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Growing Media in Organic Seedling Production

Organik Fide Üretiminde Yetiştirme Ortamları

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ÖZ

Vegetable seedlings are produced in specialized commercial nurseries. Peat is the most common growing medium used in seedling production. In organic agriculture, organic seeds and plant material should be used according to the EU Regulation No 834/2007. 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. In fact, Bio Suisse Standards recommends restricting the use of peat for the cultivation of planting material no more than 70% peat. Thus, during the last two decades many researches have been conducted on the use different by-products or compost alone or as a part of a mixture as peat substitute. This review aims to bring the researches on peat alternatives in organic seedling production and their effects on different vegetable crops.

ABSTRACT

Sebze fideleri özelleşmiş ticari fideliklerde üretilmektedir. Torf, fide üretiminde en yaygın kullanılan yetiştirme ortamıdır. Organik tarımda, 834/2007 sayılı AB yönetmeliğine göre organik tohum ve bitki materyali kullanılmalıdır. Ancak, torfun sınırlı bir doğal kaynak olması ve organik tarımın sürdürülebilirliği yaklaşımı nedeni ile kullanımına dair kısıtlama tavsiyesi olmasına rağmen, yönetmelikte torfun yetiştirme ortamı olarak kullanılmasına ilişkin herhangi bir kısıtlama yoktur. Aslında, İsviçre Organik Tarım Üreticileri Federasyonu Standartları, bitkisel üretim materyallerinin üretiminde %70'den fazla olmayacak şekilde torfun kullanımının sınırlandırılmasını önermektedir. Bu nedenle, son yirmi yıldır farklı yan ürünlerin veya kompostun tek başına ya da torf ile karışımı şeklinde kullanımı üzerine pekçok araştırma yapılmıştır. Hazırlanan bu derleme, organik fide üretiminde torf alternatiflerini ve bunların farklı sebze türleri üzerindeki etkilerini ortaya koyan araştırmaları bir araya getirmeyi amaçlamıştır.

Keywords:

Peat, vermicompost, compost, seedling quality.

Anahtar Sözcükler:

Torf, vermikompost, kompost, fide kalitesi.

INTRODUCTION

Organic agriculture is defined as *"a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved"* by IFOAM-Organics International (IFOAM, 2017). Organic agriculture area increased from 15 million ha in 2000 to 50.9 million ha in 2015 (Lernoud and Willer, 2017). Although the share of the world's organic agricultural area of all agricultural land is 1.1% percent, the global market for certified organic food and drink was estimated to be 81.6 billion US Dollars according to Organic Monitor (Willer and Lernoud, 2017).

A major factor distinguishing organic farming and production from other sustainable farming approaches is the presence of internationally acknowledged standards and certification procedures (i.e. EU legislation, NOP in USA, JAS in Japan). In EU, it has been regulated since 1991. Today the European requirements for organic production are set by Council Regulation (EC) No 834/2007 defining the official aims, objectives, principles of organic farming and production, and by two implementing regulations (No 889/2008 and No 1235/2008) detailing the organic production, labelling and importing rules (EUR-LEX, 2017).

Seedling production is the first step of vegetable production and directly affects the success of a production. During the last two decades, nurseries specialized on seedling production at a large scale have been introduced and the number and area has increased dramatically. However, organic seedling production is very limited due to lack of standart production protocols, necessary attentive care, high cost of organically produced seeds and other inputs.

Regarding to organic seedling production, "*only organically produced seed and propagating material should be used for the production of products other than seed and vegetative propagating material*" according to the rules laid down in EU Regulations No 834/2007 and 839/2008.

The most important issues, production and supply of organic vegetable seeds, growing media, fertilization, plant protection and use of beneficial organisms need to be addressed in organic seedling production. This review aims to focus on growing media due to the requirement for peat substitution in plant nursery activities since peat use in organic seedling production is an ongoing discussion (Clark and Cavigelli, 2005).

REQUIRED CHARACTERISTICS OF A GROWING MEDIUM

The substrate(s) in which plant is grown is called as growing medium and its main function is to provide physical support, aeration, supply of water and nutrients (Landis et al., 2014). Some physical (structure and structural stability, water capacity, air capacity, bulk density and wettability), chemical (pH, nutrient content, organic matter, noxious substances and buffering capacity), biological (weeds, seeds and viable plant propagules, pathogens, pest, microbial activity and storage life) and economic (availability, consistency of quality, cultivation technique, plant requirements and price) properties of growing medium components should be considered in order to improve any formulations and/or mixtures (Schmilewski, 2008).

Candidate substrates should not lose the structure after irrigation. It should have a high water holding capacity but also contain enough macrospores for the leaching of excess water. Recommendations for total porosity of a growing medium was reported about 60 to 80% or stated that it should exceed 50%. Air porosity of 20 to 25% or higher even up to 45 to 50% was recommended (Landis, 1990 based on Handreck and Black, 1984; Havis and Hamilton, 1976, Puustjarvi and Robertson, 1975). pH should be slightly acidic (5.5 to 6.5) and EC should be low, less than 0.75 dS cm^{-1} for a growing medium without fertilizers. High cation exchange capacity (CEC) helps to develop fertility programs and troubleshoot certain nutrient disorders (Robbins and Evans, 2011). It should be pathogen free, physically uniform, low cost and available (Doolan et al., 1999). Table 1 summarises optimum range of some physical, physico-chemical and chemical properties for growing medium based on Raviv et al. (1986), Bunt (1984) and Abad et al. (2001).

Table 1. Acceptable or optimum range of some physical and chemical properties for growing medium.
Çizelge 1. *Yetiştirme ortamlarının bazı fiziksel ve kimyasal özelleiklerinde kabul edilebilir veya optimum değer aralıkları.*

Properties	Value	Properties	Value
Particle size	0.25 -2.0 mm	EC	≤0.5 dS m^{-1}
Bulk density	<0.4 g cm^{-3}	pH	5.3-6.5
Total pore space	>85% vol	Water holding capacity	600-1000 ml L^{-1}
Air volume	20-30% vol	Total organic matter	>80%

PEAT AS NURSERY GROWING MEDIA

Sphagnum peat is the most common growing medium or a constituent of a mixture used for vegetable seedling production due to its physical properties allowing an adequate air to water ratio in the root zone and high CEC maintaining adequate nutrient levels (Raviv et al. 1986). Peat is relatively free from harmful elements (i.e. weeds, plant and animal pathogens), not compact, stable under storage and clean to handle (Robertson, 1993). Despite to proven advantages of peat, there is an increasing necessity to develop alternatives to peat since peat resources are limited and costly, and there is a growing social pressure to reuse the waste (De Lucia et al., 2013) Peat utilisation contradicts numerous fundamental principles of organic agriculture. However, there is no restriction in the use of peat in the growing media in the Organic Agriculture legislations 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, 2017). In fact, Bio Suisse Standards (Section 2.5 ff) recommends the use of peat for transplant production should be kept a minimum (BIO-SUISSE, 2017). EU Expert Group for Technical Advice on Organic Production (EGTOP) also recommends the use of peat in growing media should be limited to maximum 80% by volume (EGTOP, 2013).

PEAT ALTERNATIVES IN ORGANIC VEGETABLE SEEDLING PRODUCTION

The increased environmental awareness of consumers, the constant dismantling of ecologically important peat bog areas, and the pervasive waste problem all force the horticulture industry to re-examine its practices (Gruda, 2012). Besides peat, common ingredients used in the mixes include coir, perlite, sand, vermiculite, compost, etc. (Sideman, 2007). Table 2 presents some physical and chemical properties of some common materials used as growing medium.

Table 2. Some physical and chemical properties of common materials used as growing medium.
Çizelge 2. *En çok kullanılan yetiştirme ortamlarının bazı fiziksel ve kimyasal özellikleri.*

Material	Bulk Density (g cm^{-3})	Total pore space (%v/v)	Air content (%v/v)	Water content (%v/v)	pH
Sphagnum peat moss	0.07[a]	95.2[a]	37.9[a]	22.5[b]	4.5-5.0[a]
Pine bark	0.17[a]	89[a]	54.9[a]	34.1[a]	5.1[a]
Coir	0.03 to 0.09[b]	94[b]	24 to 89[b]	<1 to 36[b]	4.5-5.7[c]
Compost	0.42 to 0.66[e]	60.7 to 72.5[e]	33.7-55.1[g]	23.5 to 32.1[e]	6.3 to 7.8[e]
Vermicompost	0.22[f]	82[f]	22[f]	60[f]	7.59[f]
Sand	1.63[a]	38.3[a]	6.6[a]	31.7[a]	6 to 8[a]
Pumice	0.04[d]	85[d]	40[d]	45[d]	7.0[d]
Perlite	0.09[a]	96.4[a]	61.8[a]	34.6[a]	6.9[a]
Vermiculite	0.089[a]	94.4 to 95.6[c]	8.9 to 35.9[c]	36.5 to 6.8[c]	8.7[a]

[a]Lemaire, 1995; [b]Abad et al., 2005; [c]Bunt, 1983; [d]Boertji, 1995; [e]El-Sayed, 2015; [f]Hidalgo et al., 2006; [g]Benito et al., 2005.

During the last two decades many researches have been conducted on the use different compost or vermicompost derived from renewable and locally available wastes or by-product sources alone or as a part of a mixture as peat substitute. Among them, compost is the most widely-used one.

Different wastes have been used after composting in seedling production such as separated cattle manure and grape marc for pepper, cucumber and tomato (Inbar et al., 1986; Carmona et al., 2011) yard trimming-biosolids for tomato (Ozores-Hampton et al., 1999) and cauliflower (Kahn et al., 2013), coir in tomato (Arenas et al., 2002), animal manure, vegetable and fruit residues, vermicompost and cedar flakes for bell pepper, onion and watermelon (Russo, 2005), preconsumer food residuals or straw horse bedding (Clark and Cavigelli, 2005), coconut coir in lettuce (Colla et al., 2007), distillery wastes lettuce, chard, broccoli and coriander (Bustamante et al., 2008) and for lettuce and watermelon (Bustamante et al., 2011), forestry wastes and solid phase of pig slurry for lettuce and tomato (Ribeiro et al., 2007), municipal solid waste compost for tomato (Castillo et al., 2004; Herrera et al., 2008), cow manure and vermicompost for lettuce and cabbage (Lazcano et al., 2009; Raviv et al., 2013), backyard compost for lettuce and tomato (Alexander, 2009), industry waste for melon (Lopez-Mondejar et al., 2010), different blends of fish solids mixed with guinea grass (*Panicum maximum*) (Pantanella et al., 2011), seaweed (*Posidonia oceanica* L. Delile) residues for melon and tomato (Mininni et al., 2013), green compost and palm fibre trunk waste for tomato, melon and lettuce (Ceglie et al., 2015), roseoil processing wastes (Oztekin et al., 2017) and olive oil production wastes (Tuzel et al., 2017a).

EFFECTS of GROWING MEDIA

Effects of different growing media change according to ingredients of growing medium, their rates, physical and chemical properties of medium, crop species, growing period and crop management including irrigation, fertigation and beneficial microorganisms use.

The properties of growing media particularly affect germination rate and duration. For instance growing media composed of white peat (P), locally available peat (LP), clinoptilolite (CLI), vermicompost (VC), composted farmyard manure (CFYM) and perlite (PER) were tested for organic pepper seedling production. Germination rate reached to 97% in peat within a week, whereas germination rates were 88% in %60LP+%40VC and LP+PER+VC (1:1:1) and 70% in LP+CLI+VC (1:1:1) on the same date while there was no germination in LP+CLI+CFYM (1:1:1) and LP+PER+CFYM (1:1:1). Germination could increase up to 76 and 73% in two weeks in the latter growing media due to higher EC level of CFYM (Tuzel et al., 2018).

After completion of germination, differences in seedling growth (i.e. seedling length, root growth) and plant biomass is observed in the same growing media for different crops (Table 3). The differences could be due to higher N availability and/or correct balance in nutrient supply and nutrient availability and/or physical, chemical and/or biological properties. Responses of some crops in different growing media is

Table 3. Effects of different growing media on seedling fresh weight (g plant^{-1}) (Tuzel et al., 2017b[1] and 2018[2]).
Çizelge 3. *Fide yaş ağırlığı (g bitki^{-1}) üzerine farklı yetiştirme ortamlarının etkisi* (Tuzel et al., 2017b[1] and 2018[2]).

	LP+CLI +CFM (1:1:1; v:v)	**60%LP +40%VC (1.5:1, v:v)**	**LP+CLI +VC (1:1:1; v:v)**	**LP+PER +CFM (1:1:1; v:v)**	**LP+PER+VC (1:1:1; v:v)**	**P (control)**
Tomato (cv. Melis)[1]	1.01	1.21	1.78	0.16	0.87	1.02
Pepper (cv. Ergenekon)[2]	0.71	0.83	1.19	0.77	0.45	0.71
Watermelon (cv. Asbal)[1]	0.44	0.53	1.13	0.45	0.82	1.12
Lettuce (cv. Papiro)[1]	0.70	1.72	1.68	0.38	1.63	1.14

P: peat, LP: locally available peat, PER: perlite, CLI: clinoptilolite, VC: vermicompost, CFYM: composted farmyard manure

Table 4. The effects of growing media on different crops.
Çizelge 4. *Yetiştirme ortamlarının farklı bitki türlerine etkisi.*

Crop	Growing medium components	Response	Reason	Reference
Tomato	Peat, coir, vermiculite, or perlite	100% peat, 75% peat + 25% vermiculite, or 50% peat + 50% vermiculite had greater root dry weight, stem diameter, leaf area, shoot dry weight, and stem length; more than 50% coir exhibited reduced plant growth	High N immobilization by microorganisms and high C:N ratio	Arenas et al., 2002
Tomato	OP+WP (Old peat 65% + white peat 30% + perlite 5%); OP + MSWC (old peat 65% + municipal solid waste compost 30% + perlite 5%); WP + OP (white peat 65% + old peat 30% + perlite 5%); WP + MSWC (white peat 65% + municipal solid waste compost 30% + perlite 5%); MSWC + WP (municipal solid waste compost 65% + white peat 30% + perlite 5%).	Quality indices of tomato seedlings in white peat (65%)+MSWC (30%) were similar to those grown conventional mixtures of old and white peat sphagnum (control)	Correct balance between the compost nutrient supply and the porosity and aeration provided by white peat	Herrera et al., 2008
Tomato	Replacing commercial growing media with the different rates (0, 10, 50%) of coffee pulp compost (CP)	At CP (10%) tomato serial biomass, seedling height and no of nodes/plant were higher than pro-mix media	Improvement in physico-chemical and biological properties with the inclusion of CP	Berecha et al., 2011
Tomato	Four rates (20%, 45%, 70%, 90%; v/v) on a volume basis of olive pomace waste (OPW) and green waste compost (GWC)	Treatments GWC 20%, 45% and OPW 20% showed the best performances compared with peat.	Physical properties and EC as well as nutrient availability	Ceglie et al., 2011
Tomato	(1) local peat (LP)+ perlite (PER) + composted farmyard manure (CFYM), (1:1:1; v:v), (2) LP + clinoptilolite (CLI)+ CFYM, (1:1:1; v:v), (3) LP + PER + vermicompost (VC) (1:1:1; v:v), (4) LP + CLI + VC (1:1:1; v:v), (5) VC and (6) peat as control.	LP+VC+CLI and LP+VC+PER were found as promising alternatives	Physical charesteristics: High water retention capacity, fast water drainage, and appropriate aeration.	Tuzel et al., 2015
Tomato	Compost of rose oil processing wastes, separated dairy manure, poultry manure, and straw mixed with local peat at the rates of 25, 50, 75, and 100% (v/v). Composting method: aerated static pile or turned windrow composting methods.	Germination period was the longest in 100% compost use and shoot biomass decreased with increasing compost rates.	Physical and chemical properties of growing media	Oztekin et al., 2017
Tomato	Three different types of olive oil production wastes (two-phase and three phase olive mill wastes and olive oil waste water sludge) with separated dairy manure, poultry manure and straw were composted using aerated static pile composting method and mixed with local peat at the rates of 25, 50, 75, and 100% (v/v).	Germination period extended with the increase of compost rates. The highest shoot dry matter was in the mixture with 25 % of the enriched compost obtained from three-phase olive mill wastes.	Physical and chemical properties of media	Tuzel et al., 2017a
Tomato and cucumber	Garden wastes and cow manure compost at 0, 10, 20, 40, 60, 100% (v/v) compared with peat (100%)	Quality of tomato and cucumber transplants of 100% compost was similar to the ones grown in peat (100%)	Nutrient availability; pH & EC level were not excessively high	Ghanbari-Jahromi and Aboutalebi, 2009

Tomato, courgette and pepper	Prepared using three different residues (SMS-AB, SMS-PO and a mixture of SMS-AB and SMS-PO 50% (v/v) (SMS-50)) and peat as diluent at four different proportions of each residue (25%, 50%, 75% and 100% v/v)	Up to 75% SMS can be used in mixtures for seed germination. Any substrate elaborated with waste was found adequate for tomato seedling production. For pepper growth, only the media prepared by mixing SMS-PO or SMS-50 at a proportion up to 25% with peat and all the SMS-AB-based substrates were adequate. Regarding courgette, with low nutrient requirements, all media could be used for plant growth, except SMS-PO and SMS-50 pure and SMS-PO + P(75%).	Tolerance of tomato to salinity	Medina et al., 2009
Melon and tomato	Urban solid wastes, sewage treatment plant and vegetable wastes + white peat 47.7/47.5 (melon); 65/30 (WP/C) (tomato)	Increasing doses of compost substitution decreased germination speed of melon and tomato	High EC affected germination speed	Diaz-Perez et al., 2010
Melon	Bovine manure compost (BMC) and green compost (GC) mixed with peat at the rates of 30, 50, 70% (v/v) compared to the control (a mixture of peat, coconut fibre and perlite)	Melon (fertilization with guano) In terms of performance, seedling growth in treatments containing 30% and 50% of composts was significantly higher than in control.	BMC rich in terms of nutrient elements compared to GC	Tittarelli et al., 2009
Watermelon	Peat was compared with different media composed of local peat (LP), perlite (PER), composted farmyard manure (CFYM), clinoptilolite (CLI) and vermicompost (VC).	Performance of 60%LP+40%VC on shoot growth was the highest while peat and LP+PER+VC were better in terms of root biomass. Growing medium composed of local peat and vermicompost was found to be as good as peat in terms of shoot fresh and dry weights.	Physical and chemical properties of media	Tuzel and Oztekin, 2017
Lettuce and tatsoi	Compost derived from preconsumer food residuals mixed with yard wastes (primarily leaves) as a bulking agent (FR); compost derived from used straw horse bedding (HB); commercial peat-based potting medium (+ commercial fertilizer); both composts were mixed with a commercial substrate derived from finely shredded bark, peat and fine sand.	FR compost performed well; HB was completely unsuitable.	Higher nitrogen availability in HB	Clark and Cavigelli, 2005
Lettuce, chard, broccoli and coriander	Grape marc (70%) + cattle manure (30%); grape marc (61%) + poultry manure (39%)	Partial substitution of peat, in quantities of 25–50% by volume showed better performance.	Absence of phytotoxicity	Bustamante et al., 2008

CONCLUSION

Seedling production covers a period from seed sowing till the transplanting stage. Growing medium hosts the roots and hold the plant upright. Many researchers report different alternatives as reducing the rate of peat or as new mixture. Although compost is the most common growing media, the main drawbacks are some unsuitable physicochemical characteristics (high EC, higher concentration of potentially toxic elements), lack of uniformity of compost, discontinuous characteristics and some typologies of organic wastes are not acceptable (i.e. sewage sludge). Therefore, testing different originated composts in different ratios as a supplement in seedling growing medium have proposed a rate starting from 25%.

Independently from the chemical properties of growing media, fertilization and use of beneficial organisms (e.i. mycorrhiza, plant growth promoting bacteria) for promoting growth and/or suppress plant diseases affect seedling growth and quality.

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