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Full Length Research Paper

The effects of some agricultural wastes composts on carnation cultivation

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The wastes that come out as a result of agricultural productions are disposed randomly without being utilized in more beneficial ways. While the types and amounts of such wastes differ, it is calculated that each of them has a great volume. Cut flower carnation wastes and spent mushroom compost have a serious potential in Turkey and especially in Antalya, increase soil fertility and has economic benefits, thanks to reduction in environmental pollution can be achieved by transforming agricultural wastes into a new product. In this study, the composts that are obtained as a result of the composting of organic wastes with various additives in varying ratios as well as the effects of organic materials on the dry matter contents and macro-micro element contents of the carnation plant (standard) were examined. The effect of composts and organic material applications on the dry matter and macro-micro element contents of the carnation plant was found to be statistically significant and increases were achieved in the dry matter contents and nutrient contents of the plant with composting and organic material applications. Dry matter contents in plants increased all organic applications. The mixture ratios of %50CW+ %25SMC+ %25PM (R4) and %25CW+ %75SMC (R3) were the applications that yielded the best results in many parameters despite the increases in other mixtures compared to the control group.

Key words: Spent mushroom compost, carnation wastes, organic manure, compost, dry matter.

INTRODUCTION

Together with the increasing vegetable production, an increase is observed in the waste quantities. Anton et al. (2005) stated that the most important problem in greenhouse production was the produced wastes. Several vegetable origin wastes occurred after agricultural production and these wastes are utilized in various ways (composting, biogas, burning, etc.). Some of the agricultural production wastes that come about in Antalya region, where agricultural production is predominantly performed, include greenhouse vegetable wastes, cut flower wastes, grass wastes, horticulture wastes, banana plantation wastes, etc. Sönmez and Kaplan (2010) calculated amounts of carnation wastes as 28325 tons in Antalya and 89760 tons (fresh weight) in Turkey. In a study, it is reported that approximately 330.625 tons of greenhouse plant wastes in the province Antalya are being randomly disposed or terminated by burning (Sönmez et al. 2002). For this reason, agriculture-originated organic wastes should be utilized in useful ways. Organic fertilizer can be obtained by ensuring recycling by means of composting that is one of the best utilization methods for organic wastes. Composting is the process of obtaining a soil regulator product with a fertilizer value by degrading the organic wastes under oxygen (aerobe) conditions with micro-organisms (Diaz et al., 1993; Külcü and Yaldız, 2004; Rantala et al., 1999). However, in the process of decomposition of the organic wastes, microorganisms use oxygen in the environment and then decompose the organic structure, and at the end of the reaction, CO_2, water and heat are generated. The main factors in controlling the composting process include environmental (temperature, moisture content, pH and aeration) and material parameters (C/N ratio, particle size, nutrient content, and free air space) (Diaz et al., 2002). Jeris and

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Abbreviations: SOM, Soil organic matter; **PO,** *Pleurotus ostreatus*; **AB,** *Agaricus bisporus*; **SMS,** spent mushroom substrates; **FAS,** free air space; **PVC,** polyvinyl chloride; **ICP,** inductively coupled plasma; **EC,** electrical conductivity.

Table 1. Total cut flower and carnation production area in Antalya-Turkey (Anonymous, 2009).

Total production area (ha)	Turkey	Antalya
Total cut flower production area	1370	436
Carnation production area	816	257

Table 2. The contents of organic matter of Turkey's soils (Anonymous, 1984).

Excessive poor	Poor	Moderate	Good	High
< 1 %	1-2%	2-3%	3-4%	>4 %
19.2	49.8	22.4	5.6	3.0

Regan (1973) examined the effects of free air space (FAS) on oxygen consumption rates of mixed refuse samples. In composting, optimum C/N ratio should be 30/1, optimum humidity content should be between 30-60% and pH should be around 6.5-7.5 for microbial decomposition (Erdin, 2008).

Cut flower cultivation occupies the largest share as production volume and economic value all around the world within ornamental plant sector (Anonymous, 2003). Total cut flower cultivation area throughout the world is 610.000 ha as of the year 2006 and it is around 1273 ha in Turkey. However, there is an increasing trend compared to previous years (Anonymous, 2008). Cut flower cultivation comprises 48% of total ornamental plant production in Turkey. Carnation cultivation holds an important place within cut flower production (Table 1).

One of the major environmental problems in the mushroom producing countries remains the treatment and disposal of the spent mushroom substrates (SMS).The mushroom industry generates two main types of SMS, one for *Agaricus bisporus* (AB) and other for *Pleurotus ostreatus* (PO). SMS-AB is composed of a composted mixture of cereal straw and manure (poultry and/or horse manure and/or pig slurry), calcium sulphate, soil and residues of inorganic nutrients and pesticides, whereas SMS-PO contains fermented cereal straw and residues of inorganic nutrients and pesticides (Medina et al., 2009). Spent mushroom compost stands for the compost that is thrown away as a result of mushroom production and the amount of mushroom compost that was produced in Korkuteli has been reported to be 125.000-150.000 tons/year. It is estimated that total mushroom compost production of Turkey has reached 250.000-300.000 tons/year (Sönmez, 2009).

Organic materials are important soil additives, particularly in semiarid regions (such as Turkey) where there is low input of organic materials. Use of organic matter in arid and semi-arid regions, where soil organic matter (SOM) content is rather low, will contribute to enrich the soil with SOM. The gradual and rapid decrease in SOM content in soils under intensive agriculture practices, especially in those having hot climates, may lead to the deterioration of their chemical and physical properties (Flaig et al., 1977). The soils of Turkey are generally poor in respect of organic material contents and the ratio of soils containing organic materials at a ratio lower than 2% is around 69% which is a very high level (Table 2) (Ülgen and Yurtsever, 1988). The organic material deficiency in soils can only be reinforced with organic fertilizer applications and this causes serious economical problems. The organic material deficiency of soils can be eliminated by reusing the waste organic materials by enabling recycling.

This study is conducted to determine some agricultural wastes composted in Antalya region where an intensive greenhouse production is practiced and occurred agricultural wastes large volumes.

MATERIALS AND METHODS

127 it cylindrical polyvinyl chloride (PVC) reactors were used in composting and the reactors were isolated with 50 mm glass wool. Their dimensions were 0.80 m in height and 0.40 m in diameters. Perforated floor (#5 mm) was used at the bottom of each reactor to hold material and distribute air equally. Air was supplied with radial fan controlled with an on/off timer with a 15 min on and 45 min off work schedule for all experiments (Figure 1). Composting process was performed under controlled conditions and composts were kept waiting for maturation phase at the end of the pre-composting process.

In the study, carnation plant wastes, spent mushroom compost, poultry manure and cattle manure were mixed and composted in varying ratios (Table 3). 100% applications of organic materials and composts were applied in pots with the aim of cultivating carnation plant. All composts and organic materials were added into pot soils taking into account humidity contents in such a way that 1 ton is ha^{-1} and a vegetation period of approximately 11 months was determined. Furthermore, there was a control application (without organic material application) with only chemical application. All applications were treated with chemical fertilizer in limited ratio.

The study was carried out in a completely randomized plot design with four replications and conducted under greenhouse conditions as a pot experiment. Standard species (Lia) carnation seedlings were planted in pots in such a way to plant 4 carnations in each pot. All of the necessary cultural processes were performed during the vegetation period and experiment was finalized and plants were harvested; including the flowers that were cut during this process, the wastes that were obtained as a result of the

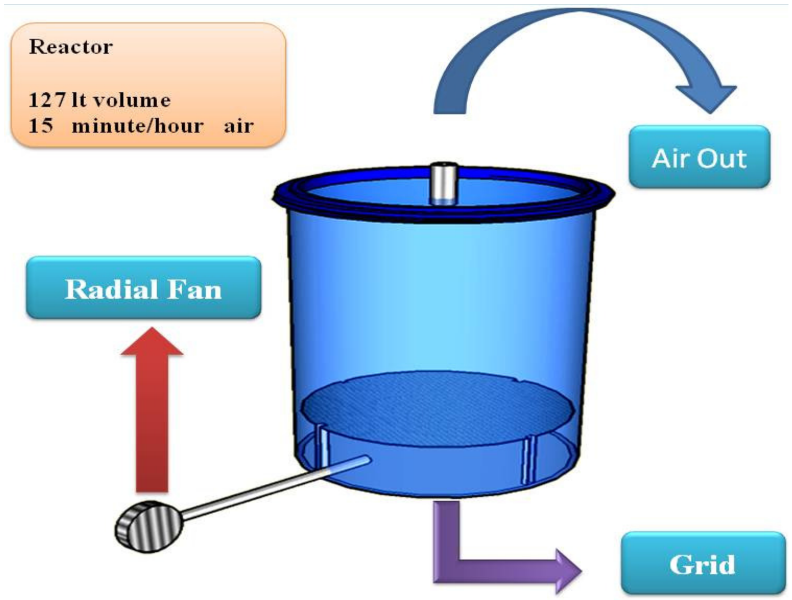

Figure 1. Properties of container composting reactor.

Table 3. Mixture ratios in the composting reactors.

Reactor number	Carnation waste ratio (%)	Spent mushroom compost ratio (%)	Poultry manure ratio (%)	Cattle manure ratio (%)
R1	75	25	-	-
R2	50	50	-	-
R3	25	75	-	-
R4	50	25	25	-
R5	50	25	-	25
R6	25	25	25	25
R7	100	-	-	-

harvest, were taken to the laboratory for analysis.

Plant samples taken were brought into the laboratories and then fresh weights were weighed. Plant samples were washed by distilled water and dried in a forced-air oven at 65°C to constant weight. After drying; dry weights were recorded. Dried plant samples of 0.5 g each were digested with 10 mL $HNO_3/HClO_4$ (4:1) acid mixture on a hot plate. The samples were then heated until a clear solution was obtained. The same procedure was repeated several times. Concentrations of K, Ca, Mg, Fe, Zn, Mn and Cu in the digestates were determined by using inductively coupled plasma (ICP) (Kacar and İnal, 2008). Phosphorus was measured by spectrophotometer (Kacar and Kovancı, 1982) and N was determined by a modified Kjeldahl procedure (Kacar and İnal 2008).

In compost and organic materials, organic carbon (Black, 1965), organic matter content (Nelson and Sommers, 1982), pH (Anonymous, 1978), 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.

Statistical methods

The experiment was arranged in randomized complete plot design with four replicates of four plants in each plot. All data were subjected to analysis of variance and a significant ($p<0,05$) F ratio detected for treatment effects, a least significant difference (LSD) value calculated by 5 % (MSTAT-C packet program).

RESULTS AND DISCUSSION

Some chemical analysis results of composts and organic materials are given in Table 4. These materials were added into pot soils taking into account humidity contents in such a way that 1 ton is ha^{-1} and the effects of carnation plants cultivation are shown positively.

The effects of composts and organic materials on the dry matter contents and macro nutrition contents (N, P, K, Ca and Mg) of the plant carnation are shown in Table 5. According to the statistical evaluations, the change in the dry matter contents of the plant carnation was found to be significant ($p<0.05$) and all applications demonstrated serious increases compared to control group. In respect

Table 4. The results of the analysis of composts and organic materials.

Analysis	R1	R2	R3	R4	R5	R6	R7	SMC	PM	CtM
N (%)	0.61	1.86	1.84	2.10	2.19	1.96	1.44	1.71	1.72	1.53
P (%)	0.55	0.59	0.56	0.45	0.48	0.49	0.45	0.27	1.49	1.01
K (%)	2.41	0.94	0.84	0.80	1.15	0.75	3.13	0.64	1.48	0.87
Ca (%)	3.17	2.91	3.23	2.91	2.12	2.97	3.03	1.73	5.88	2.04
Mg (%)	0.37	0.32	0.66	0.25	0.32	0.29	0.27	0.24	0.80	0.72
Fe mg kg^{-1}	2220	1836	2742	1266	1894	1486	2202	1716	1538	1178
Zn mg kg^{-1}	88.2	107.8	145.4	108.8	130.6	140.6	58.4	60.4	314.8	140.8
Mn mg kg^{-1}	154	134	176	124	134	112	144	92	334	142
Cu mg kg^{-1}	19	19	29	17	19	19	11	13	45	31
pH	8.32	8.10	7.85	8.52	8.19	7.85	8.89	6.80	7.54	7.56
EC dS m^{-1}	4.46	4.76	3.64	3.50	3.84	3.65	3.41	4.20	4.65	1.46
Organic Matter %	57.9	33.4	33.8	32.1	33.5	29.8	63.1	59.0	42.7	58.6
C/N	19.98	9.98	10.20	8.49	8.50	8.45	24.34	19.17	13.79	21.28

Table 5. The effects of organic material and compost treatments on the dry matter and macro element contents in plants (%)[1].

Reactors	Dry matter	N	P	K	Ca	Mg
R1	25.90 a[2]	2.63 e[2]	0.24 fg[2]	2.93 ef[2]	2.13 d[2]	0.27 d[2]
R2	26.32 a	2.79 cde	0.25 efg	2.74 g	2.14 d	0.27 d
R3	25.94 a	3.02 a	0.29 de	2.95 def	2.13 d	0.31 b
R4	24.23 a	2.99 ab	0.33 bc	3.05 cde	2.19 d	0.28 cd
R5	26.32 a	2.87 abc	0.29 de	2.86 fg	2.20 d	0.27 cd
R6	26.90 a	2.95 abc	0.31 cd	2.92 ef	2.24 d	0.29 c
R7	23.76 ab	2.86 abcd	0.27 def	3.15 bc	2.20 d	0.28 cd
SMC	26.74 a	2.68 de	0.41 a	3.43 a	2.51 c	0.36 a
PM	27.24 a	2.99 ab	0.37 b	3.27 ab	2.88 ab	0.35 a
CtM	26.75 a	2.82 bcd	0.43 a	3.11 bcd	2.72 bc	0.34 a
Control	20.03 b	2.21 f	0.24 g	2.52 h	2.96 a	0.27 d
LSD (%5)	*	***	***	***	***	***

[1]Values of n=4; *, significance; *, $p<0.05$; ***, $p<0.001$. [2]The difference between values not shown with the same letter are significant at a $p<0.05$ level.

of macro nutritional elements, on the other hand, all applications were found to be statistically significant ($p<0.001$) and demonstrated increase compared to control. With the organic material applications, an increase was achieved in the dry matter contents of plants and the effect of these applications on the dry matter fertility of the carnation plant was found to be statistically significant at $p < 0.05$ level (Table 5). While all of the organic material applications comprised the highest value group, the lowest value was obtained in the control group with 20.03 g pot^{-1} level. Mullen and Mcmahon (2001) reported that spent mushroom compost application significantly affect the useful P, pH, EC and especially dry matter amount. Ofosu-Anim and Leicth (2009) reported that organic material applications cause increases in the dry matter contents of plants.

The supply of available nitrogen in soils is often supplemented by nitrogen released from soil organic matter or organic materials added to soils like manure, residues of forage legumes, etc. (Eckert, 2011). The effects of organic materials and compost applications on the macro element contents of plants are statistically significant at $p<0.001$ level. The applications ensuring the highest level of increase in respect of N content of plants are R3, R4, R5, R6, R7 and PM (respectively, 3.02, 2.99, 2.87, 2.95, 2.86 and 2.99%) and the lowest values was obtained in the control group with 2.21%. The important increase in % N amounts in the plants thanks to the compost application in the soil is an indicator of the fact that organic materials ensure positive effects on the nitrogen nutrition of the plant. Increase can be achieved in the nitrogen content of the plant with organic material

Table 6. The effects of organic material and compost treatments on the micro element contents in plants.

Reactors	Fe	Zn	Mn	Cu
R1	64.7 cde	26.0 d	143.6 g	5.15 cd
R2	58.6 de	25.9 d	177.5 def	4.10 d
R3	73.4 b	25.3 d	189.2 de	5.68 c
R4	91.7 a	29.3 c	177.1 def	5.10 cd
R5	62.8 cde	25.3 d	169.7 ef	7.13 b
R6	68.8 bc	28.8 c	190.7 de	5.55 c
R7	61.7 cde	27.1 cd	157.25 fg	5.60 c
SMC	64.7 cde	44.0 a	219.3 c	8.28 ab
PM	63.7 cde	40.6 b	253.8 b	8.48 a
CtM	66.2 bcd	46.3 a	202.1 cd	8.93 a
Control	52.3 e	21.8 e	298.3 a	3.93 d
LSD (%5)	***	***	***	***

[1]Values of n=4; *, significance; ***, p<0.001. [2]The difference between values not shown with the same letter are significant at a p<0.05 level.

and compost applications (Song and Lee, 2010; Hirzel et al., 2009; Kalantari et al., 2010). Sarwar et al. (2009) reported that increases were achieved in N, P, K, Ca and Mg contents of plants with compost applications.

Phosphorus is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants (Griffith, 2011). The highest value of the plant in phosphorus content was achieved from 100% CtM application with 0.43% and from 100% SMC application with 0.41%, while the lowest value was 0.24% in the control group. Spent mushroom compost and cattle manure played important role in the increase of phosphorus contents in carnation plants. Kütük (2000) reported that the amount of spent mushroom compost that becomes waste in the cultivation field increased the phosphorus content of the plant croton significantly. Kocabaş et al. (2007) reported that cattle manure application caused an increase in the phosphorus contents of the Sage (*Salvia fruticosa* Mill.).

Potassium acts as catalysts for many of the enzymatic processes in the plant that are necessary for plant growth to take place. Another key role of potassium is the regulation of water use in the plant (McAfee, 2011). When the effects of organic material and compost applications on the macro element content of carnations are evaluated, applications increased the potassium contents of carnations. The highest value of the plant in potassium content was achieved from 100% SMC application with 3.43%, and from 100% PM application with 3.27%, while the lowest value was 2.52% in the control group. In some studies, it is reported that organic material applications increase K content of plants (Çıtak and Sönmez, 2009; Saha et al., 2010). Uyanöz et al. (2004) reported that spent mushroom compost increases contents of potassium of the leaf of wheat plant significantly.

Calcium also plays a role in the plant very similar to a hormone in the regulation of various cell functions. One such function is in the regulation of the protein pump that regulates the uptake and movement of nutrients into the root and throughout cells within the plant (Patterson, 2011). The highest value of the plant in calcium content was achieved from control group with 2.96% and from 100% PM application with 2.88% while the lowest values were obtained in all of the compost mixtures. The highest values of the plant in magnesium contents were achieved from 100% SMC, 100% PM and 100% CtM applications with 0.36, 0.35 and 0.34% respectively while the lowest values were recorded in R1, R2 and control group with 0.27%. Kaplan et al. (2008) achieved increases in the contents of Ca and Mg in lettuce with organic fertilizer applications. Yılmaz and Alagöz (2009) reported that organic material application in the soil in varying ratios ensured increase in Mg content in bean plant.

Micro nutritional element contents of the carnation plant (Fe, Zn, Mn and Cu) are shown in Table 6. All of the applications, in respect of micro nutritional contents of the carnation plant according to the statistical evaluations were found to be statistically significant (p<0.001) and demonstrated increases compared to control group.

In case of the micro elements essential to plant growth, they must be in available form in soils in the moment the plants need them for a good growth and production. If the soil is not able to supply micro elements, the growth will be affected and also the production (Anonymous, 2011). The effects of applications on all micro element contents are statistically significant (p<0.001). When the effects of organic material and compost applications on the micro element content of carnations are evaluated, applications increased the iron contents of carnations. The highest value of the plant in iron content was 91.7 mg kg^{-1} in R4 application while the lowest value was 52.3 mg kg^{-1} in the control application. It is reported that organic material applications increase the iron content of the plant significantly (Uyanöz et al., 2004; Schroder et al., 2008). It has been reported that chelating compounds just like stable humus components such as simple aliphatic acids, hydroxamate siderophores, phenols and phenolic acids are formed with organic material application in the soil and that these chelating compounds make iron useful for the plans (Kacar and Katkat, 2007).

Zinc (Zn) is an essential component of thousands of proteins in plants, although it is toxic in excess and zinc is transported in the xylem tissues from the roots to the shoots (Broadley et al., 2007). In this study, the highest values in the zinc contents of carnation were obtained in 100% CtM and 100% SMC applications with 46.3 and 44.0 mg kg^{-1} respectively, while the lowest value was 21.8 mg kg^{-1} in the control group. Zinc ions are bound to organic material of the soil firmly and the variable zinc amount in the soil increases in parallel to the organic material content. For these reasons, the amount of useful zinc increases on the topsoil too where organic material is abundant (Özgüven and Katkat, 2002). The available zinc contents are higher the upper layers in soils because of high level organic matter.

Manganese is an essential element for plants, intervening in several metabolic processes, mainly in photosynthesis and as an enzyme antioxidant-cofactor (Millaleo et al., 2010). The highest value in the manganese content of carnation plant in organic applications was 298.3 mg kg^{-1} in the control group while the lowest value was 143.6 mg kg^{-1} in R1 application. Uyanöz et al. (2004) reported that lower values were obtained in the manganese contents of the plant wheat that is cultivated on soils where certain organic materials are applied compared to control group of spent mushroom compost and poultry manure. Wong et al. (1999) reported that the field experiment was carried out to evaluate the growth of *Brassica chinensis* and *Zea mays* L. on soil amended with different ratios of manure compost and the contents of manganese in plants increase with organic treatments.

Copper is an important component of proteins found in the enzymes that regulate the rate of many biochemical reactions in plants. Plants would not grow without the presence of these specific enzymes (Rehm and Schmitt, 2009). The highest values in the copper content of carnation plant in organic applications were 8.93, 8.28 and 7.48 mg kg^{-1} in 100%CtM, 100%PM and 100%SMC applications. Dam Kofoed (1980) reported that poultry and cattle manures have high copper content and that these organic materials can be utilized when necessary. Mantovi et al. (2003) determined that soil metal contents (specialty zinc and copper) were affected by the intensity of manure treatments and due to the relatively high copper and zinc contents of organic materials, this practice could lead to increasing of soils and the crops grown on them.

Conclusions

This study was conducted with the aim of demonstrating the possibility of utilizing different agricultural organic waste materials. Due to the abundance of organic material variety and lack of sufficient experience in the utilization in agricultural fields, different mixtures shall be formed and composted and utilization of such composts can be increased in agricultural fields. Carnation plant wastes and spent mushroom compost are potential organic wastes that can be found in great volumes in the province Antalya and they ensure significant increases in plant development when they are composted together. Dry matter contents in plants increased all organic applications. The mixture ratios of %50CW+ %25SMC+ %25PM (R4 application) and %25CW+ %75SMC (R3 application) were the applications that yielded the best results in many parameters despite the increases in other mixtures compared to the control group. Since the utilization of organic waste materials, waste materials will no longer be a problem and this will increase the amount of organic materials and fertility parameters that are useful for soil.

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