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The effects of spent mushroom compost on growth and nutrient contents of pepper seedlings

Kullanılmış mantar kompostunun biber fidelerinin büyüme ve bitki besin elementi içeriklerine etkileri

Halil DEMİR

Akdeniz Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, 07058, Antalya

Corresponding author (*Sorumlu yazar*): H. Demir, e-mail (*e-posta*): hdemir@akdeniz.edu.tr

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ABSTRACT

Many growing medium is used to grow pepper seedlings. Of these, the mixture of 70% peat + 30% perlite in the seedling production is commercially widely preferred as the best growing medium. However, spent mushroom compost is also one of growing medium material. This study aimed to investigate the effects of growing media prepared by spent mushroom compost on growth, quality and nutrient contents of pepper seedlings. For this purpose; the fresh spent mushroom compost removed immediately after mushroom production, the aged spent mushroom compost kept under natural conditions for more than six months after mushroom production, perlite, peat, and their mixtures were used as growing medium. The experiment was conducted in the research greenhouse at the Seed Research and Development Center of Akdeniz University in Antalya, Turkey, and was set up in a completely randomized block design with four replicates. Turbo F1 (*Capsicum annuum* L.) charleston pepper variety was selected as a plant material. The results showed that the mixture of 70% aged spent mushroom compost + 30% perlite and solely the use of aged spent mushroom compost compared with the mixture of 70% peat + 30% perlite growing medium can be used as seedling medium for pepper in terms of germination ratio, stem diameter, height, leaf number and the macro element contents of the seedlings.

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ÖZ

Biber fidesi yetiştiriciliği için birçok materyal kullanılır ve bunlardan % 70 torf ve % 30 perlit karışımı en iyi ortam olarak ticari üretimde yaygın şekilde tercih edilir. Kullanılmış mantar kompostu da yetiştiricilik ortamlarından birisidir. Bu araştırma kullanılmış mantar kompostu ile hazırlanmış yetiştiricilik ortamlarının biber fidelerinin büyüme, kalite ve bitki besin elementi içeriklerine etkilerini araştırmayı amaçlamıştır. Bu amaçla mantar üretiminden hemen sonra atılmış kompost, mantar üretiminden sonra altı aydan daha uzun süre doğal koşullar altında bekletilmiş kompost, perlit, torf ve karışımları yetiştiricilik ortamı olarak kullanılmıştır. Araştırma Akdeniz Üniversitesi Tohumculuk Araştırma ve Geliştirme Merkezinde yer alan cam sera içerisinde tesadüf parselleri deneme desenine göre dört tekerrürlü olarak yürütülmüştür. Bitki materyali olarak Turbo F1 (*Capsicum annuum* L.) çarliston biber çeşidi kullanılmıştır. Araştırma sonuçları % 70 torf ve % 30 perlit karışımı ile karşılaştırıldığında % 70 açık alanda bekletilmiş kompost + % 30 perlit karşımı ile tek başına açık alanda bekletilmiş kompostun tohum çimlenme oranı, fidelerde gövde çapı, fide yüksekliği, yaprak sayısı ve makro element içerikleri bakımından fide ortamı olarak kullanılabileceğini göstermiştir.

1. Introduction

In vegetable production, seedling stage is an important stage that has influences on growth and development, early yield, total yield and fruit per plant (Spaldon and Gromova 1972; Marković et al. 1995) and use of seedlings is quite essential. Recently, the use of high quality seedlings produced in facilities where climatic conditions are kept under control has increased (Demir et al. 2010). Seedling cultivation is a sector having recently started growing in Turkey. Vegetable production from seedlings has many advantageous opportunities, such as earlier harvest, utilization of time, economization of land, energy, and seeds, healthy and homogenous production, and warning process for earliness. In order to benefit from these advantages, producers have tended to production not from seeds, but from seedlings, thus increasing their demands for the seedlings of various vegetables (Seniz 1992; Kasim et al. 2006). While seedling production was common for vegetables such as tomato, pepper, cucumber and eggplant in the past, it has been being used for cabbage and lettuce-like vegetables in recent years. In the production of seedling ready for planting, as well as climatic conditions the seed sowing media have quite significant impacts on seedling growth (Ünlü et al. 2004). To cultivate healthy seedlings, growing media is as important as the ecological conditions. So the search for high quality and use of good crop substrates is therefore critical (Sterrett 2001). Different plant growing media and some results are emphasized in the conducted experiments (Rippy et al. 2004; Moldes et al. 2007; Ostos et al. 2008). There are many kinds of materials which are used for seed sowing medium. Main properties demanded in growing media are that they can be found easily, cheaply and abundantly (Demir et al. 2010). Peat is an important medium for seedling production, but it is expensive. Peat has been used widely as the main substrate component for the production of seedlings in containers for a long time (Ribeiro et al. 2007). It is a non-renewable resource, and diminishing availability is prompting price increases. Massive use of peat as a substrate has led vegetable-growers to consider its replacement in the medium to long term (Raviv 1998; Granberry et al. 2001; Sterrett 2001).

Recent studies have sought to identify alternatives to traditional peat, focusing on reusable, recyclable materials not derived from non-renewable sources such as peat bogs (Handar et al. 1985; Raviv et al. 1986; Verdock 1988). A number of studies have shown that organic residues such as urban solid wastes, sewage sludge, pruning waste, spent mushroom and even green wastes, after proper composting, can be used with very good results as growth media instead of peat (Siminis and Manios 1990; Pryce 1991; García-Gómez and Bernal Roig 2002; Benito et al. 2005). However, the use of compost as a substrate component can cause some problems namely as a consequence of its high salt content (Ribeiro et al. 1999; Castillo et al. 2004), unsuitable physical properties (Raviv 1997; Ribeiro et al. 1999) and variable quality and composition (Vavrina 1995; Hicklenton et al. 2001). Spent mushroom compost, which is consist of a composted mixture of cereal straw and manure (poultry and/or horse manure), calcium sulphate, soil and residues of inorganic nutrients and pesticides (Medina et al. 2009), is an important alternative as sowing material which is researched on vegetable seedlings.

One of the major environmental problems in the mushroom producing countries is the waste of mushroom compost. The amount of spent mushroom compost thrown away as a result of mushroom growing was reported to be 125 000-150 000 tons/year in Korkuteli, in Turkey, where Korkuteli provides the half of mushroom and compost production (Sönmez ve Kaplan 2011). In a study conducted the proportions 25%, 50%, 75% and %100 of spent mushroom compost were mixed with peat in the production of the less salt-sensitive being tomato, the moderately salt-sensitive being courgette and the most salt-sensitive being pepper seedlings. It was reported that can be used in mixtures with peat for seed germination for three vegetable species up to %75 of spent mushroom compost substrate, any substrate could be used for tomato seedling in the growth and all spent mushroom compost substrates were adequate for growth of courgette and pepper (Medina et al. 2009). Peksen and Uzun (2008) founded that the mixture of spent mushroom compost, which was kept for 18 months in open field, and commercial peat or only spent mushroom compost can be used as vegetable seedling medium for both kale and broccoli. Islam et al. (2014) stated that the highest plant height, number of leaves, leaf length, leaf breadth, days required for curd initiation, crown length, diameter and weight of primary curd plant^{-1}, number and weight of secondary curds plant^{-1} and yield were obtained from spent mushroom compost. Also Lopes et al. (2015) reported that the use of different proportions of spent *Agaricus subrufescens* compost resulted in a decreasing trend of all the parameters such as fresh mass of root, size of root and total fresh weight in the production of the tomato seedlings compared to commercial control. Marques et al. (2014) researched on the growth of lettuce seedlings and the vigor of mature lettuce plants was found that top quality lettuce seedlings, high quality marketable heads and quality improvement can be brought about by the addition of spent mushroom substrate. Sönmez (2017) stated that the spent mushroom composts were used on eggplant seedling cultivation as growing media and especially aged spent mushroom compost can be used as an alternative to the peat.

This study aimed to investigate the effects of growing medium prepared by spent mushroom composts on growth, quality and nutrient contents of pepper seedlings.

2. Materials and Methods

This study was carried out in the research greenhouse at the Seed Research and Development Center of Akdeniz University located in Antalya. Charleston pepper (*Capsicum annuum* L.) variety known as “Turbo F1” was used as plant material. The seeds were sown into the viols filled with various growing media including the fresh spent mushroom compost, the aged spent mushroom compost, peat and perlite, and their mixtures. The study ended after ~40 days, when they come into the planting size (~15 cm high). In this study which was planned with 4 replicates, 40 seeds were sown into each growing medium.

Peat and perlite were provided from commercial products marketing as Gurkan peat and Tasper perlite. The fresh and aged spent mushroom compost (SMC) used in experiment were taken from Korkuteli region in Antalya. The fresh spent mushroom compost (FSMC) was newly removed from mushroom production rooms, the aged spent mushroom compost (ASMC) was kept in open field without using in rainy conditions more than six months. Also their mixtures were used as seedling growing media. Some physical and chemical properties of peat, perlite and spent mushroom composts (fresh and aged) used in the study are as follows (Table 1). Eight different growing media (GM) including 100% perlite, 100% turf, 100% FSMC, 100% ASMC and their mixtures were used in the experiment (Table 2).

Seedling trays were regularly irrigated with tap water in order to maintain humidity suitable for plant growing. The pepper seedlings were evaluated in terms of germination ratio (%), height (cm), leaf number (number/plant) and stem diameter (mm) between root collar and just below cotyledon leaves at the stage of planting. Additionally, nitrogen (%), phosphorus (%), potassium (%), magnesium (%), calcium (%), iron (mg kg^{-1}), zinc (mg kg^{-1}), manganese (mg kg^{-1}) and copper (mg kg^{-1}) were analyzed as well.

Plant samples were washed by distilled water and dried in air-forced oven at 65°C to reach constant weight. After drying, seedlings dry weights were recorded. The seedlings were

Table 1. Some physical and chemical properties of peat, perlite and spent mushroom composts.

Properties	FSMC	ASMC	Peat	Perlite
EC dS m^{-1}	10.91	6.85	0.50	0.86
pH (1/10)	7.14	6.66	6.81	6.30
Total N (%)	1.786	1.663	0.504	-
P (mg kg^{-1})	28280	25280	1651	0.59
K (mg kg^{-1})	20860	13170	712	19.49
Ca (mg kg^{-1})	41910	43210	12980	82.50
Mg (mg kg^{-1})	5148.0	6648.0	556.5	5.78
Fe (mg kg^{-1})	2851	7500	574	0.695
Mn (mg kg^{-1})	1021	1028	172	0.105
Zn (mg kg^{-1})	1213	1076	113	0.11
Cu (mg kg^{-1})	244.6	288.4	53.2	0.015

Table 2. Growing media in experiment.

Growing media (GM)	
GM1	100% Perlite
GM2	100% Turf
GM3	100% FSMC (fresh SMC)
GM4	100% ASMC (aged SMC)
GM5	30% Perlite + 70% Peat
GM6	30% Perlite + 70% FSMC
GM7	30% Perlite + 70% ASMC
GM8	30% Perlite + 35% FSMC + 35% ASMC

ground separately in a stainless mill to pass through 20 mesh screen and were kept in clean polyethylene bags for analysis. Dried seedling 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 performed several times. The samples were filtered and diluted to 100 ml using distilled water. Total N was determined by modified Kjeldahl method (Kacar 1972); the other elements were measured using the wet digested extracts by spectrophotometer for P (Kacar and Kovanci 1982) and ICP-OES for K, Ca, Mg, Fe, Cu, Zn and Mn (Kacar and İnal 2008).

Statistical Analysis

The experiment was carried out according to the randomized block design as four replicates. The SAS packet program (SAS 2009) was used to determine statistical differences among the applications, and the Least Significant Test (LSD) at P≤0.05 was used for comparisons.

3. Results and Discussion

The effects of different media including SMC on germination (%), plant height (cm), stem diameter (mm) and leaf number (number $plant^{-1}$) are given in Table 3. There were statistical differences in the level of $P<0.05$ among the growing media in terms of germination percentage, stem diameter, plant height and leaf number. The highest germination ratio with 95.33% was obtained from GM2, which was followed with 94.17% by GM1, and with 92.50% by GM4. The lowest germination ratio with 58.33% was found in GM3. Medina et al. (2009) reported that similar results were resulted from the content of compost as occurred in GM3 in the study which was used spent mushroom compost in tomato and pepper. The germination rates changed as according to the mixtures of aged and fresh spent mushroom compost in growing media. Sánchez-Monedero et al. (2004) and Bustamante et al. (2008) reported similar results in their study, where they used peat and waste mushroom compost mixtures.

Table 3. The effects of different media including on germination, plant height, stem diameter and leaf number.

Growing media	Germination (%)	Stem Diameter (mm)	Plant height (cm)	Leaf number (number $plant^{-1}$)
GM1	**94.17 ab**	1.41 d	4.27 e	4.8 c
GM2	**95.33 a**	**2.71 a**	**12.10 a**	**6.8 a**
GM3	58.33 e	1.18 e	2.83 f	3.73 d
GM4	**92.50 abc**	**2.06 b**	**6.63 c**	**6.6 a**
GM5	91.67 bc	**2.53 a**	**11.00 b**	**6.9 a**
GM6	75.17 d	1.20 de	2.63 f	3.73 d
GM7	91.67 bc	**1.85 bc**	5.97 d	**5.7 b**
GM8	90.83 c	1.68 c	6.00 d	**5.5 b**
LSD*	3.199	0.211	0.629	0.546

*: The difference between values not shown with the same letter are significant at a P<0.05 level.

The highest values in respect to the stem diameter were determined as 2.71 mm in GM2, and as 2.53 mm in GM5. The lowest stem diameter was also found with 1.18 mm in GM3. While the longest seedlings were measured in GM2 with 12.10 cm, followed by 11 cm in GM5, the shortest seedlings were measured in GM3 with 2.83 cm and in GM6 with 2.63 cm. When growing media were evaluated in respect of leaf numbers, the applications having the most amount of leaves per plant were GM5, GM2, and GM4 in the same group, 6.9, 6.8 and 6.6, respectively. However, the media having the least amount of leaves were GM3 and GM6 with 3.73. Sönmez et. al (2016) who had similar results with similar seedling media stated that the salt content of the spent mushroom compost was effective on germination and the characteristics of seedling quality, and declared that the spent mushroom compost kept under natural conditions in open field could be an alternative seedling medium. Wever et al. (2005) reported that spent mushroom compost decreased the growth of kohlrabi plant due to the salt concentration. Similarly, Chong and Rinker (1994) stated that the lowest seedling quality resulted from the salt content of newly removed mushroom compost from production room. Also, Zhang et al. (2012) found that spent mushroom compost can be used as seedling medium in tomato and cucumber by mixing with various materials.

The germination ratio of the pepper seeds according to different growing media is given in Figure 1. As seen in Figure 1, the earliest germination among the media took place in GM2 on the 8^{th} day, and germination ratio reached to the maximum on the thirteenth day by continuing to germinate rapidly pepper seeds within the medium. The 2^{nd} medium with regard to earliness was GM5. First germination emerged on the 9^{th} day and it was reached to maximum germination rate on the 16^{th} day. On the other hand, possible alternatives to GM5 and GM2 media used control purposeful were GM4 and GM7. The minimum germination rate and the longest germination time was GM3 medium (Figure 1).

The effects of different growing media on macro element contents in pepper seedlings are given in Table 4. There were statistically significant differences ($P<0.05$) between growing media with respect to N, P, K, Ca and Mg contents in seedlings. The highest nitrogen content was determined with 4.55% in GM4 and this medium was followed by GM7 and GM8 with 4.32% and 4.14%, respectively. The fact that the highest N content was found in the seedlings cultivated in the kept compost medium in open field indicates that the nitrogen within the medium is in an utilizable form. The lowest N content was

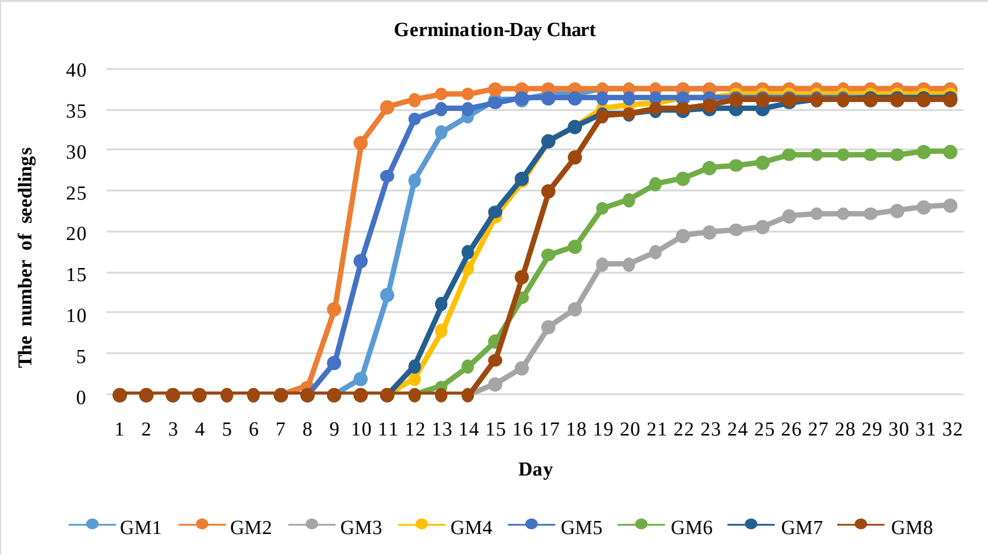

Figure 1. The germination ratio of the pepper seeds according to media based on time.

Table 4. The macro nutrient contents of pepper seedlings in different growing media.

Growing Media	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
GM1	2.57 g	0.27 c	2.55 g	**2.55 a**	**0.46 c**
GM2	3.02 f	**0.45 a**	5.63 e	**1.52 bc**	0.34 d
GM3	3.93 d	**0.33 b**	**8.00 a**	0.99 d	**0.53 b**
GM4	**4.55 a**	**0.45 a**	6.45 d	**1.56 b**	**0.69 a**
GM5	2.65 g	**0.42 a**	5.05 f	**1.57 b**	0.31 d
GM6	3.59 e	**0.31 bc**	**7.65 b**	1.05 d	**0.55 b**
GM7	**4.32 b**	**0.43 a**	**6.64 c**	**1.52 bc**	**0.68 a**
GM8	**4.14 c**	**0.33 b**	6.41 d	1.48 c	**0.65 a**
LSD*	0.112	0.055	0.117	0.082	0.058

*: The difference between values not shown with the same letter are significant at a P<0.05 level.

in GM5 and GM1 media with 2.65% and 2.57, respectively. The fact that the lowest N content was in the GM5 and GM1 media reveals that seedlings can take less nitrogen from perlite and its mixtures. The highest P contents ranged from between 0.45-0.42%, and GM2, GM4, GM7 and GM5 media were in the same group. The lowest P content was determined from GM1 with 0.27%. The highest K content in seedlings was determined in GM3 with 8.00%, the 2nd and 3rd higher contents were found in GM6 and GM7 with 7.65, 6.64% respectively. The lowest K content was in seedlings which were grown in GM1 with 2.55%. While the highest Ca content was found in GM1 as 2.55%, GM5 and GM4 which had second highest Ca content with 1.57%, 1.56% respectively and GM2 and GM7 which were in the same group statistically with 1.52% followed to GM1. The highest Mg contents were in the GM4, GM7 and GM8 media with 0.69%, 0.68%, 0.65% respectively. The abundance of nutrients of the medium (Table 1) also affected on the contents of nutrients in the seedlings. The findings are similar to those obtained from the eggplant by Sönmez et. al. (2016). Similar results were obtained from a study, where spent mushroom compost was used in cucumber and tomato seedling (Zhang et al. 2012). Medina et al. (2009) reported that spent mushroom compost positively affected the nutrient contents of tomato, courgette and pepper seedlings positively. Sánchez-Monedero et al. (2004) indicated that the ratio of N, P and K in plants varied depending on the spent mushroom compost mixtures when used for seedlings in tomato, broccoli, and onion.

The effects of different growing media on micro nutrient contents in pepper seedlings are given in Table 5. It was found that there were differences among the media (P<0.05) in terms of the micro nutrient contents in the pepper seedlings. While the highest Fe content was determined in GM6 (365.20 mg kg^{-1}) medium, this was followed by GM1, GM2 and GM4, all of which are in the same group. The lowest Fe contents, on the other hand, were found in GM7, GM5 and GM3 media (101.00, 101.00 and 97.10 mg kg^{-1}, respectively). While the highest Zn content was found in GM3 (172.90 mg kg^{-1}), GM3 was followed by GM1 and GM2 (166.90 and 143.37 mg kg^{-1}) that were in the same group. The lowest Zn content was determined also in GM7 (113.30 mg kg^{-1}). Comparing the growing medium in terms of Mn and Cu contents, while the highest Mn and Cu contents were determined in GM6 and GM7 (130.8 mg kg^{-1} and 9.93 mg kg^{-1}, respectively), both the lowest Mn and Cu contents were found in GM1 (65.32 mg kg^{-1} and 2.78 mg kg^{-1}). In contrast to the Mn and Cu nutrients, the highest Na content was determined in GM1 (765.40 mg kg^{-1}), while the lowest Na value was found in GM8 (349.90 mg kg^{-1}). Zhang et al. (2012) reported similar results to these research findings. Sönmez et. al

Table 5. The micro nutrient contents of pepper seedlings in different growing media.

Growing Media	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
GM1	**124.00 b**	**166.90 b**	65.32 e	2.78 g
GM2	**119.90 b**	**143.37 b**	88.96 c	4.73 e
GM3	97.10 d	**172.90 a**	**117.50 b**	6.99 d
GM4	**119.30 b**	140.90 d	86.23 b	7.61 c
GM5	101.00 d	133.40 e	77.37 d	3.49 f
GM6	**365.20 a**	149.00 c	**130.80 a**	9.55 b
GM7	101.00 d	113.30 f	74.80 d	**9.93 a**
GM8	110.40 c	149.60 c	**119.10 b**	**9.72 ab**
LSD*	7.186	4.631	3.388	0.325

*: The difference between values not shown with the same letter are significant at a P<0.05 level.

(2016) stated that the microelement contents of in the eggplant seedlings varied depending on the medium which included spent mushroom compost. In addition to these findings, Stofella et al. (2001) stated that composts include various amounts of microelements. For instance, Cu content in the compost generally indicates that it is being chelated by the organic materials and that the organic fractions are not suitable for plants before mineralization.

4. Conclusions

According to the results obtained from experiment, it was found that newly removed spent mushroom composts after mushroom production had a negative effect on germination, earliness, stem diameter, seedling height and number of leaves. On the other hand, it was also found that the aged spent mushroom compost kept for more than six months under natural conditions following the production and perlite mixture can be an alternative to peat and its mixture with perlite. Besides these, the highest and the second highest macro nutrient contents were obtained from solely the aged spent mushroom compost and its mixture with perlite applications. With regard to micro element contents except for Mn and Zn, the newly discharged compost displayed the highest results when compared to the aged spent mushroom compost; however, it was observed that the aged spent mushroom compost was not bad in terms of these contents. As a result, it was seen that the aged spent mushroom compost and perlite mixtures can be an alternative to the peat and perlite mixture used widespread commercially.

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