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Determination of the Possibilities of Using Different Compost Materials as Seedling Growing Medias in Tomato, Cucumber and Pepper

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ABSTRACT

In the environmental context of Türkiye, the quantity of organic matter present in the soil is a crucial factor that affects its productivity potential. While peat offers an optimal growth condition, it is an expensive material due to its limited availability globally, and in Türkiye. Hence, the research employed compost, which could be a viable replacement for peat, and is a sustainable, and independent alternative resource. The study examined the effects of 13 diverse growing media, both in pure, and mixed form, which included a control treatment of a 2:1 peat to perlite mixture, and three composts derived from grape, apple, and tomato pulps. The research investigated various growth criteria, such as seedling height, hypocotyl length, and diameter, number of leaves per seedling, root length, seedling dry weight, and root dry weight of tomato, cucumber, and pepper plants. The study indicated that grape compost, apple compost, tomato compost:peat:perlite (GAT:P:P), and grape compost:peat:perlite (G:P:P) were viable alternatives to the traditional peat/perlite mixture for tomato seedlings. Similarly, grape compost (G), apple compost (A), and apple compost:perlite (A:P) showed potential as substitutes for cucumber seedlings while apple compost (A) proved a possible option for chilli seedlings. In particular, the treatments using solely apple or grape composts, or a combination of both, exhibited superior performance in comparison to the control treatment.

Keywords: Compost, Cucumber, Pepper, Seedling, Tomato

1. Introduction

Due to the quick global, and Türkiye population growth, there is an urgent need to increase plant production swiftly to match the growing food demand. Efficient utilization of organic waste, and by-products generated by fruit juice production, vegetable residues, and tomato paste factories is essential for sustainability purposes. These by-products can improve the use of fruits, and vegetables in plant production, and be integrated into agricultural practices.

In Türkiye, organic matter content is a crucial factor that affects soil productivity. The most significant source of organic matter in the country is barnyard manure (Bayındır et al. 2004). However, the unavailability of barnyard manure in the required quantity, timely availability, and adequate maturity levels prompt growers to explore alternative sources. This situation highlights the significance of utilising waste materials as a means of organic substance in agricultural regions (Özgüven et al. 1996). Organic matter deficiency in greenhouse soils can be remedied by employing materials like barnyard manure, peat, and compost (Tüzel et al. 1992; Tüzel 1996). Direct usage or composting of vegetable, and farm residues, barnyard manure, urban residues, industrial wastes, and akin materials left after harvesting can elevate soil organic matter levels (Entry et al. 1997; Pascual et al. 1997; Madejon et al. 2001; Bhattacharyya et al. 2003).

In recent years, utilising harvest wastes produced as a result of crop production, or various fabrication wastes whose raw materials are agricultural products (such as vegetable residues), as inputs in agricultural production has become a widely adopted practice for preventing environmental pollution, and waste. Consequently, leftover materials from agricultural production processing are repurposed in the same areas, thereby mitigating adverse environmental effects. Today, numerous studies have indicated that the majority of waste materials can be readily incorporated into soil to yield organic matter, and plant nutrients, or alternatively, can be used as growth media by blending them in specific ratios (Aydeniz & Brohi 1991; Özenç 2004; Benito et al. 2005; Benito et al. 2006).

Organic, inorganic, and synthetic growing media are utilised in soilless cultivation (Leonardi 2004; Gül 2008). The depletion of global, and Türkiye peat resources, declining perlite reserves, and waste concerns surrounding rock wool have stimulated demand for readily available, cost-effective materials suitable for soilless agriculture from local sources (Frolking et al. 2001; Tüzel & Gül 2008). As a result, composts derived from vegetable, and fruit waste offer a practical solution that could considerably curtail both input costs, and reliance on foreign imports for commercial soilless agriculture, and seedling cultivation.

In this study, the possibilities of using compost materials prepared from tomato, grape, and apple pulps alone or in combination as a seedling growing medium for tomato, cucumber, and pepper were investigated.

2. Material and Methods

2.1. Greenhouse experimental area

This research was conducted in 2021 at Tokat Gaziosmanpaşa University (TOGU) Research and Application Center's greenhouse facilities. The compost production phase finished in 2020, and thereafter, compost materials underwent testing in a seedling study for tomato, pepper, and cucumber cultivation. The study aimed to analyse the implications of different compost applications as a growing medium on these seedlings. The study was conducted in the province of Tokat, situated in the Central Black Sea Region, between the Black Sea Region, and Central Anatolia Region. Its coordinates are 39°51' - 40°55' North latitude and 35°27' - 37°39' East longitude. Tokat is bordered by Samsun to the north, Ordu to the northeast, Sivas to the south and southeast, Yozgat to the southwest, and Amasya to the west.

The seedling trials were conducted in a greenhouse that had a total enclosed area of 2000 m², with 1000 m² dedicated to seedling production. The greenhouse was equipped with a heating system, a fully automated fertilization system, and had a height of 5 meters under the gutter, with polycarbonate sides, and a roof coated with polyethylene (Figures 1 & 2).

Figure 1- Exterior view of the greenhouse

Figure 2- Seedbed and full automation system

2.2. Materials used in composting

The composts utilised in this study were produced using raw materials procured from diverse organizations in Tokat. The apple, and grape pulps were sourced from Dimes Gıda San. ve Tic. A.Ş., a fruit juice factory, whilst the tomato pulp was acquired from Kazova Tomato Paste Factory. During the composting process, fresh cattle manure, slaked lime, wheat straw, urea, soil, and water were blended with the tomato, apple, and grape pomace.

2.3. Plant materials used in the trial and their properties

The seedling trial comprised Asalet F_1 (Hazera) tomatoes, İstek F_1 (Yüksel Seed) bell peppers, and Olay F_1 (AG Seed) cucumbers. Asalet F_1 tomato cultivar is ordinarily cultivated in open fields, and is ideal for cultivation during spring, and summer. It is characterized as medium-early, producing vibrant red fruits weighing between 220-260 g on average. This variety displays considerable resistance to races of *Verticilium albo-atrum* (*Va*), *Verticilium dalie* (*Vd*), and *Fusarium oxysporum (Fol 0.1)*, as well as demonstrating tolerance to Tomato spotted wilt virus (TSWV), and *Meloidogyne arenaria* (*Ma*), *Meloidogyne incognita* (*Mi*), and *Meloidogyne javanica* (*Mj*).

The İstek F_1 bell pepper cultivar boasts a long shape, and a sturdy plant structure, with an early maturation period. The fruit, which is around 8x4 cm in size, and thin-skinned, is green, and suitable for cultivation in both greenhouse, and open field environments during spring, and autumn. This cultivar also demonstrates tolerance to Tomato spotted wilt virus (TSWV).
The Olay F_1 cucumber belongs to the Beith Alpha (Mini Type Cucumber) category, and is a compact, early variety ideal for greenhouse cultivation during spring, summer, and early autumn. The fruits are cylindrical, with long stalks, fewer veins, and necks, a medium-green hue, and an extended shelf life. They range from 18 to 20 cm long, and have been noted to exhibit resistance to Zucchini yellow mosaic virus (ZYMV). The fruit pictures of the varieties are given in Figure 3.

Figure 3- Varieties used in the study

2.4. Composting

A composting pre-study was executed in 2019, composting tomato, apple, grape, and peach pomace. However, due to peach pomace's high moisture content, and low aeration level, the preliminary trial was unsuccessful in producing any beneficial compost material. Consequently, peach compost was not featured in the subsequent trial. In the initial test, the decision was made to create compost from grape, apple, and tomato residue, whose composting process was successful. The collection of the pulp was procured for composting in 2021, resulting in a successful outcome.

The composting technique, as proposed by Stoffella & Kahn (2001), and Diacono & Montemurro (2019), was adapted for the purpose of composting. The materials utilised in the composting process were weighed, and measured in accordance with their volume. The grape, apple, and tomato pulps were measured as 2 m^3 each and placed on a concrete floor. 200 kg fresh dry cattle manure, 100 kg dry straw (in the form of compressed bales), 5 kg urea, and 5 kg slaked lime powder were added as main materials. The mixture was homogenised via a manure separator. The piles were mixed three times a week during the first month, and twice a week in subsequent periods. A sprinkler system was utilized during mixing, with watering continuing until the moisture content reached approximately 50% as measured by a moisture meter. Once the raw material became uniform on the concrete floor, it was piled to a height of one metre, and covered with transparent plastic. The compost pile was mixed on a weekly basis, and watered to achieve a 50% moisture content before being covered again. The temperature of the compost was measured daily using a soil temperature meter at a depth of 50 cm. The mixture was adjusted, and moisture content regulated until the temperature of the compost stabilized. After 22 weeks of composting, the mixing process concluded, and the plastic cover over the compost was removed to allow airing, and drying. The compost was then dried to reach 20% moisture content with a moisture content meter and stored for the trial.

Composts obtained from the remains of tomato, apple, and grape, along with different combinations of peat and perlite, were utilized as the cultivation medium in the experiment. After reaching maturity, the compost materials were filtered using a 4 mm sieve and subsequently utilized to generate seedling production media (Figure 4).

Figure 4- Compost types used in the study

Table 1- Ingredients of apple, grape and tomato compost (Anonymous 2021)

Analysis	*Apple compost*	*Grape compost*	*Tomato compost*
Moisture %	71.55	48.77	47.01
Organic matter %	59.11	68.82	55.58
pH	7.84	8.52	8.68
EC (dS/m)	6.10	2.51	5.84
Bacteria count	$3.60*10^7$	$4.75*10^6$	$3.85*10^7$
Total Nitrogen (N) (%)	4.09	2.71	3.06
Total Phosphorus (P) (%)	0.88	0.58	0.68
Total Potassium (K) (%)	2.85	3.26	1.38
Total Calcium (Ca) (%)	8.91	6.54	15.8
Total Magnesium (Mg) (%)	1.17	0.72	1.10
Total Iron (Fe) (%)	0.29	0.71	0.75
Total Zinc (Zn) (ppm)	200	250	170
Total Manganese (Mn) (ppm)	288	204.5	360
Total Copper (Cu) (ppm)	200	210	180

The investigation determined that the moisture content of compost produced from apple, grape, and tomato pulps utilized in food waste management were as follows: 47.01% for tomato compost, 71.55% for apple compost, and 48.77% for grape compost. Data displayed in Table 1 reveals that tomato compost holds 55.58% whereas apple, and grape compost contain 59.11% and 68.82%, respectively. Additionally, the pH ratios for tomato, apple, and grape compost are 8.68, 7.84, and 8.52, respectively. The electrical conductivity (EC) ratios for tomato, apple, and grape compost were 5.84, 6.10, and 2.51, respectively. Lastly, the bacterial counts for tomato, apple, and grape compost were 3.85 x 107, 3.60 x 10^7, and 4.75 x 10^6, respectively.

In this study, Çerçioğlu et al. (2017) found that the organic matter content was 30%, with a pH of 8.79, and EC of 11.72. Demir et al. (2010) reported a moisture content of 31.8%, organic matter ranging between 35-45%, and pH levels of 7.2-7.4, alongside a bacterial count of $1.5*10^{12}$. Black et al. (2014) found a bacterial count ranging between $1.4*10^8$ – $6.6*10^7$. Varank (2006) reported the organic matter content to be 36.7%, with a pH of 7.7, and moisture content ranging between 35-40%. Baltazar et al. (2013) discovered that the proportion of organic matter was 49.7%, with a pH of 8.33 and electrical conductivity (EC) of 6.10. Abad et al. (1993), on the other hand, found that the EC ranged between 0.59-1.38, and the pH between 7.3-6.1. Finally, Hussain et al. (2015) determined a moisture content of 42%.

Nutrient content is a significant factor in both compost production and utilization. The experiment employed diverse compost materials, with nitrogen ranging from 2.71% to 4.09%, phosphorus between 0.58% and 0.88%, and potassium ranging from 1.38% to 3.26%. Table 1 presents the macro, and micronutrient contents of the tested composts. The nitrogen, phosphorus, and potassium levels in the composts used in the experiment were comparable to or exceeded those found in previous studies. This can be attributed to the compost's composition and structure.

Various studies have found differing levels of nitrogen content in compost. Pathak et al. (2017) identified a concentration of 1.31%, while Demir et al. (2010) recorded a range of 1.5-2.5%. Raclavska et al. (2021) measured a concentration of 4.3%, and Wu (2001) reported a value of 12.6%. Hussain et al. (2015) determined a concentration of 1.16%, while Abad et al. (1993) observed a range of 7%. 4-16.3%; Varank (2006) reported a value of 1.43%; Arikan & Öztürk (2005) measured a range of 2.1-2.2%; Çerçioğlu et al. (2017) found it to be 2.18%; Yağmur & Okur (2017) determined a value of 1.32%, while Lopez-Baltazar et al. (2013) recorded a value of 5.44%.

Raclavska et al. (2021) reported a phosphorus content of 0.1%, whereas Demir et al. (2010) found it to be between 2.0-2.5%. The study conducted by Varank (2006) found a phosphorus content of 0.77%, while Çerçioğlu et al. (2017) and Lopez-Baltazar et al. (2013) reported 0.13% and 1.07%, respectively. Hussain et al. (2015) found a phosphorus content of 1.84%, and Yağmur & Okur (2017) reported it as 0.30%. Regarding potassium content, Raclavska et al. (2021) discovered it to be 15.2%, whereas Demir et al. (2010) reported a range of 2.5-3.0%; Hussain et al. (2015) found a potassium content of 0.69%, and Yağmur & Okur (2017) stated content of 2.56%.

López-Baltazar et al. (2013) reported the pH content as 6.11-8.33, the EC value as 1.09-6.10 dS m-1 and the organic matter content as 49.7% to 72.0%.

2.5. Seedling planting and application

The three vegetable species utilized in the seedling trial were seeded on the 1st of April 2021. The plug trays utilized for sowing the seeds were covered with vermiculite, measuring 0.5 cm in thickness. After watering, the plug trays were wrapped in thin plastic before being transported to the germination room (Figure 5). The germination chamber was maintained at 20±2 °C and waiting times were species-specific. Cucumber seeds were kept for 36 hours, whereas tomato seeds were kept for 72 hours and pepper seeds for 96 hours. The plug trays were shifted to the seedling greenhouse and kept on tables at a height of 70 cm from the ground. Media filling, seed sowing, and watering of the capped multipots were carried out. The temperature of the seedling greenhouse was maintained at 20/25±3 °C with periodic verification of day/night temperatures. No fertilization was administered from seed sowing until the emergence of the first true leaves. When the first true leaves appeared, irrigation with the nutrient solution was started. The pH of the irrigation water was adjusted to 5.9 and kept at the same pH until the harvest of the seedlings. When the first true leaves emerged, irrigation using a nutrient solution was initiated. The pH of the irrigation water was adjusted to 5.9 and maintained at that level until harvesting of the seedlings. Upon aligning the cotyledon leaves with the soil surface, irrigation with a nutrient solution began. The EC value was initially set at 1.4 dS/m during the first week, followed by 1.6 dS/m in the second week, 1.8 dS/m in the third week, and finally adjusted to 2 dS/m until the evaluation of seedling quality. Fertilization was adjusted using an automated system. The stock tanks were prepared by following the N:P:K:Ca:Mg 2.5:1.0:2.5:1.0:0.5 ratio. Four tanks, each containing NPK/micronutrients/Ca/acid, constituted the stock tanks. The seedlings received irrigation from a boom irrigation system.

Figure 5- Seed sowing process

Seedlings were selected once their cotyledon leaves had emerged, and their height was measured upon observation of the first true leaf. Paclobutrazol was administered in varying doses, and quantities according to the species to regulate the growth of seedlings, and promote maturation. As the seedling greenhouse was meticulously disinfected prior to use, no pests or diseases were observed during the seedling growth period. Seedlings were sprayed with preparations equivalent to metallic copper on the 20^{th} and 35^{th} days after sowing. Upon reaching planting maturity, the seedlings in the control plots were harvested for observations and measurements. This study examined the seedling height, hypocotyl length, hypocotyl diameter, number of leaves per seedling, root length, seedling dry matter, and root dry matter of tomato, cucumber and pepper plants. Cucumber seedlings were removed after 36 days, tomato seedlings after 45 days, and pepper seedlings after 51 days (Figure 6).

The experiment was conducted with three replications based on the random plot experimental design. In each replication, 50 seedlings were cultivated and measurements were taken from 10 randomly selected seedlings. The characteristics under analysis were seedling height (cm), which was measured and averaged from the root collar to the tip of the leaves across all plots. Stem length (in cm) was measured and averaged from the root collar to the cotyledon leaves of ten seedlings. Stem diameter (in mm) was measured and averaged from ten randomly selected seedlings in each plot, 1 cm above the root collar, with the use of a digital caliper. Leaf Count (leaves per plant) - The number of leaves on each plant was counted and averaged. To determine the number of leaves per seedling, ten seedlings were randomly selected from each plot, and their true leaves were counted and averaged. Root length was measured in centimetres by uprooting ten random seedlings in each plot, washing their roots with water, and measuring them with a ruler. The dry matter content of the seedlings was recorded as a percentage. The dry matter content of the roots was also measured as a percentage. The weight of the seedlings was measured both when wet and when dry to determine their dry matter content. The Seedling dry matter content was calculated using the formula Seedling dry matter content (%) = (Seedling dry weight/ Seedling wet weight) x 100. Firstly, the wet and dry weights of the roots were measured, then the dry matter content of roots (%) was calculated using the formula (%) = (Root dry weight/Root wet weight) x 100. Composting materials were mixed either singularly or in combination with each other, along with peat and perlite. In the experiment, 13 different compost mixture were tested including the control treatment (Table 2).

Figure 6- Initial emergence and development period of the seedlings

Table 2- Seedling growing medium

1.	Control (2:1 Peat: Perlite) (C)
2.	Grape compost (G)
3.	Apple compost (A)
4.	Tomato compost (T)
5.	Grape+Apple+Tomato compost (GAT)
6.	2:1 Grape compost: Perlite (G:P)
7.	2:1 Apple compost: Perlite (A:P)
8.	2:1 Tomato compost: Perlite (T:P)
9.	2:1 (Grape+Apple+Tomato compost): Perlite (GAT:P)
10.	1:1:1:1 Grape compost: Peat: Perlite (G:P:P)
11.	1:1:1:1 Apple compost: Peat: Perlite (A: P:P)
12.	1:1:1:1 Tomato compost: Peat: Perlite (T: P:P)
13.	1:1:1:1 (Grape+Apple+Tomato compost): Peat: Perlite (GAT:P:P)

Tomato and pepper seedlings were grown in 216-cell plug trays, while the cucumber seedlings were cultivated in 150-cell plug trays. The dimensions of the plug trays that were implemented in the experiment can be found in Table 3.

Table 3- Dimensions of the plug trays used in the experiment

Plug tray	*Cell width-length-height (cm)*	*Viol cell volume (cc)*	*Trays width (mm)*	*Trays length (mm)*
150 (70+80)	4*4*6.5	50	325+325	370+470
216 (108+108)	3.2*3.2*6.5	40	347+347	470+470

2.6. Statistical analysis

The data were subjected to analysis of variance by SPSS 18 program and the means were compared using the duncan multiple comparison test (P≤0.05).

3. Results and Discussion

3.1. Tomato seedling production

In the cultivation of tomato seedlings, the seedling height was 16.93 cm in the control treatment and varied between 11.57 cm and 17.27 cm in the compost treatments. The hypocotyl length measured 3.60 cm in the control treatment, while it varied between 2.97 cm and 4.63 cm in the compost treatments. Additionally, the stem diameter was 3.81 mm in the control treatment, but it varied between 3.63 mm and 4.86 mm in the compost treatments. Seedling height, hypocotyl length, hypocotyl diameter, and the number of leaves per seedling are the most important criteria among tomato seedling characteristics. When considering the seedling height, hypocotyl length, hypocotyl diameter, and the number of leaves in the experiment, two media options (GAT+P+P and G+P+P) closely resembled or served as alternatives to peat media for cultivating tomato seedlings. The other characteristics of the seedlings grown in these two growths media were similar to those of the seedlings grown in a peat growth media.

While the number of leaves of tomato seedlings was 3.60 in the control medium, it varied between 3.20 and 4.20 in the compost medium. Root length varied between 6.40 cm in the control medium and 6.23-9.53 cm in the compost medium, while seedling dry matter content ranged from 9.34% in the control medium to 7.30-10.46% in the compost medium. Additionally, root dry matter content varied from 5.51% in the control medium to 3.86-5.45% in the compost medium. Differences among treatments in hypocotyl length and seedling dry matter content were insignificant, while differences among treatments were significant in other traits. Seedling growth, quality parameters, and significance levels of differences according to the media are given in Table 4.

Seedling cultivation is a key sector in tomato production, and like cucumber cultivation, has recently gained significant importance. While peat has historically been the predominant growing medium, its severe drawbacks, including dependence on foreign sources, necessitate exploring sustainable, local and cost-effective alternatives. Therefore, there is a demand for sustainable, local and cost-effective options. Upon analyzing Table 4, it is evident that utilizing compost media as a substitute seedling growing medium to peat in tomato cultivation has resulted in notable success. Similar alternative media studies conducted for a prolonged period in tomato seedling farming also exist for cucumber. Castillo et al. (2004) utilized a mixture of 65% peat, 30% compost, and 5% perlite. Ceglie et al. (2011) employed the use of compost derived from olive pomace and green waste. Díaz-Pérez & Camacho-Ferre (2010) utilized compost obtained from urban waste, vegetable waste, and grape pomace. Similarly, Carmona et al. (2012) successfully cultivated tomato seedlings using compost derived from grape waste. Tüzel et al. (2020) processed waste from olive plants to create compost, which was then mixed with peat in varying amounts to cultivate organic tomato seedlings.

The authors reported that the addition of 25% and 50% compost resulted in high-quality tomato plants. However, there are other successful alternatives to peat-based media for growing tomato seedlings, as indicated by previous studies. Considering the need for a single compost material in the current study, compost produced from grape pomace was found to be sufficient to rival peat, which is a commercial seedling growing medium, when mixed with perlite and peat.

Table 4- The effects of different composts and their mixtures on the quality of tomato seedlings

Media	*Seedling height (cm)*	*Hypocotyl length (cm)*	*Hypocotyl diameter (mm)*	*Leaf number per seedling (pcs. ***)*	*Root length (cm)*	*Seedling dry matter (%)*	*Root dry matter (%)*
Control (C)	16.93 ± 0.31a	3.60 ± 0.36	3.81 ± 0.20 de	3.60 ± 0.20c	6.40 ± 0.46 de	9.34 ± 2.08	5.51 ± 0.65 a
G	12.87 ± 0.99def	4.07 ± 0.15	4.24 ± 0.20 cd	3.67 ± 0.12bc	7.43 ± 0.60 bcd	8.46 ± 1.01	4.67 ± 0.27 abc
A	11.57 ± 0.96f	2.97 ± 0.55	3.63 ± 0.81 e	3.20 ± 0.35d	6.23 ± 0.70 e	8.92 ± 0.82	5.08 ± 0.30 ab
T	15.03 ± 0.45bc	3.73 ± 0.06	4.28 ± 0.23 bcd	3.87 ± 0.23abc	6.47 ± 0.31 de	9.38 ± 0.76	5.45 ± 0.50 ab
GAT	13.20 ± 0.53de	3.70 ± 0.10	4.48 ± 0.03 bc	4.00 ± 0.00ab	6.73 ± 0.23 de	8.81 ± 1.76	5.02 ± 0.21 ab
G+P	14.27 ± 0.67cd	4.37 ± 0.31	4.70 ± 0.28 abc	4.13 ± 0.31a	8.17 ± 0.38 b	7.63 ± 0.74	3.82 ± 0.48 c
A+P	12.97 ± 1.07def	4.26 ± 0.40	4.20 ± 0.37 cd	3.87 ± 0.23abc	7.33 ± 0.91 bcd	9.35 ± 1.21	3.86 ± 0.34 c
T+P	14.00 ± 0.80cde	3.07 ± 0.40	4.18 ± 0.21 cde	3.87 ± 0.12abc	6.60 ± 0.44 de	8.29 ± 1.66	5.38 ± 0.99 ab
GAT+P	13.40 ± 0.20de	3.50 ± 0.17	4.37 ± 0.06 bcd	3.87 ± 0.12abc	7.13 ± 0.58 cde	10.46 ± 0.30	4.52 ± 0.45 bc
G+P+P	16.13 ± 0.81ab	3.83 ± 0.06	4.45 ± 0.06 bc	4.00 ± 0.00ab	8.17 ± 0.51 b	8.68 ± 1.30	4.80 ± 0.28 ab
A+P+P	12.53 ± 0.21ef	3.60 ± 0.30	5.10 ± 0.29 a	3.93 ± 0.12abc	8.20 ± 0.36 b	7.30 ± 0.76	4.88 ± 0.55 ab
T+P+P	17.27 ± 0.95a	4.63 ± 0.73	4.86 ± 0.22 ab	4.20 ± 0.20a	9.53 ± 0.83 a	7.62 ± 1.51	4.94 ± 0.56 ab
GAT+P+P	16.33 ± 1.40ab	3.90 ± 0.10	4.71 ± 0.30 abc	4.13 ± 0.31a	8.03 ± 0.15 bc	7.82 ± 0.73	4.74 ± 0.33 abc
P- values	***	**ns**	***	***	***	**ns**	**

C: Control **G:** Grape, **A:** Apple, **T:** Tomato, **GAT:** Grape-Apple-Tomato, **G+P:** Grape+Perlite, **A+P:** Apple+Perlite, **T+P:** Tomato+Perlit, **GAT+P**: Grape-Apple-Tomato+Perlite, **G+P+P:** Grape+Peat+Perlite, **A+P+P:** Apple+Peat+Perlite, **T+P+P:** Tomato+Peat+Perlite, **GAT+P+P:** Grape-Apple-Tomato+Peat+Perlite, *****:** P<0.001, ****:** P<0.01, ***:** P<0.05, **ns:** insignificant

3.2. Cucumber seedling production

The most important quality characteristics of vegetable seedlings include height, hypocotyl length and diameter, as well as root length. In this study, the above-mentioned characteristics were taken into consideration as the criteria for ready-to-plant seedlings, and the media in which seedlings with similar characteristics to the control seedlings were obtained were accepted as an alternative to peat and perlite media.

In this study, which investigated the possibility of using compost materials instead of peat in seedling production, the seedling height of cucumber was 16.57 cm in the control plants, while it varied between 11.93 cm, and 20.13 cm in the compost treatments. Treatments with seedling heights between 15.50 cm, and 17.00 cm were accepted as equivalent to the control medium and accordingly seedling heights in 3 growing media grape (G), apple (A) and grape:perlite (G:P) were similar or alternative to the control treatment. The fact that the seedling height of most of the compost media in the experiment was higher than the control due to the higher organic matter and nitrogen content of compost than peat media. Seedling height is the most important criterion for deciding whether the growing medium is suitable or not. Apart from seedling height, hypocotyl length, hypocotyl diameter and number of leaves per seedling should also be taken into consideration. Other parameters other than these characteristics examined in the experiment can only be taken into consideration in addition to seedling height. The effects of growing media on cucumber seedling characteristics are given in Table 5.

The table shows that the hypocotyl length of cucumber seedlings was 3.67 cm in control and 3.10 to 4.30 cm in compost media, hypocotyl diameter was 6.04 mm in control, and 5.37 mm to 6.18 mm in compost media, the number of leaves per seedling was 4.60 in control, and 3.27 to 4.47 in compost media, the seedling height was 16.57 cm in control and 10.63 to 20.13 cm in compost media, root length 12.67 cm in control, and 8.53 cm and 13.73 cm in compost media, seedling dry matter content between 8.00% in control, and 6.19% and 8.81% in compost media and root dry matter content between 1.53% in control, and 1.51% and 3.00% in compost media.

Table 5- The effects of different composts and their mixtures on the quality of cucumber seedlings

Media	*Seedling height (cm)*	*Hypocotyl length (cm)*	*Hypocotyl diameter (mm)*	*Leaf number per seedling (pcs.***)*	*Root length (cm)*	*Seedling dry matter (%)*	*Root dry matter (%)*
Control (C)	16.57 ± 0.50 de	3.67 ± 0.21de	6.04±0.30 a	4.60±0.00 a	12.67 ± 1.85abc	8.00 ± 1.59 abc	1.53 ± 0.18d
G	10.63 ± 0.42 g	4.03 ± 0.05abc	5.89±0.29 ab	4.30±0.26 bc	13.27 ± 0.06a	7.46 ± 0.75 a-d	2.34 ± 0.18bc
A	15.67 ± 0.12 e	3.50 ± 0.20ef	6.10±0.30 a	4.17±0.06 bc	11.67 ± 0.70cd	6.67 ± 0.37 cd	2.06 ± 0.32bcd
T	17.60 ± 0.35 bcd	3.77 ± 0.06cde	5.98±0.09 a	4.20±0.00 bc	13.73 ± 0.12ab	7.41 ± 0.35 a-d	2.40 ± 0.35b
GAT	18.53 ± 0.50 b	3.77 ± 0.06cde	5.96±0.10 ab	4.17±0.06 bc	13.67 ± 0.61a	6.49 ± 0.50 cd	1.51 ± 0.28d
G+P	16.73 ± 0.58 cde	4.15 ± 0.08ab	5.88±0.26 ab	4.17±0.06 bc	11.57 ± 0.49cd	6.67 ± 0.81 cd	2.14 ± 0.22bc
A+P	15.60 ±1.22 E	3.23 ± 0.06f	5.37±0.33 c	4.23±0.15 bc	8.53 ± 0.35 e	8.49 ± 0.06 ab	1.83 ± 0.31cd
T+P	12.13 ± 0.31 F	3.10 ± 0.10f	5.51±0.35 c	4.40±0.20 ab	10.90 ± 0.70d	8.81 ± 0.76 a	1.84 ± 0.14cd
GAT+P	20.13 ± 1.85 A	4.30 ± 0.10a	6.18±0.12 a	4.07±0.23 c	11.93 ± 0.31bc	7.51 ± 0.67 a-d	2.40 ± 0.26b
G+P+P	13.27 ± 0.64 F	3.73 ± 0.40de	5.74±0.28 abc	4.47±0.31 ab	10.87 ± 1.24d	8.69 ± 1.24 a	2.47 ± 0.32b
A+P+P	18.07 ± 1.22 Bc	3.90 ± 0.00bcd	5.79±0.15 abc	4.17±0.06 bc	12.93 ± 0.90abc	7.10 ± 0.98 bcd	2.10 ± 0.16bc
T+P+P	18.73 ± 0.23 B	3.87 ± 0.06bcd	6.07±0.23 a	4.23±0.15 bc	12.67 ± 0.42abc	6.19 ± 0.85 d	1.79 ± 0.19cd
GAT+P+P	11.93 ± 0.31 Fg	4.13 ± 0.15ab	6.15±0.17 a	3.27±0.12 d	11.93 ± 0.31bc	7.28 ± 0.60 a-d	3.00 ± 0.58a
P- values	***	***	*	***	***	**	***

C: Control **G:** Grape, **A:** Apple, **T:** Tomato, **GAT:** Grape-Apple-Tomato, **G+P:** Grape+Perlite, **A+P:** Apple+Perlite, **T+P:** Tomato+Perlit, **GAT+P**: Grape-Apple-Tomato+Perlite, **G+P+P:** Grape+Peat+Perlite, **A+P+P:** Apple+Peat+Perlite, **T+P+P:** Tomato+Peat+Perlite, **GAT+P+P:** Grape-Apple-Tomato+Peat+Perlite,*****:** P<0.001, ****:** P<0.01, ***:** P<0.05, **ns:** insignificant.

It was important to investigate all treatments in the experiment to identify alternative media to the control treatment. Considering the other seedling parameters in Table 5, grape compost and perlite at a ratio of 2:1 and apple compost and perlite at a ratio of 2:1 were the most serious alternatives to the control in cucumber seedling cultivation. Although the use of apple compost without the addition of perlite also gives successful results, it is generally preferred to add perlite to the medium for homogeneous aeration of the root zone.

Sawan et al. (1997) found that composted sawdust yielded similar or superior results when compared to the control using 1:1 peat moss and vermiculite, for cucumber seedling production, plant height, number of leaves, chlorophyll content, fruit yield, and number of fruits per plant. The study concludes that sawdust compost can be used as a substitute for peat moss media at a high rate for cucumber seedling production.

Abdel-Razzak et al. (2019) study revealed that substrate mixtures enhanced with 5% and 10% tomato waste compost resulted in the best seedling response, accelerating seed germination and improving seedling morphology. These findings propose tomato waste compost as a viable replacement for peat.

Bayoumi et al. (2019), who tested compost derived from grape fruit waste as a cucumber seedling medium, found that grape compost can be successfully used instead of peat in cucumber seedling culture when mixed with coconut fibre or vermiculite in a 1:1 ratio. The data and conclusions of the researchers were demonstrated in this study conducted on cucumber seedlings, and compost was an important alternative to peat in cucumber seedling cultivation.

3.3. Pepper seedling production

The variations among treatments are statistically significant except for the number of leaves in pepper. Table 6 displays the significance levels of differences for quality parameters and seedling growth across different media. Seedling height of the pepper in the control treatment was 10.87 cm, while seedling height ranged from 12.73 cm to 18.00 cm in compost media during pepper seedling cultivation. The length of the hypocotyl was 2.07 cm in the control group, whereas it ranged from 2.27 cm to 3.67 cm in the compost groups. The hypocotyl diameter measured 2.43 mm in the control treatment, while it varied between 2.53 mm and 3.16 mm in the compost treatments. Among various seedling characteristics in pepper, seedling height, hypocotyl length, hypocotyl diameter, and number of leaves per seedling are considered significant criteria. According to the research, apple compost was found to be the nearest or equivalent alternative to peat for the cultivation of pepper seedlings.

The other characteristics of the seedlings grown in this medium were similar to the seedlings grown in the peat medium. In the experiment, while the number of leaves of pepper seedlings was 5.00 in the control medium, it varied between 5.87, and 7.07 in the compost medium. Root length varied between 5.90 cm in the control medium and between 5.00 cm and 8.20 cm in the compost medium, seedling dry matter content was 9.66% in the control medium and between 7.20% and 10.40% in the compost medium, root dry matter content was 3.44% in the control medium and between 2.82% and 6.95% in the compost medium.

Table 6- The effects of different composts and their mixtures on the quality of pepper seedlings

Media	*Seedling height (cm)*		*Hypocotyl length (cm)*	*Hypocotyl diameter (mm)*	*Leaf number per seedling (pcs. ns)*	*Root length (cm)*	*Seedling dry matter (%)*	*Root dry matter (%)*
Control (C)	10.87 ± 0.12	f	2.07 ± 0.15 f	2.43 ± 0.15 d	5.00 ± 0.53	5.90 ± 0.46 cd	9.66 ± 0.82 ab	3.44 ± 0.63 e
G	16.60 ± 0.60	ab	2.87 ± 0.06 bcd	3.16 ± 0.13 a	6.20 ± 1.11	7.00 ± 1.35 abc	7.86 ± 0.88 cde	5.40 ± 0.80 bc
A	12.73 ± 0.50	e	2.27 ± 0.38 ef	2.74 ± 0.19 bc	5.93 ± 0.31	5.00 ± 0.56 d	10.40 ± 0.09 a	6.37 ± 0.32 ab
T	14.13 ± 0.42	d	2.57 ± 0.21 de	2.87 ± 0.17 ab	6.07 ± 0.31	6.43 ± 0.29 bc	8.25 ± 0.69 b-e	3.67 ± 0.21 de
GAT	18.00 ± 0.72	a	3.20 ± 0.17 bc	3.03 ± 0.24 ab	6.27 ± 0.31	8.20 ± 0.17 a	9.15 ± 1.77 a-d	5.54 ± 1.05 bc
G+P	15.53 ± 0.23	bcd	2.93 ± 0.32 bcd	2.95 ± 0.09 ab	6.07 ± 0.31	6.13 ± 0.71 bcd	8.77 ± 0.58 b-e	3.52 ± 1.11 e
A+P	14.67 ± 0.12	cd	2.35 ± 0.13 ef	2.53 ± 0.06 cd	5.87 ± 0.50	6.50 ± 0.50 bc	9.37 ± 0.32 abc	2.84 ± 0.31 e
T+P	17.80 ± 0.69	a	3.67 ± 0.12 a	3.12 ± 0.13 a	7.07 ± 0.23	6.77 ± 0.31 bc	8.16 ± 0.24 b-e	2.82 ± 0.06 e
GAT+P	15.73 ± 0.81	bc	3.20 ± 0.26 bc	3.16 ± 0.17 a	6.73 ± 0.50	7.27 ± 0.42 ab	9.66 ± 0.90 ab	6.95 ± 0.39 a
G+P+P	16.60 ± 197	ab	2.80 ± 0.30 cd	3.04 ± 0.16 ab	6.40 ± 0.35	8.20 ± 0.35 a	7.20 ± 0.57 e	3.44 ± 0.82 e
A+P+P	14.87 ± 0.99	cd	2.90 ± 0.10 bcd	2.97 ± 0.23 ab	6.33 ± 0.42	7.30 ± 1.23 ab	8.29 ± 1.39 b-e	3.95 ± 1.08 de
T+P+P	17.53 ± 0.76	a	2.93 ± 0.15 bcd	3.02 ± 0.22 ab	6.20 ± 0.53	7.30 ± 0.56 ab	8.73 ± 0.31 b-e	3.74 ± 0.34 de
GAT+P+P	15.73 ± 0.81	bc	3.27 ± 0.32 b	3.16 ± 0.17 a	6.87 ± 0.58	7.27 ± 0.42 ab	7.75 ± 0.55 de	4.89 ± 0.82 cd
P- values	***		***	***	ns	**	*	**

C: Control **G:** Grape, **A:** Apple, **T:** Tomato, **GAT:** Grape-Apple-Tomato, **G+P:** Grape+Perlite, **A+P:** Apple+Perlite, **T+P:** Tomato+Perlit, **GAT+P**: Grape-Apple-Tomato+Perlite, **G+P+P:** Grape+Peat+Perlite, **A+P+P:** Apple+Peat+Perlite, **T+P+P:** Tomato+Peat+Perlite, **GAT+P+P:** Grape-Apple-Tomato+Peat+Perlite, *****:** P<0.001, ****:** P<0.01, ***:** P<0.05, **ns:** insignificant.

Table 6 demonstrates that apple compost is a viable alternative growing medium to peat for pepper seedlings. It is essential to follow hygiene regulations during the cultivation of pepper seedlings. Studies on alternative growing media to peat have also been undertaken for other vegetable species in pepper cultivation. Lee et al. (2000) successfully cultivated pepper seedlings using a mixture of 40% peat and 60% paddy husk. Marques et al. (2014) achieved similar success with a combination of perlite, peat, perlite + peat, and mushroom compost. Additionally, Chrysargyris et al. (2017) utilized municipal solid waste compost, and Carmona et al. (2012) utilized compost obtained from grape waste in the cultivation of pepper seedlings.

4. Conclusions

Türkiye is a prominent global producer of commercial vegetable seedlings. The growth of these seedlings involves a mixture of peat, and perlite in a ratio of 2:1 or 3:1. As imported peat is frequently employed in seedling cultivation, multiple research studies have aimed to identify alternative materials. The most promising option in this context is compost material obtained from organic waste. The study examined thirteen diverse growing media, including pure, and mixed variations, using a 2:1 peat:perlite combination as a control group. The seedlings of tomato, pepper, and cucumber cultivated with grape, and apple composts demonstrated corresponding outcomes to those grown in the control group. In particular, the treatments using solely apple or grape composts, or a combination of both, exhibited superior performance in comparison to the control treatment.

In the seedling trial conducted in 2021, compost derived from apple, and grape pomace yielded superior outcomes in growing tomato, pepper, and cucumber seedlings compared to the control treatment (peat-perlite). No indications of soil-borne diseases were detected upon using compost. Despite adequate quantities of apple, and grape pomace in Türkiye, the shortage of compost production employing these materials has been established as a significant shortcoming.

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