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EFFECTS OF VERMICOMPOSTS OBTAINED FROM DIFFERENT MIXTURE RATES OF SAME FEEDSTOCKS ON WHEAT GROWTH AND N, P,K, NUTRITION GROWN ON DIFFERENT SOILS

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Abstract

In this study, it was aimed to determine the effects of vermicomposts (VC) obtained from different mixture rates of same feedstocks on growth and N, P, K nutrition of wheat plant grown on alkaline and acidic soils. For this, 0, 5, 10 and 20 t ha^{-1} vermicomposts were mixed to the 2 kg soil containing pots. Study was conducted as greenhouse experiment for 3 months. In alkaline soil, VC differences significantly affected plant dry weight (DW) and N, P and K concentrations. Application doses significantly affected plant DW, P and K concentrations. Also, VC x dose interaction had a significant effected on plant P and K concentrations. In acidic soil, application doses affected all parameters significantly. At the same time, vermicompost types had a significant effect on P and K. Interaction of VC x dose also had a significantly effect on N, P, and K concentrations of wheat. Effect types and degree of VC were different on alkaline and acidic soils. It was also seemed that the effect of VC on plant N, P and K nutrition was higher in acidic soil than that in alkaline soil.

Key words: plant growth, soil type, mineral nutrition, vermicomposts, wheat.

INTRODUCTION

Organic manure and other agriculture organic wastes are important sources to keep soil organic matter and to sustain soil productivity. Vermicompost is one of the most effective sources for maintaining and improving soil fertility. Vermicomposting is a waste stabilization technique which converts waste into potentially recyclable materials by earth worms (Wong and Griffiths 1991). Vermicomposting is also very effective and cheapest way for solid waste management (SWM) (Aalok *et al*., 2008). Vermicomposting is one of the recycling technologies that improve the quality of feedstocks (Muthukumaravel *et al*., 2008). Soil organic matter (OM) has many roles on physical, chemical and biological properties of the soils. Sometimes OM plays role on soil fertility indirectly as described above, sometimes it play a direct role on soil fertility as well. From one side, decomposition products of OM increase the availability of unavailable nutrients in the soils, on the other side, releases of nutrients with mineralization processes from the OM have direct effect on soil fertility and plant mineral nutrition. Sometimes these both effects occur at the same time (Marschner 2012; Flores-Sanchez *et al*., 2016; Sanchez *et al*., 2016). As indicated previous studies, vermicompost can increase soil fertility by means of different ways and thus plant growth and dry matter increase (Nagavallemma *et al*., 2004; Gutiérrez-Miceli *et al*., 2007; Joshi and Vig 2010). It was reported that plant nutrients, especially N, P K and Ca in the vermicompots are mostly available forms for plant uptake during the growth (Edwards 1998). In many studies, improving effects on the soils and increasing effects on plant growth, yield and nutrient uptakes of the plants were recorded (Atiyeh *et al*., 1999; Benitez *et al*., 1999; Atiyeh *et al* 2000; Arancon *et al.,* 2004) . Some researchers indicated that there had been some growth improving products such as hormone like substances, cytokinins, auxins and humates produced with some microorganism and earthworms (Tomati *et al*., 1988; Tomati *et al*., 1990).

The aim of the study was to determine and compare the effects of vermicomposts containing different amounts of same raw materials on wheat growth and mineral nutrition grown on two different soils.

MATERIAL AND METHODS

In this study, 6 different vermicomposts (VC1, VC2, VC3, VC4, VC5, VC6) obtained from the mixture of five feedstocks in different rates were used. As composting materials municipal open market wastes (MOMW) containing fruits and vegetable wastes collected from market places, rose oil processing wastes (ROPW), which is emerged form rose oil processing factory, the dairy manure (DM), poultry manure (PM) and straw were supplied from a farm in

Isparta province. The mixing rates of the materials and chemical compositions of vermicomposts are given in Table 1 and Table 2

Table 1. Mixing rates of the feedstocks used for vermicompost productions

Vermicompost types (VC)	ROPW	DM	PM	MOMW	Straw
	Mixing rates, %				
VC1	48	40	-	4	8
VC2	32	35	-	20	13
VC3	26	24	-	38	12
VC4	22	45	11	-	22
VC5	22	-	11	45	22
VC6	17	33	-	33	17

Table 2. Mineral composition of vermicomposts containing different rates of feedstock

Nutrients		Vermicompost types					
		VC1	VC2	VC3	VC4	VC5	VC6
N	%	1,30	0,97	1,00	0,87	0,55	1,22
P		0,46	0,60	0,48	0,86	0,81	0,42
K		0,80	0,86	0,71	0,87	1,00	0,92
Ca		2,83	3,88	3,10	6,80	6,40	3,80
Mg		0,73	0,81	0,65	0,79	0,97	0,80
Fe	$mg\ kg^{-1}$	8193	8385	7057	5585	8851	7876
Cu		37,4	32,8	30,4	30,0	34,1	29,3
Zn		126	149	128,00	166	199	100
Mn		340	362	321,00	352	419	318

The experiment was planned according to randomized blocks with 3 replicates and 4 levels of vermicomposts as D0:0; D1:5; D2:10; and D3: 20 t ha^{-1} was applied. Study was conducted with 2 kg soil containing pots under greenhouse condition during 3 months. As basal fertilization, 200 mg kg^{-1} N (as ammonium nitrate), 200 mg kg^{-1} P (as triple super phosphate) and 100 mg kg^{-1} (as potassium sulphate) were added and mixed to the soil with vermicomposts. Plants were watered with top water during growth period. At the end of the experiment, plants were harvested above the soil surface and washed with top water and distilled water. Then, plants were dried at 65±5^{0}C for 24 hours and grounded for nutrient analysis.

Nitrogen (N) concentration in samples was determined according to modified Kjeldahl method. In order to determine P, K, Ca, Mg, Fe, Zn, Mn and Cu concentrations, 0.5 g of samples were wet digested and filled up to 50 ml with pure water. Phosphorus contents of samples were determined by vanadate-molybdate colorimetric method using spectrophotometer. Potassium, Ca, Mg, Fe, Zn, Cu and Mn concentrations were determined using atomic absorption spectrophotometer (AAS) (Kacar and İnal 2008). Soils were statistically evaluated separately and statistical evaluations of the values were made using MSTAT program.

Some properties of the soils used for the experiments were given in Table 3. Soil available P, exchangeable K, Ca, Mg and DPTA-extractable micro elements were determined as described by Olsen *et al*, (1954), Jackson (1967) and Lindsay and Norvell (1969). Soil texture was determined using hydrometer (Bouyoucos 1954) and CaCO3 content was measured with calcimeter (Allison and Moodie 1965). Soil organic matter was determined based on Walkley and Black (1934). Soil pH was measured using pH mater in suspension of soil and water at the rates of 1/ 2.5 (Kacar 2009).

Table 3. Some characteristics of the experimental soils

Soil type	Texture	pH	EC	$CaCO_3$	O.M	P	K	Ca	Mg	Fe	Cu	Zn	Mn
			(dS m^{-1})	(%)	(%)				(mg kg^{-1})				
Alkaline soil	CL	8,1	0,23	1,90	0,85	13	1155	6850	3745	3,1	0,9	1,4	12,2
Acidic soil	L	4,3	0,07	0,84	1,1	18	376	2067	787	6,5	1,6	1,6	14,5

EC: Electrical conductivity, CL: Clayey-loam, L: Loam

RESULTS

Effects of vermicompost tpypes (VC) dose and VC x dose interactions on examined parameters obtained from the two different soil types were investigated separately (Table 3). As indicated in Table 4, VC application doses significantly affected plant dry weights growing on both alkaline and acidic soils. The lowest plant dry weights were recorded from the control treatments. All other application doses significantly increased dry weights taken from the both soils, but their effects on dry weight were statistically similar to each other.

Table 4. Analysis of variance of the date obtain from applications were given in

Alkaline soil					
F values					
Source	DF	DM	N	P	K
VC	5	3,6***	7.4***	13***	18***
Dose	3	13,8***	Ns	91***	36***
VCxDose	15	Ns	Ns	4***	4***
Acidic soil					
F values					
Source	DF	DW	N	P	K
VC	5	Ns	Nd	11***	18***
Dose	3	12,7***	56***	20***	28***
VCxDose	15	Ns	3,2***	6***	3,6***

***: P<0.05, Ns: non-significant

Table 4. Effects of vermicomposts on plant dry weights (g pot^{-1})

VC	Alkaline soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	5,66	5,91	5,72	5,77	5,76 b*
VC2	5,66	6,22	6,91	6,74	6,38 a
VC3	5,66	6,28	6,33	6,89	6,29 ab
VC4	5,66	6,46	6,37	6,85	6,34 ab
VC5	5,66	6,56	7,11	6,79	6,53 a
VC6	5,66	5,69	6,59	6,79	6,18 ab
Means	5,66 B**	6,19 A	6,51 A	6,64 A	
VC	Acidic soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	5,83	5,61	6,27	6,86	6,14
VC2	5,83	6,33	6,81	7,14	6,53
VC3	5,83	6,42	6,44	6,45	6,29
VC4	5,83	6,71	7,27	6,79	6,66
VC5	5,83	6,68	6,73	6,61	6,46
VC6	5,83	6,53	7,28	6,46	6,53
Means	5,83 B**	6,38 A	6,80 A	6,72 A	

*: indicates the differences among the VC, **: indicates the differences between the application doses. There is a not significant difference between the values sharing same letters

Vermicompost differences also significantly affected wheat dry weight grown on alkaline soils. The lowest plant dry weight (5,76 g) were determined from the VC1 applied pots and with this value only VC1 was significantly varied from the others. Also VC x dose interaction had a significant effect on plant N concentrations. The lowest N concentrations were determined from the control treatments of all VC types, but the highest was measured from the 20 t ha^{-1} of VC4 application (Table 4).

Table 4. Effects of vermicomposts on plant N concentration (%)

VC	Alkaline soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	3,29	3,39	3,52	3,45	3,42 a*
VC2	3,29	3,40	3,29	3,61	3,40 a
VC3	3,29	2,60	2,82	2,85	2,89 b
VC4	3,29	3,24	3,32	3,59	3,36 a
VC5	3,29	3,24	3,32	3,59	3,27 a
VC6	3,29	3,50	3,64	3,57	3,50 a
Means	3,29	3,23	3,32	3,44	
VC	Acidic soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	2,59 d***	3,78 abc	3,67 bc	3,39 bcd	3,36 ab*
VC2	2,59 d	3,62 bcd	3,40 bcd	3,39 bcd	3,25 b
VC3	2,59 d	3,54 bc	3,56 bc	3,70 abc	3,35 ab
VC4	2,59 d	4,15 ab	3,13 cd	4,63 a	3,63 a
VC5	2,59 d	3,43 bcd	3,50 bcd	3,57 bc	3,27 ab
VC6	2,59 d	3,23 bcd	3,64 bc	3,67 bc	3,28 ab
Means	2,59 B**	3,63 A	3,48 A	3,73 A	

*: indicates the differences among the VC, **: indicates the differences between the application doses: ***indicates the VC x dose interactions. There is not a significant difference between the values sharing same letters

Plant P concentrations measured from the wheat plant grown on alkaline and acidic soils were significantly varied with the individual effects of the factors and their interactions. In both soils, effects of VC on plant P concentrations showed different tendency. In alkaline soil, plant P concentrations decreased with the VC doses. This tendency was also observed in VC x dose interactions generally. While the most effective VC sources on plant P concentrations were VC3, VC6 and VC5, the least effectiveness was seen from VC1, VC2 and VC4. In contrast to alkaline soil, mean plant P concentration under control treatment was the lowest in acidic soil. The most effective VC doses in acid soil were 5 and 10 t ha^{-1}. According to the means of P levels obtained from the VC, it was seen that VC3 and VC5 were significantly increased plant P concentrations comparing to other and the lowest P was measured from the VC2 vermicompost (Table 5).

Table 5. Effects of vermicomposts on plant P concentration (%)

VC	Alkaline soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	0,30 a***	0,21 de	0,18 cde	0,16 e	0,24 b*
VC2	0,30 a	0,16 e	0,16 e	0,22 bcd	0,24 b
VC3	0,30 a	0,20 b-e	0,23 bcd	0,26 ab	0,27 a
VC4	0,30 a	0,20 b-e	0,21 b-e	0,24 bc	0,24 b
VC5	0,30 a	0,23 bcd	0,23 bcd	0,24 bc	0,25 ab
VC6	0,30 a	0,25 ab	0,24 bc	0,25 ab	0,26 ab
Means	0,30 A**	0,21 B	0,21 B	0,23 B	
VC	Acidic soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	0,20 e-g***	0,29 ab	0,20 d-g	0,21 d-g	0,23 ab*
VC2	0,20 e-g	0,18 g	0,19 fg	0,22 c-g	0,20 c
VC3	0,20 e-g	0,25 abcd	0,27 a-e	0,29 ab	0,25 a
VC4	0,20 e-g	0,20 e-g	0,23 b-g	0,24 b-g	0,22 bc
VC5	0,20 e-g	0,27 abc	0,21 d-g	0,33 a	0,25 a
VC6	0,20 e-g	0,29 ab	0,22 c-g	0,23 b-g	0,24 ab
Means	0,20 B**	0,25 A	0,22 B	0,25 A	

*: indicates the differences among the VC, **: indicates the differences between the application doses, ***indicates the VC x dose interactions. There is not a significant difference between the values sharing same letters

In both soils all sources significantly affected plant K concentrations. In both soils, although there were insignificant differences among them, the effects of VC3, VC4, VC5 and VC6 on plant K concentrations were similar and significantly higher than VC1 and VC2. In acid soil, VC2 was the least effective source on plant K concentration. Increasing levels of VC doses increased plant K concentrations up to 28% in acidic soil. But in alkaline soil there were revers effect of VC levels on plant K concentrations. Looking at the VC x dose interactions, it was seen that plant K concentrations decreased with the increases of all VC types generally. However in alkaline soils, although there was not a linear increases depending on the VC doses for all VC, application doses resulted in increases in all VC types (Table 6).

Table 6. Effects of vermicomposts on plant K concentration (%)

VC	Alkaline soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	3,60 ab***	2,82 c-h	2,80 d-h	2,61 e-h	2,96 b*
VC2	3,60 ab	2,10 h	2,21 gh	2,53 fgh	2,61 c
VC3	3,60 ab	2,76 d-h	3,10 a-f	3,38 a-e	3,21 ab
VC4	3,60 ab	2,93 a-g	3,14 a-f	3,67 a	3,34 a
VC5	3,60 ab	2,89 b-g	3,03 a-f	3,46 a-d	3,25 ab
VC6	3,60 ab	3,56 abc	3,28 a-f	3,17 a-f	3,40 a
Means	3,60 A**	2,84 C	2,93 C	3,14 B	
VC	Acidic soil				
	Application doses, t ha^{-1}				
	0	5	10	20	Means
VC1	2,81 d-g	3,30 a-g	2,84 c-g	2,71 eg	2,92 b
VC2	2,81 d-g	2,57 fg	2,52 g	3,13 b-g	2,76 b
VC3	2,81 d-g	3,69 ab	3,69 ab	4,01 a	3,55 a
VC4	2,81 d-g	3,45 a-e	3,40 a-f	4.00 a	3,42 a
VC5	2,81 d-g	3,61 a-d	3,26 a-g	4,10 a	3,45 a
VC6	2,81 d-g	3,63 a-d	3,16 b-g	3,58 a-d	3,93 a
Means	2,81 C	3,38 AB	3,15 B	3,59 A	

*: indicates the differences among the VC, **: indicates the differences between the application doses, ***indicates the VC xdose interactions. There is not a significant difference between the values sharing same letters

DISCUSSION

Plant dry weights obtained from the both alkaline and acid soils were affected positively from vermicompost applications. This can be due to the increases of OM ant it's positive effect on soil fertility directly or indirectly (Tejada and Benítez 2015; Doan *et al*., 2013; Flores-Sanchez *et al*., 2016; Sanchez *et al*., 2016) and thus plants grow better (Nagavallemma *et al*., 2004; Gutiérrez-Miceli *et al*., 2007; Joshi and Vig, 2010). On these yield increases, slow release of nutrients during the plant growth and decreasing of nutrient loss by means of leakage may have effect (Cantanazaro *et al*., 1998). Also pH decrease resulted by vermicomposts might be result of dry matter increases especially in alkaline soil (Sharma et al., 2005). In alkaline soils, VC doses had no or negative effect on plant N, P and K concentrations. This may be due to the dilution effect at least for N. But in acidic soil, N, P and K concentrations in wheat increased with VC deses comparing to control (0 doses). Vermicompost consist of nutrients readily available forms for plant use. Edwards and Burrows (1988) found that vermicompost applications increased rose growth, yield and quality comparing to control. Also some humic materials released from the composts might increase availability of soil nutrient as easily to be absorbed by plant roots (Garcia *et al*., 2014) Similarly, hormone like substances from the composts might encourage root growth to take more water and nutrient from the soil (Muscolo *et al*., 1999; Canellas *et al*., 2002; Gonzalez 2006). Baldatto *et al*., (2009) determined higher amount of N, P, K, Ca, and Mg in the roots, shoots and leaves with the application of humic acids obtained from vermicomposts. Looking at the results obtained from the alkaline and acidic soils, it was clearly seen that characteristics of the soils had an effect on VC effectiveness. And it may also be said that vermicomposts have higher effect on plant nutrition on acidic soil. Plant growth, nutrient concentrations showed variation depending on the vermicompost types. This could be due to differences in mixing rates of the raw materials for vermicomposting as indicated by Atiyeh *et al*., (2000).

As conclusion, vermicomposts can be used to improve soil properties when applied to soil. Looking at the plant dry weights, it seems that there were not significant differences among the vermicompost types except for VC1 in alkaline soils. In acid soils, there were not any differences among the all vermicompost types. Looking at the doses effect on dry weight again, all doses had the same effect, so 5 ton ha^{-1} is sufficient for both acid and alkaline soils. The results of this study showed differences among vermicomposts and doses based on their nutrient contents and influence on plant growth and plant N, P and K concentrations. Also it was seen that effects of vermicomposts on plant growth and nutrient concentrations showed variation depending on the soil properties.

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