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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Effects of Different Growing Media on The Yield in Tomato, Cucumber and Pepper, and on Seedling in Tomato

Sera Koşullarında Farklı Yetiştirme Ortamlarının Domates, Hıyar ve Biberde Bitki Gelişimi ve Verimi ile Domateste Fide Kalitesi Üzerine Etkileri.

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Abstract

This study was conducted to investigate the effects of different growth media on the yield of tomato, cucumber and pepper, which are widely grown in the area; and on the germination and seedling quality of tomato seeds. The study was establishedwith 4 plant types x 5 growth media x 6 repetitions and 120 pots in total for 2 vegetation periods. Fantastic and Truss tomatoes, Demre long green pepper and local cucumber seedlings were used in the study. Mixture1 and Mixture2 consisted of peat and perlite and Mixture3 consisted of soil+ animal manure + perlite. The seedlings were distracted in pots containing the Mixture1, Mixture2, Mixture3, mere perlite and mere peat. As the germination media for the seeds, the mixture consisting of peat and perlite; and the mixture consisting of soil, animal manure, perlite, angular stream sand. The seeds were planted in seedling trays with 45 cells. The highest germination rate was obtained in the media with upper part perlite and lower part peat and mere peat medium with 96%. The 50% peat 50% perlite mixture was the second best with 94%. The highest fruit yield and plant height were obtained in Truss tomatoes by Mixture1, in Fantastic tomatoes by Mixture2, and in Pepper and Cucumber by Mixture 1.

Keywords: Peat, perlite, tomatoes, pepper, cucumber, growth media.

Öz

Bu çalışma, değişik yetiştirme ortamlarının yörede yaygın olarak yetiştirilen domates, hıyar ve biber bitkilerinin gelişme ve verimleri ile domates tohumunun çimlenmesine ve fide kalitesine etkilerini araştırmak amacıyla yapılmıştır. Çalışmada Hibrit fantastik ve salkım domates çeşitleri, Demre sivrisi biber ve yerli hıyar tohumları kullanılmış, yetişme ortamı olarak hacim üzerinden %62 torf %38 perlitten oluşan karışım II,%29 torf %71 perlitten oluşan karışım 1, yalnız perlit, yalnız torf ile 1:1:1 oranında dişli dere kumu, yanmış hayvan gübresi ve killi tınlı topraktan oluşan harç kullanılmıştır. Her bitki için her yetişme ortamından 6 adet saksı kullanılmıştır. tohumlar için çimlenme ortamı olarak %50 torf, %50 perlitten oluşan karışım, yalnız perlit, yalnız torf, 1:1 oranında üstü perlit altı torf olan 2 katmanlı ortam ile 1:1:1 oranında dişli dere kumu+yanmış hayvan gübresi + perlitten oluşan harç kullanılmıştır. Bu ortamlar kullanılarak hazırlanan 45 gözlü fide viyollerine 14 Nisanda tohumlar yerleştirilmiştir. Fidede tüm bitkilerde en yüksek çimlenme oranı ve en iyi fide kalitesi %96 ile yalnız torf ile üstü perlit altı torf olan ortamda gerçekleşmiştir. %50 torf %50 perlit karışımı %94'le ikinci, yalnızca perlit %88'le üçüncü,1:1:1 oranında toprak, gübre, perlit karışımı %57 ile son sırayı almıştır. Her iki domates çeşidinde de karışım II, Biberde ve Hıyarda karışım 1 ile en yüksek verim elde edilmiştir.

Anahar Kelimeler: torf, perlit, karışım, harç, yetiştirme ortamı

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Turkey ranks the fourth in the greenhouse existence in the world, and the third among the Mediterranean countries after Spain and Italy; and the second in the greenhouse where vegetables are grown after Spain (Ilbay et. al. 2015). Tomato, cucumber and pepper are important vegetables that are grown widely in Turkey. The constant use of greenhouse soil cause problems due to infections, and the necessary precautions to eliminate these problems increase the costs, and cause environmental problems.

Facility in supply, being light and homogenous, having suitable cost, facility in processing, having high water-retention capacity and sufficient aeration are among the important chemical, physical and biological characteristics in horticulture industry (Mathur and Voisin, 1996; Sahin *et al.*,2002; Ingram *et al.*,2003; Raviv *et al.*, 2002; Sahin and Anapali, 2006; *Yılmaz et. al.* 2014). Cultivation without soil is considered as the safest alternative to soil and closed-soilless culture systems in terms of disinfection (Wohanka, 2002). De Boodt and Verdonck (1972) and Fonteno *et al.* (1981) conducted a study and reported that ideal media must have Total Pore Space (TPS) of over 85%. Michiels *et al.* Conducted a study in 1993 and reported the same ratio as 85-95%. It is generally accepted that the pH values, the nutrients and salt contents being lower is good for the media (De Boodt and Verdonck, 1972). An ideal growth medium must have a pH range between 5.3 and 6.5; and the EC level must be less than 0.50 dSm^{-1} (Raviv *et al.*, 1986: Abad *et al.*, 2001). However, there has not been any single ideal growth media for the nursery produced horticultural crops (Poole *et al.*, 1981, Raviv *et al.*, 1986, Bugbee and Frink, 1996).It has been reported that high organic matters support the growth of plants (Abad *et al.*, 2001).

The components of a growth medium have been classified by Schmilewski (2008). He classified those under 4 categories, which are; (1) Peats (i.e. Bog peats and fen peats); (2) Composted materials (green wastes, barks, wood wastes, etc.); (3) Other organic materials (barks, coir, wood fiber, wood chips, rice hulls, etc.); and (4) Mineral Materials (perlite, clay, vermiculite, sand, pumice, mineral wool, etc.). Peats have several physiochemical properties that make them be considered as one of the major components of potting (Handreck and Black, 2002). However, they also cause some environmental problems as well as being beneficial (Granberry *et al.*, 2001; Wilson *et al.*, 2001; Tsakaldimi, 2006; Chalker-Scott, 2014).

A great deal of alternative growth media without soil has been investigated throughout history, which are; pumice stone (Karaman and Brohi, 1995), dried lake soils mixed farm yard manure (Karaman, M.R., Brohi A.R. and Er, F., 2003) coconut coir (Arenas *et al.*, 2002), wood fibers (Gruda and Schnitzler, 2004), rice hulls (Evans and Gachukia, 2004). Also, Herrera et al. (2008); Kasmi et al. (2012) recommended the use of municipal solid wastes; Atiyeh *et al.* (2000); Bachman and Metzger (2008) recommended using vermin-composts; and Ceglie *et al.* (2011) suggested using green waste composts.

Despite these struggles in developing alternative growth media, peats are still among the most important substances in terms of growth media (Reinhofer *et al.*, 2004; Schmilewski, 2008; Michel, 2010). Verdonck, (1991), Olympios, (1992), Kreen *et al.* (2002) and Sirin *et al.* (2010) reported that when peats were mixed with perlite increased the growth parameters of plants because peats had high cation exchange capacity, and the results showed that the yield was more in peat-perlite mixtures.

Lazcano *et al.* (2009) and Danaher *et al.* (2011) conducted studies and reported that substitution of ≥50% container-mix with alternative media without soil developed the plant growth in tomatoes.

The aim of this study was to investigate the effects of using peats (Peat), perlite and soil-based growth media as potting media on cucumber, tomato and pepper; and to evaluate the influences of the media on the Growth and Fruit Yields. It was also evaluated on the germination and quality of tomato seedlings.

Materials and Methods

Typical characteristics of a continental climate are observed in the study area, summers are hot and dry, and winters are cold and wet. Sometimes, the temperature drops to -26^0C in January and February, which are the coldest months. Major irrigation sources are underground water, Beysehir Lake, and Apa Dam.

Experimental Design (The Fruit Yield on pepper, tomato and cucumber)

The study was conducted with 4 plant types x 5 growth media in 6 repetitions; 120 pots in total for 2 vegetation periods in Glass Green House of S.U. Çumra Vocational High School in plastic pots of 13-liter volume. The growth media used in the study are as follows;

1. Mixture I (M1): This medium was prepared with 71% perlite and 29% peat by mixing them based on the volume.

2. Mixture II (M2): This medium was prepared with 38% perlite and 62% peat by mixing them based on the volume.
3. Mixture III (M3): This medium was prepared by mixing 1 cup of burnt animal manure, 1 cup of angular stream sand, and 1 cup of loamy-clay soil.
4. Perlite: The whole of this medium consists of the pilot produced by Etibank Company
5. Peat: The whole of this medium consists of manure added peat.

The Demre long pepper, local cucumbers, Truss tomatoes and Fantastic tomato seedlings were used. The seedlings, which were planted and grown from the seeds in sterile multi-celled seedling trays on 14th of April, were distracted to pots when they were 5-6 weeks old on 28th of May, which is recommended by Peet and Welles (2005) and Zeidan (2005).

The distance between the plants in pots was approximately 60 cm. The first harvest was on 20th July, and the latest was on 15th November. The products obtained from the harvest were recorded after they were weighed in the sensitive scale, and the plant heights were measured with a measuring device during the vintage time.

In order to feed the plants the nutrition solution containing approximately 300 mg K, 200 mg N, 100 mg Ca, 30 mg Mg, 40 mg P and sulphur, iron, zinc, mangan, boron, copper, molybdenum; and ammonium nitrate, mono potassium phosphate (MKP), potassium sulfate, calcium nitrate, magnesium sulfate per liter were given, to perlite pots once a day to ensure 20% drainage and to allow accumulation of water at the bottom of the pots at full level. To the others, the nutrients and water were given at a rate of 40% of the field capacity by considering the water demand and the moisture holding capacity of the plants. Drainage was ensured at each irrigation; and ammonium nitrogen was used at a rate of 20% to prevent salinization and pH increase. The pH value of the media was kept at <7,0; and the EC value was kept at< 1,5 dS/cm conditions during the growth season. The pH and EC values were measured by digital devices. The city water, which had EC x 10^6 <300 µS/cm, SAR< 10 (C2S1 characteristics) was used.

90 pieces of Fantastic tomato seeds for each growth medium were also placed in plastic trays containing 45 cells on 4th of April; and the feelings were watered from the upper parts by using mini sprinkler caps. In order to prevent the seedlings from being influenced by the cold, the radiant heating system, which was established on the roof of the greenhouse, was used. The seedlings, which appeared after germination, were distracted to the pots, which contained the above-mentioned growth media on 14th of May. The day on which the seeds germinated and appeared on the surface for the first time was accepted as the first emergence date, and the number of the plants that emerged on this date (the time starting of seedlings) was assessed as the first emergence percentage (%). The germination percentages and the heights of the seedlings in different media were assessed in a statistical manner.

In order to feed the seedlings, a solution containing approximately 100 mg N, 30 mg K, 30 mg P, 30 mg Mg, 30 mg Ca and sulphur, iron, zinc, mangan, boron, copper, molybdenum for per liter was used. The growth media for germination in 45-cell plastic trays are as follows;

1. Perlite+PeatMixture (M4): This medium was prepared by mixing 50% perlite and 50% peat based on the volume.
2. Perlite on the upper part, and Peat on the lower part (M5): This mixture was prepared by placing perlite and peat on top of the other one with equal amounts without mixing them.
3. Soil+animal manure+perlite Mixture (M6): This medium was prepared by mixing soil+manure and perlite at a rate of 1.1.1.
4. Perlite: The whole of this medium consists of the perlite produced by Etibank Company
5. Peat: The whole of this medium consists of manure added peat.

Data Analysis

In order to analyze the effects of the treatments on the yield and quality, the Analysis of Variance (ANOVA) was used. Also, the Least Significant Difference (LSD) Test was conducted for the comparison and ranking of the

treatment media. The difference was accepted as being significant at a value of $P \leq 0.05$.

Results and Discussion

Fruit Yields

The variance analysis results of the effects of different growth media in greenhouse conditions on Truss tomatoes, Fantastic tomatoes, Pepper and Cucumber are given in Table 1; and the average yield values are given in Table 2.

Table 1.The variance analysis results of the effects of different growth media in greenhouse conditions on Truss tomatoes, Fantastic tomatoes, Pepper and Cucumber.

Variation Source	S.D.	Quadratic Means
Plant types (A)	3	19473925.9 **
Growth Medium (B)	4	2232627.7 **
A*B	12	218017.9 **
Error	40	17861.7
General	59	1198016.5

****p>0.01**

Table 2. The average yield values (gr/pot) of the tomatoes, tomatoes, pepper and cucumber; and the comparison of these according to the LSD Test.

Growing Media	Truss tomatoes	Fantastic tomatoes	Pepper	Cucumber
Turf	3643 b	3200 c	958 b	1747 b
Perlite	3097 c	3148 c	913 b	1850 b
Loamy soil + Manure + Perlite(M3)	2500 d	2437 d	810 b	1730 b
Mix 1 (M1)	3950 a	3688 b	1322 a	2540 a
Mix 2 (M2)	3927 a	4035 a	1030 b	2520 a
LSD (5%)	220.5			

As it is seen in Table 1, the effect of the plant types (A), Growth Medium (B) and A*B interaction on the yields of the plants that were included in the study is at a statistically significant level (p>0.01). This situation shows that the yield values obtained vary according to the plant type, which is a natural result; and vary at a significant level depending on the Growth Medium.

As a matter of fact, as it may be observed in Table 2, the highest fruit yields were obtained in (M1) and (M2) media. In Truss tomatoes in M1 media, more fruit yields were obtained at a rate of 8.4%, 27.5%, %58 and 0.6%, respectively, when compared with the peat, perlite, M3 and M2 media. According to LSD Test, the M1 and M2 constituted the first group (a), Peat constituted the second group (b), Perlite constituted the third group (c), and M3 constituted the fourth group (d) in terms of the yield obtained from Truss tomatoes. The differences between these groups were found to be statistically significant (p>5%).

In Fantastic tomatoes, in the M2 Growth Medium, where the highest yield was obtained, increases were obtained at a rate of 26.1%, 28.2%, 65.6%and 9.4%, respectively when compared with the peat, perlite, M3 and M1 media. In terms of the yield obtained from Fantastic tomatoes, the differences between the media other than M1 and M2 were found to be at a statistically significant level with 5% (Table 2).

Pepper gave the highest yield in M1 Growth Medium; and according to the LED Test, the medium constituted the first group (a) and the other media constituted the second group (b). Although there is no significant difference between the two groups in statistical terms in terms of pepper yield, the differences between the growth media that constituted the second group were found to be at insignificant levels. The fruit yield of pepper obtained with M1 medium was found to be higher by 38%, 44.8%, 63.2% and 28.3% than Peat, Perlite, M3 and M2, respectively.

The yield values of cucumber changed depending on the growth media, and in terms of average yield values, M1 and M2 constituted the first group (a), peat, perlite and M3 constituted the second group (b). The differences

between the groups are at a statistically significant level with 5%. The yield in cucumber in M1, which gave the highest yield, was higher at a rate of 45.4%, 37.3%, 46.8%and 0.8% when compared to peat, perlite, M3 and M2 media.

The Variance Analysis results of the effect of different growth media in greenhouse conditions on plant height of Truss tomatoes, Fantastic tomatoes, Pepper and Cucumber are given in Table 3; and the average height values are given in Table 4.

Table 3. The Variance Analysis on plant height.

Sources of variation	S.D.	Root Mean Square
Crops (A)	3	41498.5 **
Growing media(B)	4	11669.8 **
A*B	12	863.0 **
Error	40	54.9
General	59	3114.0

****P>0.01**

Table 4.Average height (cm) and the comparison of these values according to the LSD Test.

Growing Media	Truss Tomato	Fantastic Tomato	Peeper	Cucumber
Turf	128 b	163 b	58 b	189 c
Perlite	113 c	130 c	40 c	174 d
Loamy soil + manure + Perlite (M3)	89 d	102 d	45 c	112 e
Mix 1 (M1)	181 a	175 a	72 a	217 a
Mix 2 (M2)	187 a	176 a	66 a b	203 b
LSD (%5)	12.2			

As it is seen in Table 3, the effect of the plant types (A), Growth Medium (B) and A*B interaction on the plant heights grown in the study was at a statistically significant level (P>0.01). This situation shows that plant heights change at a significant level depending on the Growth Medium because the change of plant heights according to plant types is a normal result. As a matter of fact, as it may be observed in Table 4, the highest plant height increase was obtained in M1 and M2. The plant height changed between 89 and 187 cm in Truss tomatoes, depending on the Growth Medium. According to the LSD Test, M1 and M2 first group (a), Peat second group (b), Perlite third group (c) and M3 fourth group (d). The differences between these groups have been found to be at a statistically significant level (p>5%).

The plant height in Fantastic tomatoes changed between 102-176 cm depending on the growth media, and the M2 and M1, which gave the highest plant height values, constituted the first group (a), Peat constituted the second group (b), Perlite constituted the third group (c) and M3 constituted the fourth group (d). The differences between the groups were at a statistically significant level with 5%.

The best plant height growth was observed in the pepper in Mixture1. However, the differences between the M1 and M2; and M2 and Peat media were found to be at a statistically insignificant level in terms of the plant height of pepper (Table 4). The height values of cucumber also changed according to the growth media, and the best height was obtained in M1 as the first group (a), followed by M2 as the second group (b), by Peat as the third group (c), by Perlite as the fourth group (d),and by M3 as the fifth group (e). The differences between the groups are at a statistically significant level with 5%.

No significant differences were found between the M1 and M1 media in terms of the height and yield values. For this reason, for growing tomatoes and cucumber, preferring either M1 or M2 according to cost-effective considerations will be suitable. In pepper, the situation is a little different. Although there is no statistically significant difference between M1 and M2 in terms of pepper growth and yield, more yields were obtained from M1 than M2 at a rate of 28.3%. Therefore, M1 may be recommended for growing peppers in greenhouse conditions. The findings are consistent with the results of the study conducted by Sahin*et al.* (1998), who reported that mere peat and peat mixed at a rate of 50% were recommended. Several studies have reported similar results

in media that contained peats and perlite; for example Petunia peats + 10% perlite and *Pelargonium* and *Salvia* less than 25% of compost+ perlite were recommended by Popescu, G. and Popescu. M (2015) and Do and Scherer (2013), respectively. Yılmaz*et al.*(2014) conducted a study and reported that peat, perlite, vermiculite, pumice and coco peats were important media to produce seedlings. Rippy *et al.* (2004) conducted a study and reported that although the percentage of 1stclass fruits were lower in Conventional Media (CM) than Organic Media (OM) for F99 tomato, the total yield of them was similar (peat / perlite / vermiculite and others). Although perlite has higher stability values (as inorganic medium), no development was observed in yield for bell pepper or long English cucumber compared to the sawdust (Nichols and Savidov, 2009).

Peat and perlite are standard and sterilized, and therefore ensure high germination rates, and easy to obtain, which are important advantages. Verdonck (1991), Olympios (1992), Kreen*et al.* (2002) and Sirin*et al.*(2010) conducted studies and reported that mixed peat + perlite gave an important yield in all growth periods. Peat has high cation exchange capacity, and the roots are aerated and watered well in perlite. Adding perlite to peat decreases the costs and increases the quality and yield, which make this option become even more advantageous. The price of perlite is extremely cheaper than peat in Turkey.

The Germination and Seedling Development

The first starting date of the seeds placed in the trays is given in Table 5, the germination rates obtained in seedlings, seedling heights and the dates when the seedlings exceeded 25% are given in Table 6.

Table 5. The first starting dates of the seeds placed in different germination media on 4th of April.

Germinating media	The time starting to surface	%
Turf	13 April	21
Turf + perlite (M4)	13 “	4
Perlite	15 “	2
Perlite + Turf double layer (M5)	15 “	12
Loamy soil + Manure + Perlite (M6)	21 “	18

As it is seen in Table 5, the earliest starting to surface was obtained with peat, peat + perlite mixture (M4) follows this, and the latest starting was observed in the medium which contained soil + perlite + manure mixture (M6). There was a starting date difference of 8 days between the mere peat and soil + perlite + manure mixture. While the rate of starting to surface rate on the 9th day was 21% in the peat, the rate of starting was observed as being 18% in the soil + perlite + manure mixture on the 17th day. Peat is in the first rank to be preferred in seedlings in terms of being early and in terms of germination and seedling quality. Adding perlite to peat in seedbed compost decreases the cost, which is an important benefit. As it is observed well, there is a considerable earliness and a high germination rate in peat medium, and the distraction of the seedlings is easier and safer. Peat is in the position of being the first material to be preferred in terms of earliness, germination rates and quality in the seedlings. The results are parallel to the results reported by Jankauskienė (2012), which claimed that cultivating tomatoes in peat bags could be transplanted both in younger and older age; and the growth stage had no influences on the average tomato fruit weight.

The germination rates of the seedlings are given in Table 6 after their heights were measured. In addition, the starting dates of the 25% of the seeds in each medium are also given in the table.

Table 6. The seedling rates, heights and the starting dates of 25% of them.

Germinating media	Germination / seedlings rates (%)	Average length of Seedlings (cm)	The time starting to surface 25% of seedlings
Turf	96	9,8	14 April
Perlite + Turf double layer (M5)	96	9,7	17 “
Turf + Perlite (M4)	94	9,7	14 “
Perlite	88	6,5	17 “
Loamy soil + manure + Perlite (M6)	57	4,5	24 “

As it is seen in Table 6, the highest seedling number was obtained in the peat and M5. The seedling rate of the peat and M5 was 96%; and M4 followed this with 94%; perlite with 88%; and M6 with 57%. In terms of

the heights of the seedlings, the peat was the first with 9,8 cm; M4 and M5 were the second with 9,7cm. Perlite and M6 followed this with 6,5cm and 4,5cm, respectively. The best results were obtained in the peat medium in terms of seedling height. It is observed that the growth media consisting of peat; and peat + perlite mixtures provide important advantages. However, mixing perlite and peat at a rate of up to 50% will be more beneficial because this will decrease the cost without affecting the yield and quality. The perlite-peat mixture is found to be recommendable in growing vegetables when the issues like the facility of obtaining, being standard and sterile and being easy to apply are considered; and the peat is recommendable in seedling production. The results are parallel to the results reported by Verdonck (1991), Olympios (1992), Kreen *et al.* (2002) and Sirin *et al.*(2010).

Conclusion

In recent years, because of weariness, salination, infection of disease factors, and similar other negative elements, modern greenhouses stopped growing plants in natural greenhouse soil. The companies are in need of new media and methods instead of soil.

It is observed that the growth media consisting of peat; and peat + perlite mixtures provide important advantages. However, mixing perlite and peat at a rate of up to 50% will be more beneficial because this will decrease the cost without affecting the yield and quality. The perlite-peat mixture is found to be recommendable in growing vegetables when the issues like the facility of obtaining, being standard and sterile and being easy to apply are considered; and the peat is recommendable in seedling production. The mixture with soil in seedlings is not considered suitable because the soil is not standard. Furthermore, controlling the salt and pesticides is difficult for farmers, and it has less germination rates when compared to the other media. However, when mere peat is used, the surface of the peat must be prevented from forming a crust until the seeds are germinated and started. Otherwise, the seedlings cannot break this crust and cannot start to the surface, and die after some time.

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