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Araştırma Makalesi/*Research Article (Original Paper)*

Effects of Different Vermicompost and Soil Moisture Levels on Pepper (Capsicum *annuum*) Grown and Some Soil Properties

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Abstract: Pot capacity (PC) is defined as optimum moisture level of the pot-soil for irrigation in greenhouse experiments, is not same field capacity (FC) defined for field conditions. In this study, vermicompost was applied to different levels (0%, 0.75%, 1.5%, 2.25% w/w) for a sandy loam soil. Pepper was grown in greenhouse conditions. The irrigations were carried out at the levels of 80% PC and FC. Yield and some yield components were determined after 70 days from sowing. Effects of vermicompost were also, investigated on soil field capacity, wilting point and dispersion ratio. The differences found for plant height, weight, root weight, yield, leaf chlorophyll content were statistically significant. In addition, vermicompost applications provided to reduction of dispersion ratio.

Keywords: Dispersion ration, Field capacity, Pot capacity, Vermicompost, Yield components

Farklı Düzeylerde Vermikompost ve Sulama Uygulamalarının Bazı Toprak Özellikleri ve Biber (*Capsicum annuum*) Gelişimi Üzerine Etkileri

Özet: Sera denemelerinde sulamaya ilişkin optimum nem düzeyi olarak yapılan saksı kapasitesi tanımlaması, normal arazi koşullarındaki tarla kapasitesinin tam karşılığı değildir. Vermikompostun farklı düzeylerinin %0, %0.75, %1.5, %2.25 (w/w) uygulanmış olduğu kumlu tın bir toprak kullanılarak gerçekleştirilen sera çalışmasında; tarla kapasitesi ve saksı kapasitesinin yaklaşık %80'i düzeylerindeki günlük sulama koşulları altında biber (*Capsicum annuum*) yetiştirilmiştir. Biber fidelerinin dikiminden 70 gün sonrası verim ve bazı verim bileşenleri ile yaprak klorofil (SPAD) içeriği belirlenmiş, ayrıca vermikompostun toprağın tarla kapasitesi, solma noktası ve dispersiyon oranı üzerine etkileri araştırılmıştır. Biber bitki boyu, toprak üstü yaş ağırlığı, kök yaş ağırlığı ve verim ile yaprak klorofil içeriğinde sulama düzeylerinin neden olduğu farklılıkların istatistiksel olarak önemli olduğu ve vermikompost uygulamalarının dispersiyon oranlarının azalmasını sağladığı bulunmuştur.

Anahtar kelimeler: Dispersiyon oranı, Tarla kapasitesi, Saksı kapasitesi, Vermikompost, Verim bileşenleri

Introduction

The greenhouse gases emitted into the atmosphere by industrialized countries causes to global warming. It leads to reduction of water resources, to melting of glaciers, to changes of precipitation and temperature and to drought. According to various climate change scenarios, increase of temperature will cause to increase of evaporation (IPCC 2014). Therefore, an accurate determination for water needs of plants is a necessity to optimum use of irrigation water. Soil moisture constants, field and pot capacities respectively for field and greenhouse conditions, used for irrigation are different from each other. While amount of water held after remove of excessive water from the soil under free drainage conditions in the land is regarded as the moisture level of field capacity, for soils in the greenhouse pot conditions is defined as the pot capacity (Kirkham 2005; Karahan et al. 2014). Soil moisture amount in the pot capacity was also, higher than those in the field capacity.

In the pot experiment studies conducted under greenhouse conditions were used both field capacity and pot capacity applications for ensure optimum soil moisture levels. Fernando et al. (2013) used levels of 75, 50 and 25% of the field capacity in a study in which investigated the effects of a polymer called GAM-sorb. Abou El-khair et al. (2014) investigated effects of different levels moisture and manure applications on some chemical properties of calcareous soils, and are based on the field capacity moisture level for irrigation. On the contrary, Mostafazadeh-Fard et al. (2008) used the pot capacity moisture level for irrigations in their study which investigated the effects of different levels salt and water on plant growth. On the other hand, Rahbarian and Sardoei (2014) used pot capacity in their study but their expressed as field capacity this moisture level. Ünlükara et al. (2010) studied the effects of salinity on evapotranspiration and eggplant growth, and used electrical conductivity values determined for pot capacity moisture level in the regulation process of irrigation water salt content.

The ability to provide nutrient of soil are significant as much as moisture level among the factors that affect plant growth. In this context, the use of various organic materials that contribute to the physico chemical properties of the soil is becoming increasingly more widespread. One of the latest organic materials is vermicompost, a composted material, occur during digestion by earthworms of different organic residues and wastes.

In some studies, positively impact of vermicompost on plant nutrient content (Küçükyumuk et al. 2014), plant growth (Atiyeh et al. 2000), yield (Kizilkaya et al. 2012), soil physical and chemical (porosity, bulk density, pH and EC) properties (Azarmi et al. 2008) have been identified. Hence, vermicompost applications that encouraged plant growth, further increased the importance of soil moisture level. The objectives of this study were to; (1) determine the impact of different moisture levels, field and pot capacities on the pepper growth, and (2) investigate the variations caused by vermicompost on the some soil properties.

Materials and Methods

This study was conducted in a glass greenhouse in Agricultural Research and Application Centre of Suleyman Demirel University, Isparta, Turkey. The experimental design was a completely randomized in triplicates conducted in pots. Soil was characterized by clay loam texture (sand %, silt %, clay %). Field (FC) and pot capacity (PC) moisture levels were 18.5% and 30.5%. pH was 7.9, EC was 975 dS/m, $CaCO_3$% was 26.5, and organic substances content was 1.5%. Three kg of soil was placed in each pot according to dry weight basis. For vermicompost, moisture and organic substances contents were 22% and 42%, respectively, pH was 7.9, and EC was 3.7 mS cm^{-1}. The doses of vermicompost incorporated to the soil were 0 (V0), 0.75 (V1), 1.5 (V2), 2.25 (V3)% (weight / weight). After planting of the pepper seedling, the daily irrigations based on weighting were carried out at about 80% level of the field and pot capacities. The amounts of diminished water to the exclusion of the weight gain caused by plant growth, were determined utilizing from the other pots in the same conditions. At the end of vegetation period (70 days), plant fresh weight were determined by cuting from the 1 cm height of the soil surface. The peppers collected and weighed to determine the yield. The roots removed from ponding pots were weighed after waiting for 30 minutes in the room temperature.

Mechanical analysis of soils by hydrometer method, and FC (0.33 bar) and wilting point (WP) (15 bar) determinations by using Pressure Plate Apparatus (Demiralay 1993) was performed. The PC was found by determining amount of the moisture held in the soil after removing of the excess water from saturated trial pot (Alpaslan et al. 2005). Dispersion ratio was estimated by using the equality that 100 minus the percent aggregation. The percentages of aggregates <50 micron were also, determined according to U.S.Salinity Lab.Staff (1954). pH (Kacar 2009) and EC (US Salinity Lab. Staff 1954) were determined in the 1:1 soil-water suspension. $CaCO_3$% by using Scheibler calcimeter, and organic matter content by Walkley Black method were found (Kacar 2009). Minolta SPAD -502 (Spectrum Authorized Dealer) chlorophyll meter was used for determining the intensity of the green color in leaves. For statistical analysis of the data was performed by using software program Minitab-16. The experimental design was a completely randomized and the data were subjected to ANOVA as variance analysis technique. Tukey test was used as post-hoc test.

Results and Discussion

Yield and yield components

Variations in the height of the pepper plant for both different levels of vermicompost and under conditions water application based on field and pot capacity were given Table 1. The plant heights obtained from vermicompost applications did not show a regular change for studied water levels. The highest plant heights for PC and FC moisture levels were found in the V1 and V0 applications, respectively. No differences ($p>0.05$) were detected between the vermicompost applications, it was evaluated that the reason why there was no significant effect of vermicompost applications on plant height can be explained by the low application levels. In many other studies where positive effects on plant height were also, obtained differently from this study, the high application rates of the vermicompost were observed (Narkhede et al. 2011; Çıtak et al. 2011). The changes in plant height depending on the water levels applied were statistically significant ($p<0.01$). Approximately 51% more water application resulted in an average increase of over 30% in plant height. Similar results regarding the positive effects of water level on plant height are frequently found in the literature (Sezen et al. 2007; Acar et al. 2008; Dağdelen et al. 2009; Yıldırım et al. 2015; Karasu et al. 2015; Sahin et al. 2016).

The effects of different vermicompost and water level applications on plant fresh weight were statistically significant (Table 1). For the V1 application, there was an increase in plant weight at both water levels, where the main outstanding pot capacity was the 55% difference determined for the moisture level. The same was true for the average plant fresh weight value obtained for V2 application. Compared to V0 application, plant weight was increased both V1 and V2 but V3 was found statistically similar with V0. Küçükyumuk et al. (2014) investigated the effects of vermicompost and mycorrhiza on growth and mineral nutrition of pepper plants and reported that vermicompost application caused an increase in plant fresh and dry weights. Interaction effects were found to be statistically significant for plant height ($p<0.05$) and weight ($p<0.01$). In addition to the high numerical differences between PC and FC, due to moisture retention, evaporation, salt content and other possible differencess between the vermicompost aplication levels, that is the reason for significant interactions.

Regardless of the level of vermicompost application, it was determined that the pot capacity water level resulted in higher plant fresh weight values than in the field capacity water level. Evaluation based on the effects of water levels on the average plant fresh weight was indicated a large difference as about 89%. This effect, that was found statistically significant ($p<0.01$) of water levels on plant fresh weight. Interaction effects were found to be statistically significant for plant height ($p<0.05$) and weight ($p<0.01$). In addition to the high numerical differences between PC and FC, due to moisture retention, evaporation, salt content and other possible differencess between the vermicompost application levels, that is the reason for significant interactions.

The effects of water levels were statistically significant ($p<0.05$) on the yield (Table 1). Yield increases depend on the water levels in this study were accordant with the results reported by Kırnak et al. (2002) , Demirtaş and Ayas (2009). The effects on pepper yield of vermicompost application levels not only exhibited a change in the form of increase and decrease for field capacity moisture level but also was extremely variable, and was difficult to explain for pot capacity water level. The average yield values were found to be higher for all the vermicompost application levels, but had statistically no significant differences.

Variations of the SPAD values in the pepper leaves were caused by the applications at the different levels of vermicompost and water were given in Table 1. These values that exhibited a downward trend depend on vermicompost applications for PC water level, did not show similar variation for FC water level. Interaction effects were not found to be statistically significant between applications. Chlorophyll contents of pepper plants that were grown on the conditions with the mulch and different irrigation time applications, varied between 53 and 68 (Ngouajio et al. 2008; Mujdeci et al. 2011). Mirabad et al. (2013) and Ghahfarokhi et al. (2015) also, reported that chlorophyll content was decreased in the event of water shortage. In addition, Kırnak and Demirtas (2002) reported that slowing the rate of chlorophyll synthesis may be associated with decreasing of the leaves water content. Luján-Hidalgo et al. (2016) stated that the leaves SPAD values of the tomatoes that were grown under the phosphate rock, vermicompost, worms vermicompost water applications were not significantly affected by the vermicompost applications.

Variations of the pepper fresh root weights for vermicompost and water application levels were determined to be statistically significant (Table 1). The pepper fresh root weights relation to vermicompost application levels were higher than in control for both water levels. The highest pepper fresh root weight were obtained as 15.6 g from V2 and PC water level applications. When the vermicompost applications compared, V1, V2 and V3 were statistically similar. Variation range of the values (4.6- 15.6 g / pot) found for pepper fresh root weights was quite wide. Similarly, Ezzo et al. (2010) reported that the average pepper root weight ranged between 15.75 and 35.75 grams in different soil and water regime conditions, and the root growth was affected positively by increasing water level. In addition, Najar et al. (2015) stated that there was an increase in the dry root weight were caused of the vermicompost applications (0, 2, 4 and 6 t ha^{-1}) for the eggplants.

Table 1. Effects of different levels vermicompost and irrigation applications on pepper yield and yield components

Vermicompost Aplications	Soil Moisture Levels (80%)	Plant Height (cm/pot)	Plant Weight (g/pot)	Root Weight (g/pot)	Chlorophyll (SPAD)	Yield (g/pot)
V0	FC	38.9*bcd**	35.1*cd*	4.6	64.9	26.1
	PC	44.4*ab*	51.9*b*	11.0	67.7	59.2
	Mean	41.6	43.5B	7.7B**	66.3	42.7
V1	FC	35.8*bcd*	37.4*bcd*	12.2	60.7	31.5
	PC	50.9*a*	80.5*a*	14.2	67.4	60.9
	Mean	43.4	58.9A	9.4AB	64	46.2
V2	FC	32.6*d*	33*bcd*	8.7	63.1	40.2
	PC	49.5*a*	78.8*a*	15.6	67.2	50.4
	Mean	41.1	55.9A	12.1A	65.1	45.3
V3	FC	35.0*cd*	33.3*d*	5.8	63.9	32.6
	PC	42.5*abc*	51.3*bc*	14.6	67.1	53.8
	Mean	38.8	42.3B	10.2AB	65.5	43.2
Mean	FC	35.6b	34.7b	5.9b***	63.1b	32.6b
	PC	46.8a	65.6a	13.8a	67.3a	56.1a
Variations Resources				P		
Vermicompost, 3 df		0.211	0.000	0.053	0.215	0.983
Soil moisture, 1df		0.000	0.000	0.000	0.000	0.012
Vermicompost x soil moisture, 3 df		0.022	0.000	0.632	0.278	0.816
Variations Resources				F		
Vermicompost, 3 df		1.57	8.78	3.51	1.56	0.05
Soil moisture, 1df		57.22	117.48	62.99	29.32	7.78
Vermicompost x soil moisture, 3 df		3.60	7.56	0.61	1.33	0.31

The doses of vermicompost were 0 (V0), 0.75 (V1), 1.5 (V2), 2.25 (V3)% (weight / weight)
FC: Field capacity moisture level (80%), PC: Pot capacity moisture level (80%)
* Italic letters indicate the interaction of soil moisture and vermicompost applications
** Capital letters indicate the difference between the vermicompost applications
*** lower case letters indicate the difference between soil moisture applications

Some soil properties

Vermicompost applications provided that increases were not statistically significant on field capacity (18.4-19.3%) and wilting point (10.5- 11.2%) moisture content of the soil (Table 2). Significant variations according to the control was found in the V1 or V2 applications of the findings related to developing of soil moisture retention properties of the vermicompost that contained rich organic matter, were consistent with the literature. Abadi et al. (2012) reported that field capacity and wilting point were positively impacted by the different vermicompost applications (T1= control, T2= chemical fertilizer, T3= 20 tons vermicompost + 0.5T2, T4 = 20 tons / hac vermicompost + 0.5T2, T5= 40 tons vermicompost + 0.5T2, T6= 40 tons / hac vermicompost).

Vermicompost applications caused a decrease in the soil dispersion ratio values. The average dispersion ratio value that was determined as 53.6% in the control application, decreased with increasing vermicompost applications (50.9, 46.4 and 44.1%). This variation was found statistically significant ($P<0.05$) (Table 2). The decrease in the dispersion rate for the highest vermicompost application level was significantly higher than in other applications. When the vermicompost applications compared, V1, V2 and V3 were statistically similar. Negative effect of the organic matter on the dispersion rate has been frequently referred in other studies, Indeed, Gülser (2006) pointed out that the dispersion rate was negatively correlated with organic matter. In addition, Aksakal et al. (2015) reported that the lowest dispersion rate was obtained from the highest application level in a study.

Table 2. Effects of different levels vermicompost and irrigation applications on some soil properties

Vermicompost Applications	Soil Moisture Levels (80%)	Fild Capacity %	Wilting Point %	Dispersion Ratio
V0	FC	18.4	10.9	48.9
	PC	18.5	10.9	58.3
	Mean	18.5	10.9	53.6A*
V1	FC	18.5	10.9	49.4
	PC	19.2	10.5	52.4
	Mean	18.9	10.7	50.9AB
V2	FC	19.4	11.0	43
	PC	19.2	11.0	49.7
	Mean	19.3	11.0	46. 4AB
V3	FC	19.2	11.1	45.7
	PC	19.3	11.2	42.5
	Mean	19.3	11.2	44.1B
Mean	FC	18.9	11.0	46.8
	PC	19.1	10.9	50.7
Variations Resources			P	
Vermicompost, 3 df		0.532	0.238	0.036
Soil moisture, 1df		0.794	0.623	0.099
VermicompostxSoil moisture, 3 df		0.677	0.702	0.273
Variations Resources			F	
Vermicompost, 3 df		0.75	1.48	3.83
Soil moisture, 1df		0.07	0.25	3.15
VermicompostxSoil moisture, 3 df		0.51	0.48	1.45

The doses of vermicompost were 0 (V0), 0.75 (V1), 1.5 (V2), 2.25 (V3)% (weight /weight)
FC= Field capacity moisture level (80%), PC= Pot capacity moisture level (80%)
* Capital letters indicate the difference between the vermicompost applications

Conclusion

The results of this study showed that PC water level on yield and yield components of pepper plant more effective than FC water level without being dependent the application of vermicompost in greenhouse pot experiments. Only 80% of the water level of the PC (30.5x0.80 = 24.4%) is above the water level of the FC(18.5%), it is extremely important that this study shows why we are focusing on the water level. The effects of vermicompost application levels were only important for pepper plant fresh weight and root weight. It can also be controlled with high application levels possible evident differences between the application levels of vermicompost that had the significant effect on dispersion ratio. Consequently, PC water level was more positively effect on plant growth on pot experiments.

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