the vegetation periods, while the minimum head height value was obtained in control treatments (Table 4). Some researchers have reported that plant growth was affected positively compared to control plants by adding organic matter and compost to soil [26, 27, 28]. Sönmez et al. [4] determined that compost added to soil increased leaf number, head height and head diameter of lettuce.

The effects of composts on marketable-total yield values of the lettuce are presented in Table 5. Vitamin C values were found to be statistically significant in the treatments only in autumn ($p<0.05$) and the maximum Vitamin C value in autumn was shown in the control treatment (32.0 mg 100 g^{-1}). Sönmez et al. [4] determined that more vitamin content was observed in control applications than in compost-added soils. The differences between treatments for marketable and total yields among compost applications in both seasons were found to be significant ($p<0.001$). The total and marketable yield with the compost applications increased significantly compared to the control. The maximum marketable yield values in autumn were recorded in M1 (371.5 g $plant^{-1}$), M2 (350.0 g $plant^{-1}$), M4 (353.5 g $plant^{-1}$) and M5 (356.3 g $plant^{-1}$) applications and in the spring growing season, were recorded in M4 (395.7 g $plant^{-1}$) application. The minimum marketable yields were recorded in the control application in both seasons. The maximum total yield values in autumn and spring seasons respectively were recorded in M3 (623.7 g $plant^{-1}$) and M4 (435.2 g $plant^{-1}$) applications. The minimum total yields were recorded in the control application in both seasons. The M3 application increased almost 4 times compared to the control in autumn and the M4 application increased 2.7 times compared to the control in spring. Xu et al. [29] determined that vegetables grown with organic manure resulted in a higher total yield than those grown with chemical fertilizers. Some researchers have reported that organic manure increased yields in vegetables [4, 26, 30, 31, 32]. ElNour et al. [12] reported that the plant weights of sorghum increased with compost obtained from

banana plant waste. Rui et al. [33] stated that some organic manure (pig manure and sludge) increased yields of lettuce and are effective for crop production.

The color values (L, Hue, Chroma) were not significantly affected by the applied treatments in both growing seasons (Table 6) and all applications were included in the same group.

The effects of compost treatments on the macro element concentrations of the lettuce are presented in Table 7. While the phosphorus, potassium and magnesium concentrations of lettuce were found to be significant statistically in the autumn season, the nitrogen and phosphorus concentrations of lettuce were found to be significant in the spring season. The macro element concentrations of the lettuce with the compost treatments increased significantly compared to the control except for calcium concentration.

TABLE 4
The effects of different composts on head height, head diameter, and leaf number of lettuce[1]

	Head height cm		Head diameter mm		Leaf number per plant^{-1}	
Season	1	2	1	2	1	2
M1	14.4b[2]	23.3a[2]	14.91b[2]	22.97a[2]	34.5a[2]	43.5
M2	18.5a	24.0a	17.89a	25.01a	33.8a	44.8
M3	19.3a	23.0a	18.13a	24.41a	31.8a	44.0
M4	18.8a	24.3a	18.75a	26.51a	33.3a	44.3
M5	19.0a	24.0a	17.89a	23.60a	31.3a	43.5
Control	12.0c	13.3b	9.17c	15.79b	26.0b	35.8
Sign.[b]	***	***	***	***	*	ns

[1] 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.
[2] Significance levels: *: $p<0.05$ ***: $p< 0.001$ ns: not significant

TABLE 5
Effects of compost treatments on Vitamin C, marketable yield and total yield of lettuce[1]

	Vitamin C mg 100 g^{-1}		Marketable yield g plant^{-1}		Total yield g plant^{-1}	
Combinations	Autumn	Spring	Autumn	Spring	Autumn	Spring
M1	23.3bc[2]	43.6	371.5a	382.2ab	483.8c	411.5ab
M2	19.8c	38.7	350.0a	347.8b	576.8b	386.8b
M3	28.6ab	36.6	312.2b	377.1ab	623.7a	408.7ab
M4	30.6ab	45.7	353.5a	395.7a	576.2b	435.2a
M5	29.9ab	40.4	356.3a	373.5ab	581.4b	404.5ab
Control	32.0a	35.2	145.0c	153.5c	154.0d	160.9c
Sign.[b]	*	ns	***	***	***	***

[1] 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.
[2] Significance levels: ***: $p< 0.001$ ns: not significant

TABLE 6
Effects of compost treatments on L, Hue, Chroma values (color) of lettuce [1]

	L		Hue		Chroma	
Season	Autumn	Spring	Autumn	Spring	Autumn	Spring
M1	53.82	44.95	118.58	122.54	45.58	31.81
M2	53.61	44.96	119.56	123.12	42.25	31.76
M3	53.66	48.01	119.60	122.88	43.45	33.34
M4	49.65	44.88	120.88	123.41	39.97	33.27
M5	52.71	46.37	119.86	123.47	42.33	35.54
Control	52.85	46.44	119.17	121.93	43.92	30.62
Sign.[b]	ns	ns	ns	ns	ns	ns

[1] 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.
[2] Significance levels: *: $p< 0.5$ ns: not significant

TABLE 7
Effects of compost treatments on macronutrient concentrations of lettuce [1]

	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
Season	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
M1	2.37	3.32a[2]	0.38a[2]	0.36a[2]	6.30a[2]	6.00	0.86	0.81	0.42 a[2]	0.39
M2	2.42	3.43a	0.34ab	0.28b	6.58a	6.43	0.77	0.84	0.35 ab	0.38
M3	2.43	3.24a	0.23c	0.35a	6.14a	5.72	0.59	0.79	0.27 b	0.36
M4	2.20	3.13a	0.28bc	0.31ab	5.18ab	5.77	0.61	0.75	0.29 b	0.36
M5	2.11	3.38a	0.35ab	0.31ab	7.04a	5.30	0.67	0.63	0.35 ab	0.33
Control	1.98	2.46b	0.25c	0.22c	3.70b	4.28	0.49	0.77	0.30 b	0.26
Sign.[b]	ns.	**	**	**	*	ns	ns	ns	*	ns

[1] 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.
[2] Significance levels: *: $p<0.5$ **: $p< 0.01$ ns: not significant

TABLE 8
Effects of different composts on micronutrient concentrations of lettuce [1]

	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})	
Season	1	2	1	2	1	2	1	2
M1	109.38	233,45	76.94	103.04a[2]	56.30ab[2]	56.71b[2]	6.99a[2]	8.08
M2	82.35	444,62	64.69	94.07ab	48.14b	52.69b	6.60ab	9.76
M3	81.10	357,92	59.09	85.51ab	49.91b	64.74b	4.97b	8.95
M4	91.28	361,15	49.94	86.62b	48.41b	60.55b	5.98b	9.80
M5	82.30	169,15	48.62	77.69b	41.72b	49.16b	6.94a	7.81
Control	72.18	340,15	48.77	74.13b	73.56a	108.08a	5.22b	7.76
Sign. [b]	ns	ns	ns	*	*	***	*	ns

[1] 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.
[2] Significance levels: *: $p<0.5$ ***: $p< 0.001$ ns: not significant

The nitrogen concentration of lettuce increased with all compost treatments and the minimum value was found in the control treatments in the spring season. However, the nitrogen concentration of lettuce in autumn did not vary significantly. The maximum phosphorus concentration of lettuce was obtained from M1 (0.38%) treatment in autumn, and from M1 (0.36%) and M3 (0.35%) in spring. The phosphorus concentration of lettuce increased with M1 treatment in both seasons. The minimum phosphorus concentration of lettuce was obtained from the control treatment in both periods. The potassium concentration of lettuce in autumn were obtained from M1 (6.30%), M2 (6.58%), M3 (6.14%) and M5 (7.04%) treatments and the minimum value was determined in the control (3.70%) treatment. However, the potassium concentration of lettuce in autumn did not vary significantly. The calcium concentration of lettuce did not vary significantly in both seasons. The highest magnesium content of lettuce in autumn was obtained from M1 (0.42%) treatment and the minimum value was determined from the control (0.26%) treatment. Nitrogen and organic matter treatments have been previously shown to increase the nutrient concentrations of plants [4,34,35,36]. Gezgin et al. [37] determined that humic acid materials at different doses increased the nutrient contents of lettuce. Vidigal et al. [38] reported that N, P and K contents of leaf increased with rising compost rates except for Ca content. Rodrigues and Casali [39] reported that the treatments of organic manure increased the yield and nutrient content in lettuces. Malinowska [40] reported that the compost applied affected the macronutrient concentration in ryegrass and their total amount in the biomass.

The effects of composts on the micro element concentrations of the lettuce are presented in Table 8. The iron concentrations in both seasons were not found to be statistically significant. Furthermore, the manganese concentrations in autumn and the copper concentration in spring were not found to be significant. The zinc contents of lettuce were found to be significant in both seasons.

The maximum zinc content was obtained from the control application in both seasons. The highest manganese concentration of lettuce in spring was determined from M1 (103.04 mg kg^{-1}) treatments. The highest copper concentration of lettuce in autumn was determined from M1 (6.99 mg kg^{-1}). The metal concentrations in lettuce increased in the spring season in particular. It is estimated that the decomposition of organic matter further decomposed micro elements in the spring season. Abdel-Sabour and El-Seoud [41] determined that the metal concentrations depend on the amount of compost applied to the soil and the treatment period. Sönmez et al. [4] reported that composts obtained from different agricultural plant wastes increases the plant growth and nutrient contents. Özgüven and Katkat [42] reported that the amount of available zinc increased on the topsoil because of the high level of organic matter. Sönmez and Kaplan [43] determined that the metal

concentrations of carnations increased with compost treatments.

CONCLUSION

This study was conducted to determine the effects of agricultural waste on plant growth, yield and nutrient content of lettuce. Composts obtained from banana plant waste, greenhouse plant waste and spent mushroom compost were observed to provide significant increases in many parameters in plant development. While all composts are effective in general, the M3 (50%BPW+40%GPW+10% SMC) and M4 (40%BPW+50%GPW+10%SMC) treatments were prominent in the development and productivity parameters of lettuce compared to the control group. M1 (70%BPW+20%GPW+10% SMC) treatment was determined as the best treatment for plant nutrient content. Agricultural waste is an important problem in farming areas and the best method of re-use is composting in terms of the environment and health. Thus, it is possible to get rid of both waste and soil properties and to increase productivity.

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