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Effects of Different Growing Media on Organic Pepper Seedling Production

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Abstract
Seedlings are produced in specialized commercial nurseries during the last two decades. Peat is the most common growing medium in the conventional or organic seedling production. However, there is a need to develop alternative growing media due to the concerns about the peat in particularly in organic seedling production. The aim of this research was to develop growing medium using local resources as peat alternative in organic pepper seedlings production. Bell and sweet pepper cultivars cv. Ergenekon F_1 and cv. Sağnak F_1 respectively were sown into trays having 6 treatments composed of (1) local peat + clinoptilolite + composted farmyard manure (LP+CLI+CFM) (1:1:1; v:v), (2) local peat + vermicompost (60%LP+40%VC)(1.5:1, v:v), (3) local peat + clinoptilolite + vermicompost (LP+CLI+VC)(1:1:1; v:v), (4) local peat + perlite + composted farmyard manure (LP+PER+CFM)(1:1:1; v:v), (5) local peat + perlite + vermicompost (LP+PER+VC)(1:1:1; v:v) and (6) peat (P)(as control). After germination in a growth chamber for 3 days, seedlings were moved to a PE greenhouse which is specialized for seedling growing. Seedlings were fertilized by liquid composted farmyard manure (30 L ha^{-1}) once a day. Germination rate of seeds, stem and root length, fresh and dry weight of seedlings were determined when they were ready for planting in 38 days. The results showed that among the tested media for both pepper cultivars, LP+CLI+VC and 60%LP+40%VC were found as promising peat alternatives for commercial use considering their effects on seedling quality.

Keywords: Peat, Perlite, Clinoptilolite, Vermicompost, Composted Farmyard Manure

1. Introduction

In organic agriculture, organic seeds and plant material should be used according to the EU Regulation 2092/91. However, there is no restriction in the use of peat in the growing media in the Regulation although there is a comment on peat as a limited natural resource and restriction of its use with the approach of sustainability of organic agriculture (eur-lex.europa.eu). In fact, Bio Suisse Standards recommends restricting the use of peat for the cultivation of planting material no more than 70% peat (organicstandard.com.ua).

During the last decade many researches have been conducted on the use different wastes or by-products or compost as peat substitute based on such as food residuals with landscape wastes as a bulking agent or used horse bedding (Clark and Cavigelli, 2005); municipal solid waste compost (Herrera et al., 2008); distillery wastes (Bustamante et al., 2009); bovine manure and green compost (Titarelli et al., 2009); spent mushroom compost (Medina et al., 2009); solid urban waste, vegetable waste, and vine pomace (Diaz-Perez and Camacho-Ferre, 2010); coffee pulp (Berecha et al., 2011); olive and/or olive oil wastes (Ceglie et al., 2011; Tüzel et al., 2017); dealcoholised grapevine marc and grape stalk (Carmona et al., 2012); pine bark (Ceglie et al., 2015), rose oil processing wastes (Öztekin et al., 2017); vermicompost (Atiyeh et al., 2001, 2002; Zaller, 2007; Atmaca, 2012).

The aim of this research was to improve growing medium for pepper seedling by using locally available resources for the substrate in comparison with conventional peat.

2. Materials and Methods

This research was conducted in 2015 at the nursery of the Department of Horticulture at Ege University (38°27′ 15.8″ N; 27°13′ 16.9″ E).

Six different substrates namely peat (P) (Klassman TS1, Germany), local peat (LP) (provided from Denizli peatlands from western region of Turkey), perlite (PER) (IZPER Perlite, Izmir-Turkey), composted farmyard manure (CFM) (Biofarm® - Camli Yem Besicilik, Izmir-Turkey), clinoptilolite (CLI) (Gordes Zeolite, Izmir-Turkey) and vermicompost (VC) (Ekosol®, Istanbul-Turkey) were involved in the growing medium. The treatments were composed of (1) LP+CLI+CFM (1:1:1; v:v), (2) 60%LP+40%VC (1.5:1, v:v), (3) LP+CLI+VC (1:1:1; v:v), (4) LP+PER+CFM (1:1:1; v:v), (5) LP+PER+VC (1:1:1; v:v) and (6) peat (P) (as control). Some physical and chemical properties of each growing medium are given in Table 1. Seedlings were fertilized by liquid composted farmyard manure (30 L ha^{-1}) once a day (Table 2).

Table 1. Some physical and chemical properties of growing media.

Parameters	LP+CLI+CFM	60%LP+40%VC	LP+CLI+VC	LP+PER+CFM	LP+PER+VC	P
pH	6.61	6.10	6.4	7.01	6.43	6.37
EC (dS m^{-1})	5.23	3.67	3.37	8.6	3.64	1.21
$CaCO_3$ (%)	1.60	1.62	1.60	4.01	2.41	0.40
Org. Mat. (%)	16.7	22.1	11.4	18.7	16.1	38.8
N (%)	0.84	1.10	0.57	0.94	0.80	0.92
P (mg kg^{-1})	201	270	274	370	373	190.8
K (mg kg^{-1})	29250	5622	21390	25580	7883	3097
Ca (mg kg^{-1})	5000	5227	4231	3447	4408	4570
Mg (mg kg^{-1})	1475	954.4	1338	1595	1538	1005
Fe (mg kg^{-1})	18	76	19	30	35	28
Cu (mg kg^{-1})	5.18	8.69	2.01	6.79	3.14	3.3
Zn (mg kg^{-1})	22.43	32.60	6.06	59.74	8.31	3.1
Mn (mg kg^{-1})	11.96	113.1	6.13	16.58	9.89	3.98

P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

Table 2. Nutrient composition of liquid composted farmyard manure.

Macro elements		Micro elements	
N (%)	0.12	Fe (mg kg^{-1})	73
P (%)	0.0009	Cu (mg kg^{-1})	-
K (mg kg^{-1})	253	Zn (mg kg^{-1})	67.0
Ca (mg kg^{-1})	4065	Mn (mg kg^{-1})	13.0
Mg (mg kg^{-1})	253		

Bell and sweet pepper cultivars respectively cv. Ergenekon F_1 and cv. Sağnak F_1 (Bircan Seeds, Antalya-Turkey) were sown on the 17th of October 2014 in substrates in the trays having 128 cells. The trays were left in a germination room for three days at 24/24°C and 80 % RH in dark conditions and then moved to a climate controlled greenhouse (24/18°C) until harvest. Germination rate, shoot and root lengths, fresh and dry weight of seedlings were determined. Germination rate was calculated by counting the number of germinated seeds into cells and expressed as %. Germination period was determined as the number of days required for 50% of seed emergence. Seedlings were removed after 38 days when they have 4 or 5 true leaves stage. Each treatment had 3 replicates and each replicate included 42 seedlings in all experiments. From each replicate 20 seedlings were selected for measurements. Roots were washed and shoot and root fresh weights were measured and then dried at 65℃ in oven in order to determine dry weights of shoots and roots.

Data were subjected to analysis of variance to determine any statistically significant differences among growing media by using the SPSS statistical analysis package program (IBM Corp.). Duncan test was conducted at 5% importance level ($P \leq 0.05$) in order to identify the differences between the means.

3. Results

3.1. Germination rate

The individual and interaction effects of treatments on germination rate were found significant. The highest germination rate was in peat in both cultivars; however germination rates of cv. Ergenekon in %60LP+%40VC and LP+PER+VC were as high as in peat (Table 3).
Germination rate reached to 97% in peat within a week, whereas germination rates were 88% in %60+%40VC and LP+PER+VC and 70% in LP+CLI+VC on the same date while there was no germination in LP+CLI+CFM and LP+PER+CFM. Germination could increase up to 76 and 73% in two weeks in the latter growing media (Fig. 1).

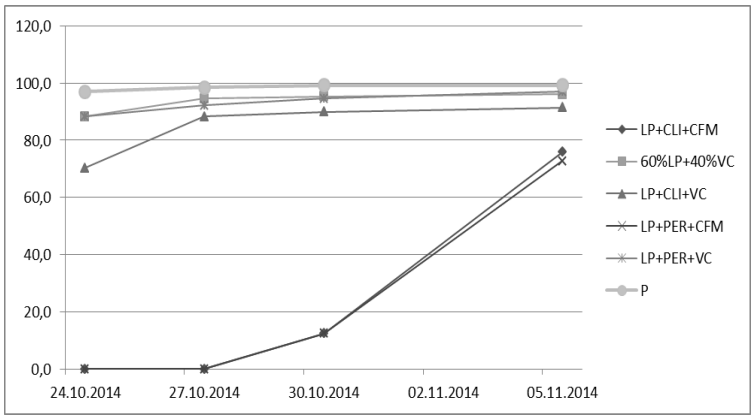

Figure 1. Seed germination rate of cv. Ergenekon
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

Germination was later in cv. Sağnak. Germination rate could increase up to 98% in peat in two weeks however germination rates were 85, 91, 73, 76 and 93% in LP+CLI+CFM, %60LP+%40VC, LP+CLI+VC, LP+PER+CFM and LP+PER+VC, respectively (Fig.2).

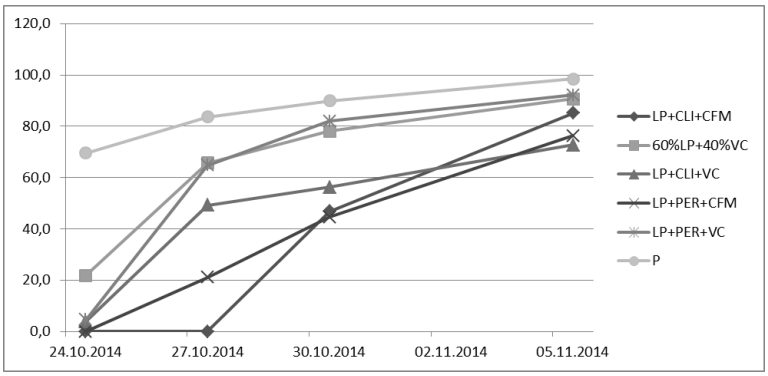

Figure 2. Seed germination rate of cv. Sağnak (right).
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

3.2. Seedling growth
Effects of treatment on growth were found significant. Shoot and root lengths were slightly higher in cv. Sağnak. Among the tested media LP+CLI+VC, LP+CLI+VC and 60%LP+40%VC gave the highest in shoot lengths. The shoot length was the highest in LP+CLI+VC in cv. Ergenekon, while in addition to LP+CLI+VC, LP+PER+VC and %60LP+%40VC were in the same statistical group in cv. Sağnak (Table 4). In terms of root length, growing medium excluding LP+PER+CFM and LP+PER+VC had higher values in cv. Ergenekon, while in cv. Sağnak, P, LP+CLI+VC and %60LP+%40VC had higher root length (Table 4).
Shoot fresh weight was the highest in cv. Ergenekon, while there were no significant differences on dry weight. LP+CLI+VC showed better performance in terms of shoot fresh weight in cv. Ergenokon while P, 60%LP+40%VC and LP+CLI+VC had higher performance in cv. Sağnak. Same trend was observed on shoot dry weight. Among the tested media LP+CLI+VC gave the highest shoot fresh and dry weights (Table 5).

cv. Ergenokon gave the higher root fresh and dry weights than cv. Sağnak. Root fresh and dry weights were higher in P among the tested growing media. Root fresh and dry weights were higher in P, 60%LP+40%VC and LP+CLI+VC in cv. Ergenekon and only in Peatt in cv. Sağnak (Table 6).

Table 3. Seed germination rates (%).

Treatments	Ergenekon	Sağnak	Mean$_{(media)}$
LP+CLI+CMF	75.78 c	85.15 c	80.46 B
%60LP+%40VC	96.09 a	90.62 b	93.35 B
LP+CLI+VC	91.40 b	72.65 d	82.03 B
LP+PER+CFM	72.65 d	76.56 d	74.60 D
LP+PER+VC	96.87 a	92.18 b	94.53 B
P	99.21 a	98.43 a	98.82 A
Mean$_{(cultivar)}$	18.35 A	17.94 B	

Different letters represent significant differences according to Duncan's multiple range test ($P \leq 0.05$)
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

Table 4. Seedling and root lengths (cm).

	Shoot length			Root length		
Treatments	Ergenekon	Sağnak	Mean$_{(media)}$	Ergenekon	Sağnak	Mean$_{(media)}$
LP+CLI+CFM	7.11 c	7.32 bc	7.16 D	6.62 a	6.15 b	6.39 B
60%LP+40%VC	7.90 b	7.98 ab	7.94 B	7.03 a	7.35 a	7.19 A
LP+CLI+VC	9.03 a	8.30 a	8.66 A	6.70 a	7.20 a	6.95 A
LP+PER+CFM	6.58 c	6.80 c	6.69 E	5.28 c	6.33 b	5.80 C
LP+PER+VC	7.00 c	7.78 ab	7.39 CD	5.80 b	6.15 b	5.98 C
P	7.80 b	7.55 b	7.68 BC	6.93 a	7.03 a	6.98 A
Mean$_{(cultivar)}$	7.09 B	7.14 A		6.83 B	7.27 A	

Different letters represent significant differences according to Duncan's multiple range test ($P \leq 0.05$)
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

Table 5. Seedling shoot fresh and dry weights (g)

	Shoot fresh weight			Shoot dry weight		
Treatments	Ergenekon	Sağnak	Mean$_{(media)}$	Ergenekon	Sağnak	Mean$_{(media)}$
LP+CLI+CFM	0.71 b	0.62 b	0.66 C	0.07 cd	0.07 bc	0.07 D
60%LP+40%VC	0.83 b	0.79 a	0.81 B	0.08 bc	0.07 ab	0.08 C
LP+CLI+VC	1.19 a	0.81 a	1.00 A	0.13 a	0.09 a	0.11 A
LP+PER+CFM	0.77 b	0.58 b	0.68 C	0.07 cd	0.06 bc	0.07 D
LP+PER+VC	0.45 c	0.46 c	0.46 D	0.05 d	0.06 c	0.06 D
P	0.81 b	0.76 a	0.78 B	0.09 b	0.08 a	0.09 B
Mean$_{(cultivar)}$	0.79 A	0.67 B		0.08	0.08	

Different letters represent significant differences according to Duncan's multiple range test ($P \leq 0.05$)
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

Table 6. Seedling root fresh and dry weights (g)

	Root fresh weight			Root dry weight		
Treatments	Ergenekon	Sağnak	Mean$_{(media)}$	Ergenekon	Sağnak	Mean$_{(media)}$
LP+CLI+CFM	0.35 c	0.26 b	0.30 BC	0.28 c	0.02 bc	0.02 C
60%LP+40%VC	0.42 ab	0.27 b	0.34 BC	0.38 ab	0.03 b	0.03 B
LP+CLI+VC	0.41 ab	0.26 b	0.33 B	0.04 a	0.02 bc	0.03 B
LP+PER+CFM	0.32 bc	0.22 b	0.28 C	0.03 bc	0.02 c	0.02 C
LP+PER+VC	0.29 c	0.25 b	0.31 BC	0.28 c	0.02 bc	0.02 C
P	0.44 a	0.40 a	0.42 A	0.04 a	0.04 a	0.04 A
Mean$_{(cultivar)}$	0.38 A	0.28 B		0.04 A	0.03 B	

Different letters represent significant differences according to Duncan's multiple range test ($P \leq 0.05$)
P: peat, LP: local peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFM: composted farmyard manure

4. Discussion

A growing medium supports the plant and provides water and nutrients. Selection of a good growing medium is fundamental for a good nursery management and healthy plant growth (Jacobs et al., 2009). Physical (structure and structural stability, water holding capacity, bulk density, pore space/air capacity, wettability), chemical (pH, electrical conductivity, nutrient content, organic matter, cation exchange capacity, buffer capacity), biological (absence of pathogens, pests, weeds, microbial activity, presence of beneficial organisms, storage life) and economical (availability, consistency of quality, price, plant requirements, cultivation technique) characteristics of a growing medium should be taken into account for seed germination and early plant growth in a limited volume (Schmilewski, 2008).

In this study, five growing media composed of locally available substrates were compared with peat. Among the tested media, 60%LP+40%VC and LP+PER+VC had the germination rate as high as peat in bell pepper cultivar. This could be related to the moisture level and physical parameters of growing media. Similar results were obtained in tomato (Tüzel et al., 2015) and watermelon (Tüzel and Öztekin, 2017).

The responses of the growing media in terms of shoot growth, LP+CLI+VC in Ergenekon and growing media containing VC had higher shoot length and fresh weights. This could be attributed to the physical characteristics and nutrient content of clinoptilolite (Trinchera et al., 2010) and vermicompost (Ievinsh, 2011). However, higher EC levels in the growing media particularly the ones having composted farmyard manure also affected adversely root growth and biomass (Jacobs and Timmer, 2005).

It was concluded that for both cultivars among the tested media, LP+CLI+VC and 60%LP+40%VC were found as promising peat alternatives for commercial use considering their effects on seedling quality.

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