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COMPARING THE EFFECTS OF COMPOST AND VERMICOMPOST ON CORN GROWTH, NUTRIENT CONCENTRATION AND UPTAKE DURING THE DIFFERENT GROWTH PERIODS

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Abstract

In this study, it was aimed to compare the effects of vermicompost (VC) and compost (C) containing same originated organic materials (oil rose processing waste, dairy manure, poultry manure and straw on materials) on the growth, nutrient concentrations and nutrient uptakes of corn plant. Vermicomposts and compost were applied with the rates of 0, 10, and 30 t ha^{-1}to 2 kg soil containing pots. Study was conducted in glasshouse conditions for eight weeks with three replicates. During the growing periods plants were harvested 2 weeks intervals. After each harvest, plants were analysed for mineral nutrient concentrations (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu) and nutrient uptakes were calculated using dry weight and nutrient concentrations. No significant differences were observed between C and VC in terms of plant dry weight, but increasing dosage of both C and VC significantly increased plant dry weight. Plant Ca, Mn and Zn concentrations were significantly affected from the individual effects of sources (C and VC) and also Ca, Fe and Zn concentrations were significantly affected from source x week interactions. Plant N and other micronutrient concentrations increased with the dosage. While only plant P, Zn and Cu uptake significantly varied with C and VC and their interactions, all nutrient uptakes significantly increased with the application levels.

Key words: *compost, plant growth, nutrient concentration, nutrient uptake, vermicompost.*

INTRODUCTION

Organic matter (OM) is one of the most effective components on soil fertility. With the direct and indirect roles, organic matter has many roles on preserving and maintaining soil productivity since it has not only a positive effect on soil physical, chemical, and biological properties but also is a source of many nutrients mainly carbon, nitrogen, sulphur and phosphorus (Follett et al., 1981; Barakan et al., 1995; Zink and Allen 1998; Doan et al., 2013; Doan et al., 2014). With these properties soil organic matter, a key component of soils, affects many reactions that occur in these systems. As known, the main sources of soil organic matter are death plant and animal residues at various stages of decomposition, ranging from fresh undecomposed materials through partially decomposed and short-lived products of decomposition to well-decomposed humus. In a fertile soil, it should contain at least 3% OM. But, because of the mineralization process, agricultural practices, natural events, and some other factors, organic matter in the soils decreases continuously. Soil OM content should be preserved for sustainability of soil productivity and diminishing parts of soil should be replaced. There are several ways to protect or increase soil organic matter. Although, the most common way of adding organic matter to the soil is farmyard manure; compost, vermicompost, green manure, and farmyard manure are another sources for OM. Composting is defined as biological aerobic transformation of an organic materials into stabilized products that can be applied to the soil as soil amenders and nutrient suppliers and can be used also as seedling media (Atiyeh et al., 2000; Agegnehu et al., 2015; Showler 2015; Aynacı and Erdal, 2016). Decomposition and stabilization of organic substrates by soil organisms can be defined as vermicomposting. Due to favourable physical properties and available nutrient contents, leading to better growing environment for plants, vermicompost are desirable materials (Edwards, 1988).

The objective of the research is to determine and compare the effects of same-originated compost and vermicompost on the growth, nutrient concentrations, and nutrient uptakes of corn plant.

MATERIALS AND METHODS

Study was conducted under greenhouse conditions as pot experiment during 8 weeks. The experiment was planned according to the randomised parcels design with 3 replications. Compost (*C*) and vermicompost (*VC*) were added to the 2 kg soil containing pots at the rates of 0, 10 and 30 t ha^{-1} and 300 ppm N (as ammonium nitrate), 200 ppm P (as triple super phosphate) and 100 ppm K (as potassium nitrate) were added as basal fertilization. The experiment consisted of two sources (C and VC), 3 doses (0, 10, 30 t. ha^{-1}), 4 growing periods (2, 4, 6 and 8 weeks) and 3 replicates and thus 72 (2x3x4x3) pots were used. Corn plant was used as plant materials. In order to see periodical effects of C and VC on plant growth and nutrient concentrations, plants were harvested two weeks intervals during the growth periods.

In order to determine soil available nutrients, P extracted with $NaHCO_3$ (Olsen et al., 1954), K, Ca, and Mg extracted with NH_4AOC (Jackson, 1967) and Mn, Zn, Fe, and Cu extracted with DTPA (Lindsay and Norvell, 1969). P measurement was done using spectrophotometer; others were measured with Atomic Absorption Spectrophotometer. Soil texture was determined using hydrometer (Bouyoucos, 1954) and $CaCO_3$ content was measured with calcimeter (Allison and Moodie, 1965). pH was determined using pH meter in suspension of soil and water at the rates of 1/2.5. Soil organic matter (OM) was determined based on Walkley and Black (1934).
Some physical and chemical properties of the experimental soil and total nutrient concentrations of C and VC are given in Table 1 and Table 2.
After each harvest, plants were washed with tap water and distilled water. After wards samples were dried, grounded and wet digested with microwave oven. Phosphorus concentrations of samples were determined with a spectrophotometer (Shimadzu UV-1208) at 430 nm according to the vanadomolybdo phosphoric acid method. Potassium, Ca, Mg, Fe, Cu, Zn, and Mn concentrations were determined using atomic absorption spectrophotometer (Varian, 240 FS). Total nitrogen was analysed according to Kjeldahl method. The same procedures were applied to determine total nutrient concentrations of C and VC.
Results were evaluated statistically using MSTAT program for one-way analysis of variance applied to determine any significant difference at 0.05%.

Table 1. Some characteristics of the soil used for the experiment

Texture	pH	$CaCO_3$ (%)	OM (%)	Plant available nutrients (mg kg^{-1})							
				P	K	Ca	Mg	Fe	Cu	Zn	Mn
CL	8.0	15	1.5	14	850	5500	170	2	1.5	0.7	4

Table 2. Total nutrient concentrations of composts and vermicomposts

Nutrients	Sources	
	Compost	Vermicompost
N, %	2.2	2.2
P, %	0.75	0.73
K, %	2.28	2.18
Ca. %	3.87	3.30
Mg, %	1.25	0.93
Fe, ppm	235	238
Zn, ppm	33.7	42.9
Mn, ppm	27	27
Cu, ppm	8.0	8.4

RESULTS AND DISCUSSIONS

Dry weight

Increasing levels of both compost and vermicompost increased plant growth significantly ($P<0.01$). Looking at the interaction effects for each harvest, it can be clearly seen that both sources led to increase in dry weight. Increment rates at the weeks of 2, 4, 6 and 8th week dry weights were 84 %, 337 %, 99 %, 42 % for C and 8 %, 102 %, 94 %, 28 % for VC, respectively. Effects of sources on dry weight showed different effect depending on the harvest time.

Table 3. Effects of C and VC on plant dry weight (g pot^{-1})

Harvest week	Dosage ($t\ ha^{-1}$)	VC	C
2	0	0.13 c*	0.13 c
	10	0.20 b	0.15 bc
	30	0.24 a	0.15 bc
	mean	0.19 A**	0.14 B
4	0	0.40 d	0.40 d
	10	0.68 c	0.45 d
	30	1.75 a	0.97 b
	mean	0.94 A	0.61 B
6	0	1.71 d	1.71 d
	10	2.12 c	2.72 b
	30	3.40 a	3.31 ab
	mean	2.41 A	2.58 A
8	0	3.66 d	3.66 d
	10	4.66 b	4.33 c
	30	5.18 a	4.66 b
	mean	4.50 *A*	4.22 A
General means for VC and C		2.01 A	1.89 A
General means of dosages			
0		1.48 *C****	
10		1.91 *B*	
30		2.45 *A*	

*shows the interaction effect for each harvest week (P< 0.01)
** shows the differences between the sources for each harvest week (P< 0.01)
*** shows the differences depending on the dosages (P< 0.01)

While first two harvests dry weights at 2nd and 4th weeks, significantly affected by VC and C, there were not significant differences between the dry weights obtained at 6th and 8th week. Also no significant variation was observed between the general means of dry weights obtained from VC and C applied pots. Comparing to control, application doses significantly increased general means of dry weights at rates of 29% and 66 % with 10 and 30 t ha^{-1} dosages respectively (Table 3).

Nutrient concentrations

Plant macro element concentrations were given in Table 4. Except for 4th week, plant N concentrations were not affected by dosages and sources and their interaction. Also it was seen that there were not a significant differences in the general means of the values obtained from sources and dosages. But plant K concentrations significantly varied by the effect of dosage x source interactions in every week. Plant K concentrations increased similarly with the dosages of VC and C dosages. There were not significant differences between general means of VC and C applications, but the average means of application levels significantly varied each other and the highest K concentration was reached with 30 t ha^{-1} dosage. Plant Ca concentrations measured from the each harvest period affected significantly by the interaction, but the individual effects of sources had no effect on Ca. Except for first two harvests, plant Mg levels were not affected from the interaction effects. There was no difference between VC and C, both on a weekly basis and in general. Means of the dosages obtained from VC and C showed that plant Mg concentration increased about 21 % and 15 % when compared to control.

Effect of VC and C and their doses on periodical micronutrient concentrations were given on Table 4 As it can be seen from the Table 5, micro element concentrations of plant were affected from the dosage x source interactions generally. Compared to control, plant micronutrient concentrations increased with the dosages at each period with VC and C applications generally. General means showed that increasing dosages of VC and C resulted in increase of Cu, Mn, Fe and Zn, but no significant differences were found between the sources.

Table 4. Effects of VC and C on plant macronutrient concentrations (%)

Harvest week	Dosage ($t\ ha^{-1}$)	N		K		Ca		Mg	
		VC	C	VC	C	VC	C	VC	C
2	0	2.4	2.4	2.4 c	2.4 c	1.3 c	1.3 c	0.18 b	0.18 b*
	10	2.1	2.1	3.7 b	3.7 b	1.5 b	1.8 a	0.27 a	0.25 a
	30	2.4	2.4	3.9 a	4.0 a	1.6 ab	1.3 c	0.26 a	0.25 a
	mean	2.3	2.3	3.3	3.4	1.5	1.5	0.24	0.23
4	0	1.4 b	1.4 b	3.1 ab	3.1 ab	1.8 a	1.8 a	0.16 d	0.16 d
	10	1.6 ab	1.6 ab	2.9 b	3.4 a	1.7 ab	1.8 a	0.25 b	0.31 a
	30	1.6 ab	1.8 a	3.4 a	3.4 a	1.3 c	1.5 b	0.21 c	0.25 b
	mean	1.5	1.6	3.1	3.2	1.6	1.7	0.21	0.24
6	0	1.0	1.0	2.8 b	2.8 b	1.3 ab	1.3 ab	0.20	0.20
	10	1.1	0.9	3.0 ab	3.0 ab	1.5 a	1.3 ab	0.21	0.19
	30	0.9	1.0	3.4 a	3.3 a	1.2 b	1.1 b	0.21	0.18
	mean	1.0	1.0	3.1	3.0	1.4	1.4	0.21	0.19
8	0	0.7	0.7	2.7 b	2.7 b	1.5 a	1.5 a	0.20	0.20
	10	0.8	0.7	2.9 a	2.9 a	1.5 a	1.1 b	0.21	0.19
	30	0.7	0.8	2.9 a	3.0 a	1.2 b	1.2 b	0.20	0.20
	mean	0.7	0.7	2.9	2.9	1.2	1.3	0.20	0.20
General means for VC and C		1.4	1.5	3.1	3.1	1.5	1.5	0.22	0.22
General means of dosages									
Dosage	0	1.4		2.8 B**		1.5		0.19 B	
	10	1.4		3.1 AB		1.5		0.23 A	
	30	1.5		3.4 A		1.4		0.22 A	

*shows the interaction effect for each harvest week ($P< 0.01$)
** shows the differences depending on the dosages ($P< 0.01$)

Table 5. Effects of C and VC on plant micronutrient concentrations ($mg\ kg^{-1}$)

Harvest week	Dosage ($t\ ha^{-1}$)	Cu (mg/kg)		Mn(mg/kg)		Fe(mg/kg)		Zn(mg/kg)	
		VC	C	VC	C	VC	C	VC	C
2	0	8.4 b*	8.4 b	42 d	42 d	102	102	33 bc	33 bc
	10	14.4 ab	14.0 ab	67 a	50 bc	114	106	29 c	40 ab
	30	15.9 a	17.0 a	57 b	47 bcd	112	116	38 b	49 a
	mean	12.9	13.3	55 A	46 B	109	108	33 B	41 A
4	0	8.3 b	8.3 b	70 b	70 b	81 c	81 c	24 ab	24 ab
	10	8.9 b	12.3 a	54 c	71 b	90 bc	99 b	20 b	27 a
	30	10.3 a	10.9 a	75 ab	81 a	106 ab	124 a	24 ab	28 a
	mean	9.2 B**	10.5 A	66 B	74 A	92	101	23	26
6	0	8.1 ab	8.1 ab	92 a	92 a	92 b	92 b	15 b	15 b
	10	6.8 b	9.8 a	92 a	75 b	91 b	86 b	18 ab	18 ab
	30	8.8 a	9.2 a	96 a	97 a	98 ab	122 a	18 ab	21 a
	mean	7.9 B	9.0 A	83	88	94	100	17	18
8	0	6.0 c	6.0 c	96 ab	96 ab	98 c	98 c	17 abc	17 abc
	10	11.1 a	5.7 c	86 b	61 c	109 bc	103 c	19 a	15 c
	30	7.8 b	9.9 ab	99 ab	111 a	112 b	147 a	20 a	16 bc
	mean	8.3 A	7.2 B	94	89	106	116	19	16
General means for VC and C		9.6	10.0	78	74	100	106	23	25
General means of dosages									
Dosage	0	7.7 B***		75 B		93 B		21 B	
	10	10.4 A		70 B		98 B		23 B	
	30	11.2 A		83 A		117 A		27 A	

*shows the interaction effect for each harvest week ($P< 0.01$)
** shows the differences between the sources for each harvest week ($P< 0.01$)
*** shows the differences depending on the dosages ($P< 0.01$)

Plant nutrient uptakes

Nutrients uptakes of corn for each growth period were affected significantly by dosage source interactions.

Looking at the values obtained from both periodically results and general means, the effect of both sources VC and C, had similar effect on plant macronutrient uptakes generally. General means get from both sources showed that macro nutrient uptakes of by plant increased with the dosages (Table 5).

Micronutrient removal of corn for all harvest week significantly varied with source x dosage interactions.

Although VC and C variation had significant effect on plant periodic nutrient removal in some cases, there were not a significant variations at the general means of VC and C.

Comparing the control (0 t ha^{-1}) Increases in VC and C dosages significantly increased plant Cu, Mn, Fe and Zn uptakes by above ground parts of corn (Table 6).

Table 5. Macronutrient uptake of corn by above ground biomass (mg $plant^{-1}$)

Harvest week	Dosage (t ha^{-1})	N		K		Ca		Mg	
		VC	C	VC	C	VC	C	VC	C
2	0	3.1 c*	3.1 c	3.1 d	3.1 d	1.7 c	1.7 c	0.2 b	0.2b
	10	4.2 b	3.2 c	7.4 b	5.6 c	3.0 ab	2.7 b	0.5 a	0.4 ab
	30	5.8 a	3.6 bc	9.4 a	6.0 c	3.8 a	2.0 c	0.6 a	0.4 ab
	mean	4.4	3.3	6.3 A**	4.7 B	2.8	2.1	0.5 A	0.3 B
4	0	5.6 d	5.6 d	12.4 c	12.4 c	7.2 c	7.2 c	0.6 d	0.6 d
	10	10.9 cd	7.2 d	19.7 c	15.3 c	11.6 bc	8.1 c	1.7 c	1.4 cd
	30	28.0 a	17.5 b	59.5 a	33.0 b	22.8 a	14.6 b	3.7 a	2.4 b
	mean	14.8	10.1	29.5 A	20.1 B	15.0 A	10.4 B	2.0	1.5
6	0	17.1 c	17.1 c	47.9 d	47.9 d	22.2 c	22.2 c	3.4 d	3.4 d
	10	23.3 b	24.5 b	63.6 c	81.6 b	31.8 b	35.4 ab	4.5 c	5.2 bc
	30	30.6 a	33.1 a	115.6 a	109.2 a	40.8 a	36.4 ab	7.1 a	6.0 b
	mean	23.7	24.9	73.9	78.3	32.1	31.8	5.0	4.9
8	0	25.6 b	25.6 b	98.8 c	98.8 c	54.9 ab	54.9 ab	7.3 c	7.3 c
	10	37.3 a	30.3 b	135.1 b	125.6 b	69.9 a	47.6 b	9.8 a	8.2 b
	30	36.3 a	37.3 a	150.2 a	139.8 b	62.2 a	55.9 ab	10.4 a	9.3 a
	mean	33.1	31.1	127.5 A	121.0 A	63.0 a	53.5 B	9.2 A	8.3 B
General means for VC and C		27.9	28.3	62.1	59.3	29.1	26.8	4.2	3.7
General means of dosages									
0		20.4 B***		41.4 C		22.1 B		2.80 B	
10		26.7 B		59.2 B		28.6 B		4.39 A	
30		36.8 A		83.3 A		34.3 A		5.39 A	

*shows the interaction effect for each harvest week

** shows the differences between the sources for each harvest week.

*** shows the differences depending on the dosages.

Table 6. Micronutrient uptake of corn by above ground biomass (µg plant^{-1})

Harvest week	Dosage (t ha^{-1})	Cu		Mn		Fe		Zn	
		VC	C	VC	C	VC	C	VC	C
2	0	1.1c*	1.1c	5.5 b	5.5 b	13.3 c	13.3 c	4.3 d	4.3 d
	10	2.9 b	2.1 b	13.4 a	7.5 b	22.8 ab	15.9 bc	5.8 c	6.0 c
	30	3.8 a	2.6 b	13.7 a	7.1 b	26.9 a	17.4 b	9.1 a	7.4 b
	mean	2.5	1.9	10.5 A**	6.4 B	20.7 A	15.1 B	6.3	5.7
4	0	3.3 d	3.3 d	28.0 c	28.0 c	32.4 d	32.4 d	9.6 d	9.6 d
	10	6.1 c	5.5 cd	36.7 c	32.0 c	61.2 c	44.6 d	13.6 c	12.2 c
	30	18.0 a	10.6 b	131.3 a	78.6 b	185.5 a	120.3 b	42.0 a	27.2 b
	mean	8.6	6.4	62.0 A	45.1 B	86.5 A	61.6 B	21.6 A	15.9 B
6	0	13.9 b	13.9 b	157.3 c	157.3 c	157.3 e	157.3 e	25.7 d	25.7 d
	10	14.4 b	26.7 a	195.0 b	204.0 b	192.9 d	233.9 c	38.2 c	49.0 b
	30	29.9 a	30.5 a	326.4 a	321.1 a	333.2 b	403.8 a	61.2 a	69.5 a
	mean	19.0	23.2	200.0 B	227.0 A	226.5 B	258.0 A	41.0	46.4
8	0	22.0 c	22.0 c	351.4 c	351.4 c	358.7 e	358.7 e	62.2 d	62.2 d
	10	51.7 a	24.7 c	400.8 b	264.1 d	507.9 c	446.0 d	88.5 b	65.0 d
	30	40.4 b	46.1 a	512.8 a	517.3 a	580.2 b	685.0 a	103.6 a	74.6 c
	mean	38.0 A	30.9 B	421.6 A	377.6 B	482.3	496.6	84.8 A	67.2 B
General means for VC and C		17.2	15.7	179.1	164.4	205.5	210.0	38.6	34.2
General means of dosages									
0		11 C***		111 B		138 C		31 B	
10		20 B		133 B		187 B		44 B	
30		27 A		203 A		287 A		66 A	

*shows the interaction effect for each harvest week
** shows the differences between the sources for each harvest week.
*** shows the differences depending on the dosages.

If a general evaluation was made looking at the results of plant dry weights, nutrient concentrations and plant nutrient uptakes it was clearly seen that VC and C applications had positive effects on the examined parameters in this research. One of the reasons of the positive roles VC and C can be the organic matter addition to the soil. As indicated previous studies, organic matter has an impressing role on plant growth and mineral nutrition due to its direct and indirect effect (Follett et al., 1981; Barakan et al. 1995; Zink and Allen, 1998). Although some nutrient concentrations in plant were not affected by VC and C applications, uptakes of all nutrients by above plant biomass showed increment with the application and their dosages generally. This could be attributed to dilution of the nutrient concentration in plant tissue with the plant growth (Erdal et al., 2014; Erdal and Ekinci, 2017). In some cases Recently, VC and C are widely used materials for increasing soil fertility and plant nutrition. In a study conducted by Aynaci and Erdal (2016) increasing of plant growth and plant mineral nutrition was attributed to nutrient release from the compost by means of mineralization and some other positive direct and indirect roles of compost. Also it was implied that vermicompost is a good even better source as soil conditioner. As explained previous studies conducted as field or pot experiments, vermicompost can increase soil fertility by means of different ways and thus plant growth and dry matter increase (Nagavallemma et al., 2004; Gutierrez-Miceli et al., 2007; Joshi and Vig, 2010). On these yield increase, slow release of nutrients during the plant growth and decreasing of nutrient loss by means of leakage may have effect as indicated by Cantanazaro et al., (1998). Although Edwards (1998) indicated that vermicompost had higher effect on increasing growth and yield of some vegetables, fruits and flowers when compared to other composts and pot soils, we could not see significant differences between both sources in terms of examined parameters.

CONCLUSIONS

In conclusion, plant growth and mineral nutrition of corn plant positively affected by vermicompost and compost generally. The highest yield and nutrient uptakes were obtained from the 40 t ha^{-1}. Also the effects of VC and C were similar generally.

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