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The Effect of NPK Fertilizer and Vermicompost Application on Plant Growth and The Nutrient Contents of Radish (*Raphanus Sativus* L.)

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ABSTRACT

Vermicompost production and applications are increasing in our country recently. There are also many commercial products on the market. Vermicompost may act both as soil conditions and organic fertilizer. In addition to the effect of this product on improving the physical properties of the soil; the effect of plant growth on different plants should be studied. In this study conducted for this purpose; commercially produced radish (*Raphanus sativus* L.) cv. "Cherry Belle" was planted in growing medium mixed with different doses of vermicompost (0 - 2.5 – 5 – 10 %). In order to determine NPK and NPK + Fe. Zn fertilizer needs of the plants, these elements contained fertilizers were applied. According to the pot experiment results, important increases in some element contents and fresh root weights of radish plant were determined with increasing vermicompost applications. The average fresh root weight changed between 47.89-77.70 g pot^{-1}. The average N concentration of in leaves and in roots changed between 3.09-4.69 % and 1.19-2.67 %, respectively. The K of in leaves and in roots changed between 1.27-1.46 % and 1.39-2.13 %, respectively, and the P concentration of in leaves and in roots changed between 0.46-0.50 % and 0.36-0.45 %, respectively. Application of vermicompost had statistically significant effect on growth of radish.

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Introduction

Radish (*Raphanus sativus* L.) is a popular vegetable in tropical and temperate regions (Kumar et al.,2014), but it is also grown in cool climate zones and is widely used as root vegetable, tender leaves and green. It is an excellent source of carbohydrates, proteins, vitamin C, folic acid, potassium, B6, riboflavin, magnesium, and calcium (Zohary and Hopf, 2000). In Turkey, the total production of radish, which is one of the widely produced vegetables in our country, is 196.984 tons at 2018 year. The most cultivated variety is red radish (TUIK, 2017), which accounts for 73% of radish production, while the rest is made up of other radishes (Anonymous, 2019). The provinces with the highest amount of radish production in our country are Osmaniye, Samsun, Ankara, Kahramanmaraş, Konya and Adana respectively (TUIK, 2019). The heavy structure of the soil affects the root development of radish negatively and cannot be growing roots of radish plants in such soils. Organic fertilizer, vermicompost, compost, biofertilizer, and low-dose chemical fertilizer applications are increased the production parameters of radish and dry matter production (Subramani et al., 2010, Imthiyas and Seran, 2015, Kiran et al., 2016). Turkey's soils (except for the Black Sea region) is generally poor in organic matter content and organic matter content of at least 65% of our country is very poor. In terms of soil quality and production, it is desirable to have more than 3% (good level) organic matter content in soils (Saltalı,2019).

In various studies have been reported that; vermicompost (50%) + poultry manure (50%) increased in radish cv. Japanese White growth parameters and yield (Kumar et al., 2014); vermicompost and peat mixture increased radish leaf and root weight (Alsina et al., 2013); with 5 tons ha^{-1} vermicompost and 90 kg N ha^{-1} application were taken high yield from radish (Reddy et al., 2011). Moreover, the application of vermicompost could significantly promote the growth of the cherry radish root and the transportation of assimilation products from shoots to roots (Wang et al., 2010). Durukan et al. (2019) determined that the solid vermicompost higher effect on the yield and nutrient uptake

of plant than liquid vermicompost. This study was carried out because the soil of our country is poor in organic matter and the cultivation of different radish varieties in various cultivation areas is intense.

For this purpose, due to its positive effects on both organic matter source and soil physical properties; the effect of different doses vermicompost and fertilizer application (with NPK and trace elements at conventional doses), on growth and nutrient concentration of radish were investigated.

Materials and Methods

The experiment was carried out in the greenhouse conditions in Konya and arranged according to the coincidence plot trial pattern. The soil used in the pot experiment was taken from 0-20 cm depth from the land of Sarıcalar Application and Research Farm of Agricultural Faculty of Selçuk University. The soil, which was air dried, was sieved by a 4 mm sieve, weighed and filled in pots (2.7 kg dry soil pot^{-1}). The soils were analysed. Particle size analysis was done by the hydrometer method (Gee and Bauder, 1986), soil pH was measured in H_2O (1:2.5 soil: water), $CaCO_3$ content (using Scheibler calcimeter). EC was determined directly on the saturation paste. Organic matter was determined using a modified Walkley-Black procedure (Walkley and Black, 1934). Soil available P was determined by the Olsen sodium bicarbonate procedure (Olsen and Sommers, 1982). The DTPA soil test of Lindsay and Norvell (1978) was used to determine Fe, Zn, Mn, and Cu contents of the soil. The pH of the test soil is 8.14, EC is 455 mS cm^{-1}, the lime content is 13%, the organic matter is 3.78% and the texture is silty clay. Ca, Mg, K, P content of the soil are 3525, 333, 790 and 16.25 mg kg^{-1} respectively. The contents of Zn, Fe, Cu and Mn are 0.51, 4.84, 1.70 and 7.36 mg kg^{-1}, respectively. The vermicompost obtained from a special company was applied to the pots as 4 doses (0% - 2.5% - 5% - 10%) (V_0-$V_{2,5}$-V_5-V_{10}) on dry weight basis (Table 1). Some features of the vermicompost used in the experiment are presented in Table 2.

In addition to the different doses of vermicompost also NPK fertilizer (9 kg N da^{-1}, 4 kg P_2O_5 da^{-1} and 9 kg K_2O da^{-1}) and NPK + trace element fertilizer (specified 9.4.9 ratios + 0.5 kg Zn + 0.5 kg Fe + 0.5 kg Mn + 0.5 kg Cu da^{-1}) were applied (Table 1).

The trial was experimented in a total of 36 pots as 3 replications. In the experiment was used as test plant "big red 950- cherry belle radish (commercial seed)". The seeds were sown in pots and the water needs of the plants were met by taking into account the soil moisture condition. When the root development was completed at the end of 70 days. Fresh root weight and fresh leaf weight were determined after harvest. Plant leaf and root samples were burned by wet burning method (Lindner and Harley,1942; Lindner, 1944) and then element contents of the extracts were determined by AAS (Perkin Elmer Analyst 700 Model). Nitrogen contents of samples were analysed with Kjeldahl N method (Kacar 1972). In this study, all the results were expressed on a dry weight basis. The results obtained from the greenhouse experiment were compared through variance analysis and Tukey's tests by using the MINITAB software.

Table 1 Treatments used in this experiment

V	V+NPK	V+NPK+TE
V_0	V_0+NPK	V_0+NPK+te
$V_{2,5}$	$V_{2,5}$+NPK	$V_{2,5}$+NPK+te
V_5	V_5+NPK	V_5+NPK+te
V_{10}	V_{10}+NPK	V_{10}+NPK+te

V: Vermicompost (%), V+NPK: Vermicompost+ NPK, V+NPK+TE: Vermicompost+ NPK+ trace elements(te)

Table 2 Some features of vermicompost used in the experiment

Vermicompost	Content
Total Organic Matter (%)	46
Total Humic Fulvic Acid (%)	32
Total CaO (%)	3
Water Soluble K_2O (%)	1
Total P_2O_5 (%)	1
Total N (%)	2
Organic Carbon (%)	23
Moisture (%)	20
pH	6-8
EC (ds/m)	5.0

Result and Discussion

The effect of vermicompost applications, which are mixed with soil in different ratios, on fresh root and fresh leaf weight is presented in Figure 1. As can be seen from the figure, there was a significant increase in these parameters compared to the control with vermicompost applied in increasing rates ($P<0.01$). The average fresh root weight was 47.89 g pot^{-1} at control treatment, while at V_5 and V_{10} applications were the 73.56 and 77.70 g pot^{-1}, respectively. Fresh leaf weight increased with increasing vermicompost application and reached the highest value with 47.04 g pot^{-1} at V_{10} dose. In the study, vermicompost had a significant and positive effect on plant growth. Zohary and Hopf (2000) has been reported that the administration of vermicompost significantly supports the growth of the radish root and the transfer of the assimilation products from the shoots to the roots, and the increasing application rates of vermicompost significantly increase the various antioxidant substances including nutrients, soluble sugars, soluble proteins, amino acids and flavonoids, total phenolics and vitamin C. To reduce the use of chemical fertilizers in various studies and to increase the development of radishes; positive results were obtained by using low-dose chemical fertilizer together with organic fertilizer(Subramani et al.,2010; Kumar et al.,2014; Sharma et al.,2013); for example, 20 t ha^{-1} compost application yielded higher leaves and dry matter production than chemical fertilizers alone (Imthiyas and Seran, 2015). In another study; maximum yield, nutrient uptake (134,4 N kg ha^{-1}, 17,59 P kg ha^{-1} and 232,59 kg ha^{-1}) were recorded with 50% NPK+50% FYM+Biofertilizers as compare to 100% NPK under the foothill condition of Nagaland (Sentiyangla et al., 2010).

The effect of vermicompost applications on leaf and root element concentrations of radish is presented in Table 3 and 4. Vermicompost application increased N and K concentration of radish leaf, and also N, P and K concentrations of radish root. N concentration increased with increasing doses of vermicompost and reached the highest degree in V_{10} dose and nitrogen concentrations ranged between 3.09-4.69 % in leaf and 1.19-2.67 % in root. When compared with the limit values in mature leaf (Jones et al., 1991), it was especially good for V_5 and V_{10} applications. Phosphorus concentration changed in the adequate range (0.33-0.60%), but K concentration was found to be deficient (3.00-3.49 K %). This shows that the plant cannot use potassium although there is a sufficient amount of K in the soil.

When the mean values were taken into consideration, the Fe and Zn concentration of radish leaf and Cu and Zn concentrations of radish root showed significant differences with vermicompost applications (P<0.01) (Tables 4). Vermicompost applications generally increased micro element concentrations compared to control.

In this study, the effect of vermicompost application and NPK fertilizer applications were statistically insignificant on leaf and root weight, and on leaf and root element concentrations, except Mn concentration in root. The interaction effect of vermicompost and fertilizer applications was significant at Mn concentration in root(P <0.01) (Table 5). In a study conducted by Baloch et al. (2014), an increase in nitrogen levels from 100 to 150 kg ha^{-1} positively affected all growth and yield parameters of radish at Pakistan condition. Brintha and Seran (2009) said that higher amounts of potassium are required by radish for tuberous root formation. Bilekudari et al. (2005) were of the view that higher growth and yield parameters were due to a greater amount of nutrients (130:55:55 NPK/ha) provided to radish. In another study, in a Latosol with high P and K levels, the supply of up to 400 kg ha^{-1} of P_2O_5 and 240 kg ha^{-1} of K_2O does not increase the productivity of radish culture (Filho et al., 2017).

However, when the average values were taken into consideration, it was determined that the radish leaf and root weights; N, Zn concentrations of radish leaf, P concentration of radish root, and total P removed from soil showed statistically significant differences between fertilizer applications (P<0.05) (Table 6, 7).

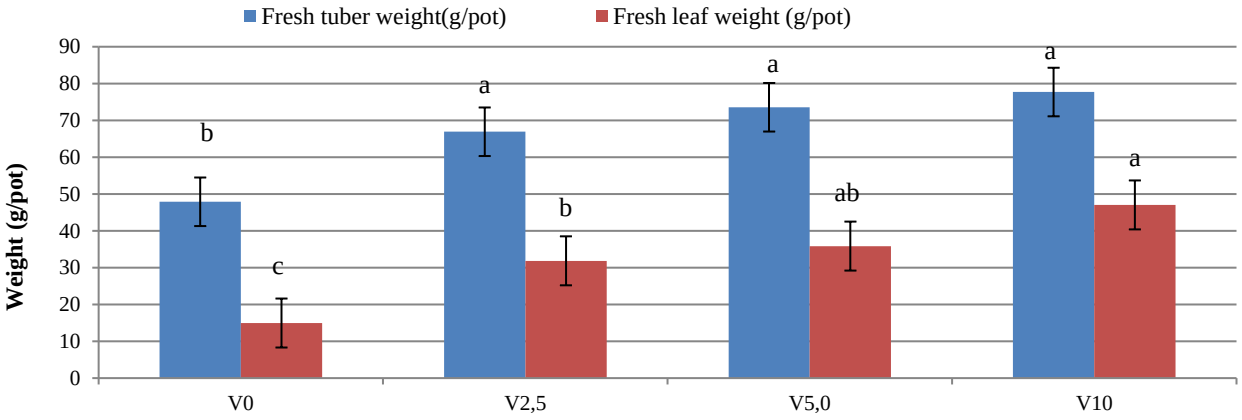

Figure 1 The effect of vermicompost on fresh tuber and fresh leaf weight of radish(g pot^{-1})

Table 3 N, P and K concentration of root and leaves of radish and total removed P and K from soil (n = 3; **P<0.01)

V	NL	PL	KL	NR	PR	KR	TPS	TKS
V0	3.09^{c}	0.50	1.27^{b}	1.19^{c}	0.36^{b}	1.39^{c}	5.27^{c}	17.52^{c}
V2,5	4.06^{b}	0.47	1.39^{ab}	2.22^{b}	0.42^{a}	1.59^{bc}	9.73^{b}	32.88^{b}
V5,0	4.32^{b}	0.49	1.46^{a}	2.53^{a}	0.43^{a}	2.05^{ab}	10.88^{ab}	43.10^{ab}
V10	4.69^{a}	0.46	1.40^{ab}	2.67^{a}	0.45^{a}	2.13^{a}	12.47^{a}	48.87^{a}

V: Vermicompost, NL: N in leaf (%); PL: P in leaf (mg kg^{-1}), KL: K in leaf (%), NR: N in root (%), PR: P in root (%), KR: K in root (%), TPS: total P removed from soil (mg kg^{-1}), TKS: total K removed from soil (mg kg^{-1}), (Means fallowed by the same letter are not significantly different according to Tukey's test at 1% significant level, n = 3, **P<0.01)

Table 4 The effect of vermicompost on Fe,Zn,Cu and Mn concentration of root and leaves of radish (n = 3; **p<0.01)

V	Fe	Cu	Mn	Zn	Fe	Cu	Mn	Zn
	Leaf (mg kg^{-1})				Root (mg kg^{-1})			
V0	148.5^{a}	14.3	196,7	83.1^{ab}	73.8	7.8^{b}	43.5	51.3^{b}
V2,5	120.6^{b}	28.5	190.6	77.3^{b}	111.3	10.4^{a}	51.2	56.2^{ab}
V5,0	139.4^{ab}	15.3	204.8	85.7^{ab}	114.9	10.1^{a}	48.8	57.7^{ab}
V10	116.8^{b}	15.9	177.6	95.8^{a}	96.9	10.9^{a}	41.8	60.5^{a}

V: Vermicompost, (Means fallowed by the same letter are not significantly different according to Tukey's test at 1% significant level,n = 3, **P<0.01)

Table 5 The effect of vermicompost on element concentrations of root and leaves of radish (n = 3; **P<0.01)

F	V	FR	FL	CR	CL	MnR	MnL	ZnR	ZnL	NL	NR	PL	PR	KL	KR
		(mg/kg)								(%)		(mg/kg)		(%)	
1	V0	91,61	160,55	7,89	15,29	46,39ab	189,76	52,22	90,08	2,98	1,25	4808	3586	1,33	1,45
	V2,5	194,06	121,05	12,78	57,10	65,89 a	213,91	58,00	77,09	3,78	2,13	4849	4737	1,41	1,57
	V5,0	81,72	150,41	10,50	16,13	47,39ab	211,08	60,89	99,13	4,41	2,56	4919	4641	1,47	2,63
	V10	73,11	124,16	9,95	14,68	34,56b	155,37	63,39	114,49	4,34	2,52	4509	4544	1,50	1,91
2	V0	65,94	125,47	7,83	13,80	46,66ab	207,30	50,11	74,41	3,19	1,20	5268	3592	1,17	1,38
	V2,5	75,11	129,97	9,39	14,39	47,28ab	183,27	55,89	79,88	4,17	2,33	4575	3929	1,39	1,55
	V5,0	186,11	117,84	9,78	14,31	52,44ab	199,10	56,89	74,97	4,31	2,44	4845	4327	1,46	1,70
	V10	91,28	104,53	11,39	15,47	42,94b	186,86	59,67	82,28	4,73	2,66	4503	4122	1,39	1,97
3	V0	63,94	159,51	7,78	13,84	37,50b	192,93	51,50	84,85	3,10	1,12	4806	3586	1,30	1,35
	V2,5	64,72	110,76	9,06	14,14	40,45b	174,57	54,72	74,85	4,22	2,19	4813	4038	1,36	1,63
	V5,0	76,94	149,88	9,89	15,54	46,56ab	204,37	55,28	83,10	4,25	2,58	4774	4014	1,46	1,83
	V10	126,17	121,64	11,22	17,79	47,78ab	190,52	58,39	90,71	5,00	2,84	4887	4762	1,30	2,50

1: NPK0, 2: NPK, 3: NPK+Zn.Fe, F: Fertilizer, V: Vermicompost, FR: Fe in root, FL: Fe in leaf, CR: Cu in root, CL: Cu in leaf, MnR: Mn in root, MnL: Mn in leaf, ZnR: Zn in root, ZnL: Zn in leaf, NL: N in leaf, NR: N in root, PL: P in leaf, PR: P in root, KL: K in leaf, KR: K in root, Means fallowed by the same letter are not significantly different according to Tukey's test at 1% significant level,n = 3, **P<0.01

Table 6 The effect of fertilizer applications on N, P and K concentration of root and leaves of radish and total removed P and K from soil (n = 3; **P<0.05)

Fertilizer	NL	PL	KL	NR	PR	KR	TPS	TKS
NPK_0	3.88b	0.48	1.43	2.12	0.44a	1.89	10.62a	39.65
NPK	4.10ab	0.48	1.35	2.16	0.40b	1.65	9.76ab	35.25
NPK+te	4.14a	0.48	1.35	2.18	0.41b	1.83	8.39a	31.88

NL: N in leaf (%); PL: P in leaf (mg kg^{-1}), KL: K in leaf (%), NR: N in root (%), PR: P in root (%), KR: K in root (%), TPS: total P removed from soil (mg kg^{-1}), TKS: total K removed from soil (mg kg^{-1}), (Means fallowed by the same letter are not significantly different according to Tukey's test at 1% significant level, n = 3, **P<0.01)

Table 7 The effect of fertilizer applications on Fe, Zn, Cu and Mn concentration of root and leaves of radish (n = 3; **P<0.05)

Fertilizer	Fe	Cu	Mn	Zn	Fe	Cu	Mn	Zn
	Leaf (mg kg^{-1})				Root (mg kg^{-1})			
NPK_0	139.0	25.8	192.5	95.2^{a}	110.1	10.3	48.6	58.6
NPK	119.5	14.5	194.1	77.9^{b}	104.6	9.6	47.3	55.6
NPK+te	135.5	15.3	190.6	83.4^{ab}	82.9	9.5	43.1	55.0

Conclusion

As a result, it was determined that vermicompost application had a positive effect on plant nutrient uptake, especially considering the effect of V_{10} dose on root growth. When the effect of fertilizer application is taken into consideration, it is observed that there is generally no difference between applications. There were observed statistically significant differences between N and K concentrations in leaves (P<0.05 and P <0.01), and N, P and K concentrations in roots (P <0.01). When compared with vermicompost applications and NPK and NPK + trace element applications, it was observed that there was no significant difference in the development parameters of fertilizer application. This situation is related to the sufficient P, K, Ca, Mg, Fe, Cu and Mn concenrations of the soil used in the study. As the application of vermicompost on study soil, which has silty clay texture, has a positive effect on soil physical properties, plant and root development have been good. As a result, total fresh root weight was highest in 10% vermicompost application and 5% in vermicompost application. In this case, if the nutrient content in the soil is sufficient, it may be advisable to mix vermicompost into the growing medium at a dose of 5%, because it is more economical than 10% in radish cultivation.

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