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The Effects of Different Growing Media and Humic Acid Applications on the Growth of Tomato Plants

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Abstract

This study was carried out to determine the effects of different growing media (peat + perlite, cocopeat, hazelnut husk, rock wool) and different humic acid doses (2, 4, and 8 ml L^{-1}) on tomato plant growth. The performance of the seedlings from planting to fruit set was evaluated to determine the growth of the tomato plant. For this purpose; stem diameter (mm), plant height (cm), leaf number, first flowering, first fruit set, total plant dry weight (g), root volume (m^3), and relative growth rate (g cm^{-2} $days^{-1}$) parameters were examined. According to the results, the highest stem diameter of 15 mm was obtained in the hazelnut husk media at a dose of 4 ml L^{-1} of humic acid. As a result, while the best root growth was obtained at 2 ml L^{-1} humic acid doses in peat-perlite media, the fastest growth and N (3.33%), P (0.58%) and K (3.91%) content were obtained at 8 ml L^{-1} humic acid doses in cocopeat media. The best leafing, flowering and fruit set were obtained in hazelnut husk media with 2 ml L^{-1} humic acid doses. As a result, the highest relative growth rate (0.064 g cm^{-2} $days^{-1}$) was determined at 8 ml L^{-1} doses of humic acid applied in the cocopeat media.

1. Introduction

While agricultural chemicals are used unconsciously to meet the nutritional needs of the global population and increase yield and resource efficiency, it causes adverse effects on human health, environmental pollution and deterioration of soil structure. On the other hand, there are product returns due to pesticides, especially from foreign markets, which harms the country's economy. Over time, polluting agricultural lands with chemical fertilizers will decrease the productivity of the soils and cause an increase in social problems and the need for food. Due to these concerns, organic agriculture and organic fertilization have become widespread in recent years to reduce synthetic agricultural chemicals such as pesticides and fertilizers and increase the sustainability of agricultural production systems. Improving organic matter in the soil applying organic fertilization; it has been revealed by the researchers that it improves the physical and chemical properties of the soil, increases the amount of microbial biomass, and increases the plant yield and quality by increasing the nitrogen fixation events (Fraser et al., 1988; Tüzel et al., 2011; Özer and Uzun, 2013; Özdemir and Özer, 2016).

Humic acid is an organic soil conditioner with a very high organic matter content, whose colors can change from yellow to black, produced in the form of pellets or as the liquid in concentrated form by processing lignite coal or solid leonardite. At the same time, humic acids have an international certificate of conformity to organic farming (Akıncı, 2011; Kacar, 2013; Sayarer, 2020). Humic acid, an organic soil conditioner, increases the soil water holding capacity, removes the salt in the soil from the root zone, and increases the plant's nutrient uptake by regulating the soil pH. The positive effects of humic acid on plants growth and development are due to increased availability of nutrients with water, plant root zone development, and increased chlorophyll content. Sabzevari et al. (2010) found that humic acid application had a positive effect on germination rate, seedling growth and emergence rate; Demirtas et al. (2014) revealed in their study that humic acid increases N, P, K, Fe and Cu plant nutrients in tomato plants and significantly affects fruit quality.

Different media are used in tomato production, especially seedling and plant growing. In today's seedling cultivation, organic (peat, bark, hazelnut husk, sawdust, straw-straw and cocopeat) and inorganic (sand, gravel, perlite, vermiculite, pumice, rock wool and zeolite) media are used as growing media (Taşdelen et al., 2021). In many studies, it has been revealed that the effects of different growing environments on different plants may be different (Polat et al., 2017; Yıldırım and Hatipoğlu, 2020; Taşdelen et al., 2021). However, the interaction of these media with different growth regulators and their effects on growth rate after planting have not been studied. In this study, it was aimed to determine the effects of organic cultivation of tomato seedlings produced in different growing media (peat+perlite, rock wool, cocopeat, hazelnut husk) and different humic acid doses (2, 4 and 8 ml L^{-1}) until the first fruit set period after planting.

2. Material and Method

The research was carried out in the glass greenhouse and open field of Ondokuz Mayıs University, Faculty of Agriculture, Department of Horticulture, between April-July 2022. The seeds of H-2274 tomato cultivar were used as plant material in the study. Four different seed sowing media (peat-perlite (65% + 35%), cocopeat, hazelnut husk and rock wool) were used in this study. Peat, perlit, cocopeat and rock wool are commercial growing media. However, hazelnut husk media was prepared. The hazelnut husk waste, which have completed their natural drying processes, were the grinding process with an 8 mm sieve diameter. Before the seed sowing process, the pH values of the environments were determined with the pH meter (Adwa waterproof), and the EC values were determined with the EC meter (Adwa waterproof). A suspension was prepared to measure pH and EC values by taking 1:10 media/pure water from the media into a beaker. Prepared suspensions were shaken on a magnetic stirrer for 1 hour, and then pH and EC values were measured (Table 1).

The tomato seeds used in the study were sown in 210 well viols with 2.6 × 2.6 cm diameter cells containing four different media. In the study, a total of 360 seeds, 30 in each replication, were sown with three replications. The viols, in which the seeds were sown were placed on the growing benches in the glass greenhouse with heating control, and five minutes of irrigation were applied three times a day (at 10.00, 14.00 and 16.00) throughout the growing period. Greenhouse temperature (°C) and relative humidity (%) (KT100, Kimo, France) values were measured during the seedling growing period (Table 2).

In the trial, three different humic acid doses (2, 4 and 8 ml L^{-1}) were applied to the seeds planted in cocopeat, rock wool, hazelnut husk, and peat-perlite. To obtain the humic acid used in the application, after heating 310 L of water at approximately 80°C, the mixture obtained by adding 13 kg of potassium hydroxide (-OH) was completed to 400 liters by adding 80 kg of leonardite, salicylic acid (250 ppm) and IBA (500 ppm). Humic acid was applied every 15 days after germination of the seeds until the 4 leaf seedling stage. Humic acid was sprayed to the leaves in such a way that all the leaves of the seedlings were wet. Seedlings that reached the four leaf stage were planted in the open field, and their growth performances until fruit sets were examined. In the study, planting sites were prepared in areas where tomatoes were not grown in previous years. Soil samples were taken from 0-30 cm depth from different points to represent the trial area before planting. In the texture analysis of soil samples belonging to the experimental area; clay (36.5%), sand (27.3%), silt (36.2%), pH (7.92), EC (0.24 dS m^{-1}), organic matter (6.02%), total nitrogen (0.24%), plant available phosphorus (11.4 ppm) and exchangeable potassium (0.72 cmol kg^{-1}) values were determined according to Kacar (2009). The raised bed was prepared with

Table 1. pH and EC values of seed sowing media.

Growing media	pH	EC (dS cm^{-1})
Peat + Perlite	5.49	0.55
Cocopeat	5.73	0.51
Hazelnut husk	6.45	0.81
Rock wool	8.03	0.21

Table 2. Temperature and relative humidity values in the greenhouse during the seedling and growing period.

	Greenhouse		Field	
	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
Lowest	16.1	40.4	12.6	27.2
Highest	41.6	91.9	39.1	81.4
Average	29.2	66.5	25.7	66.6

a height of 20 cm and a width of 1 m as the planting site. Drip irrigation pipes with a dripper spacing of 25 cm were placed in the prepared planting places (raised beds) in a way suitable for double-row planting. Irrigation was carried out with a system that can irrigate according to soil moisture throughout the growing period. Then, ground mulch was applied over the planting areas. Tomato seedlings were planted on the prepared tubes in accordance with the randomized blocks trial design, with a row spacing of 50 × 50 cm. No additional fertilization was made since planting.

In order to determine the quality of the seedlings, the seedlings were uprooted at the first fruit set; they were divided into roots, stems and leaves. Plant height was measured in meters from root collar to growth tip. Stem diameter was measured in mm from the root collar with the help of a digital caliper. The number of leaves was determined as pieces by counting the number of leaves manually since planting. After planting, the number of days until the first flowering and first fruit set was calculated and determined as flowering and fruit set. Leaves, roots and stems separated from seedlings and plants were placed separately in small paper bags in an oven at 65°C. The drying process was carried out for at least 48 hours. It was decided whether the drying process was completed by applying the weight change method on the samples that did not complete their drying during this period. When it was understood that the samples were completely dry, the dry weights of the leaves, root and stem were weighed with a balance sensitive to 0.01 g. After weighing 0.5 g of the ground samples, dry digested at 550°C for 4-8 hours in the ash furnace, the ash was dissolved in hydrochloric acid. The total nitrogen (N) content of the plant samples was determined according to the Kjeldahl method, the phosphorus (P) contents were determined spectrophotometrically according to the vanado-molybdophosphoric acid method in the obtained solutions, and the potassium (K) content was determined using atomic absorption spectrophotometer in the obtained solutions (Jones, 2001).

WinRhizo root analysis program (Regent Instrument Inc. Canada) was used to examine tomato plants root anatomy and determine the rooting levels in detail. Plant roots taken after planting were carefully washed and dried with a paper towel. The root part was placed on the scanner part of the device and transferred to the computer environment in three dimensions. Root volume (cm^3), which reveal root architectures in detail, were examined as a result of root scanning with the WinRhizo program. Root, stem and leaf dry weights and their ratios, leaf area (using the previously created models), net assimilation rate and relative growth rate analyzes were made according to Uzun (1996). The study was conducted in a Randomized Complete Block Design in split-plot arrangements with three replications. SPSS 17.0 statistical software was used to analyze experimental results using two-way ANOVA (growing media × humic acid doses). The differences between treatment was determined by the Duncan's multiple comparison tests at the $p<0.05$ significance level.

3. Results and Discussion

Peat + perlite and coconut fiber media came to the fore in seed germination rate in the study. Considering the pH (5.49-5.73) and EC (0.55-0.51 dS cm^{-1}) values of these media, it is seen that they were in the appropriate range for plant growth and development (Table 1). Thus, it is known that peat is a suitable environment for seedling cultivation due to its low volume weight and high water holding capacity (Munsuz et al., 1982, Demiral, 2016). It is thought that the hazelnut husk media has a higher EC (0.81 dS cm^{-1}) value compared to other environments that harm seed germination. It is known that salinity inhibits seed germination, reduces nutrient use in the seed and goes into dormancy (Ahmad et al., 1992; Yıldız et al., 2007). The lowest seed germination determined in the hazelnut husk media with the highest electrical conductivity.

The effects of different growing media (peat-perlite, cocopeat, hazelnut husk and rock wool) and humic acid doses (2, 4 and 8 ml L^{-1}) on stem diameter, plant height, number of leaves, flowering and fruit set times were investigated. According to the findings obtained, the stem diameter, the plant height, the number of leaves, the flowering and fruit set time were found to be statistically significant (**$p < 0.01$; *$p < 0.05$) (Table 3).

The maximum stem diameter (15 mm) was obtained from the 4 ml L^{-1} dose of hazelnut husk media, followed by 4, 2 and 8 ml L^{-1} doses of peat+perlite media, respectively. Considering the tomato plant height values, the highest plant height was obtained from the 2 ml L^{-1} doses of rock wool (45.7 cm) and hazelnut husk (45.7 cm) media. These values were followed by the 4 ml L^{-1} dose of rock wool (45 cm) media. Considering the leaf number values, it was found statistically significant at the doses of 2 ml L^{-1} for hazelnut husk (9 leaves) and 2-4 ml L^{-1} for rock wool (9 leaves). While there were similarities between the flowering times and fruit set times of the grown tomato plants, the latest flowering and fruit set was achieved at 2 ml L^{-1} of hazelnut husk media. Similar results were obtained in the study in which the effects of seedling quality on flowering and fruit set in tomatoes were examined, while the earliest flowering date was 27 days. The earliest fruit set date was 30 days (Özer and Kandemir, 2016).

The highest root volume (5967 cm^3) was found to be statistically significant in the peat + perlite media at a dose of 2 ml L^{-1}. The humic acid application doses of peat + perlite media were

Table 3. The effects of different growing media (peat-perlite, cocopeat, hazelnut husk and rock wool) and humic acid doses (2, 4 and 8 ml L^{-1}) on stem diameter, plant height, leaf number, days from planting to first flowering and fruit set.

Growing media	Doses (ml L^{-1})	Stem diameter (mm)	Plant height (cm)	Leaf number	Flowering	Fruit set
Peat-perlite (65% + 35%)	2	12.4 c	31.0 f	7.0 b	33.0 ab	36.0 b
	4	13.0 b	30.7 f	7.0 b	38.0 ab	43.0 ab
	8	12.2 c	34.7 de	8.0 ab	30.0 b	34.0 b
Cocopeat	2	7.0 ı	31.7 f	7.0 c	33.0 ab	38.0 ab
	4	8.7 h	35.3 d	7.0 c	38.0 ab	42.0 ab
	8	8.1 g	38.7 c	8.0 ab	33.0 ab	37.0 ab
Hazelnut husk	2	11.4 d	45.7 a	9.0 a**	41.0 a**	45.0 a*
	4	15.0 a**	33.5 e	7.0 c	33.0 ab	36.0 b
	8	10.4 d	33.6 e	7.0 b	34.0 ab	38.0 ab
Rock wool	2	9.4 e	45.7 a**	9.0 a**	28.0 b	34.0 b
	4	7.7 h	45.0 a	9.0 a**	33.0 ab	37.0 ab
	8	11.2 d	42.7 b	8.0 b	29.0 ab	35.0 b
Main effects						
Growing media	Peat-perlite	12.6 a**	32.1 b	7.6 b	33.8 ab	37.4 ab
	Cocopeat	7.9	35.2 ab	7.2 b	34.4 ab	38.9 b
	Hazelnut husk	12.3 a	37.6 ab	7.4 b	36.0 b	40.0 b
	Rock wool	9.4	44.4 a*	8.3 a*	30.1 a*	35.4 a*
Doses	2 ml L^{-1}	10.6	37.5	7.7	35.1 ab	39.8 ab
	4 ml L^{-1}	10.5	37.3	7.8	32.0 b	36.4 a *
	8 ml L^{-1}	10.6	37.2	7.3	33.7 a*	37.7 ab

$^{**}p < 0.01$; $^{*}p < 0.05$

Table 4. The effects of different growing media (peat-perlite, cocopeat, hazelnut husk and rock wool) and humic acid doses (2, 4 and 8 ml L^{-1}) on root volume, total dry weight, relative growth rate, N%, P% and K%.

Growing media	Doses (ml L^{-1})	Root volume (cm^3)	Total dry weight (g)	Relative growth rate (g cm^{-2} days $^{-1}$)	N (%)	P (%)	K (%)
Peat-perlite (65% + 35%)	2	5967 a**	42.5 a**	0.029 j	2.99 b	0.48 d	2.66 e
	4	3050 c	29.3 c	0.026 l	2.30 g	0.32 h	2.43 ı
	8	3410 b	21.6 g	0.034 d	2.38 d	0.30 i	2.97 c
Cocopeat	2	42 k	21.50 g	0.032 ı	2.04 h	0.24 j	2.58 f
	4	27 l	13.29 ı	0.035 c	2.87 c	0.55 b	3.66 b
	8	424 e	12.73 i	0.064 a**	3.33 a**	0.58 a	3.91 a**
Hazelnut husk	2	170 j	38.47 b	0.025 m	2.37 e	0.45 e	2.57 g
	4	337 f	23.15 e	0.027 k	1.44 k	0.50 c	2.74 d
	8	208 i	18.63 h	0.030 i	1.95 ı	0.35 g	2.45 h
Rock wool	2	268 g	25.53 d	0.032 h	1.77 j	0.38 f	1.86 k
	4	680 d	22.17 f	0.033 g	1.88 i	0.32 h	2.14 i
	8	234 ı	23.40 e	0.041 b	1.34 f	0.31 ı	1.91 j
Main Effects							
Growing media	Peat-perlite	4142 a**	26.75 b	0.030 ab	2.75 a*	0.45 a*	3.39 a*
	Cocopeat	164 b	31.10 a*	0.044 a*	1.66 b	0.33 b	1.97 b
	Hazelnut husk	238 b	23.70 b	0.028 b	2.57 a	0.37 b	2.69 ab
	Rock wool	394 b	15.84 c	0.036 ab	1.93 b	0.43 a	2.59 ab
Doses	2 ml L^{-1}	1235	24.43	0.033	2.30	0.39 ab	2.42 ab
	4 ml L^{-1}	1234	24.32	0.034	2.13	0.42 a*	2.74 ab
	8 ml L^{-1}	1236	24.30	0.036	2.26	0.38 ab	2.82 a*

$^{**}p < 0.01$; $^{*}p < 0.05$

higher than other media. Similarly, the highest plant total dry weight was determined as 42.5 g in peat+perlite media, where a 2 ml L^{-1} humic acid dose was applied during the seedling period. Considering tomato plants relative growth rate values, it was determined that the highest values were obtained from the 8 ml L^{-1} dose of cocopeat (0.064 g cm^{-2} days^{-1}). According to the results obtained, the lowest relative growth rate (0.029 g cm^{-2} days^{-1}) was obtained in the application (Peat-perlite and humic acid doses; 2 ml L^{-1}) with the highest root volume. When we examined the main effect, it was determined that 0.044 g cm^{-2} days^{-1} with the highest relative growth rate was in the cocopeat application, while the effect of humic acid doses on growth was not determined (Table 4). Bozkurt (2005) stated that humic and fulvic acids accelerate the plant's growth by accelerating cell division. They reported that there was rapid growth, especially in the seedling period. In this respect, the study's findings are similar to ours. In our study, the significant effects of the humic acid doses applied during the seedling period on the total dry weight of the plant could not be determined. However, the highest dry weight (31.10 g) was determined in the cocopeat media with the highest growth. Uzun et al. (1998) stated that plant growth should grow slowly and steadily.

Slow and stable growing plants accumulate dry matter in the roots and stems in their early development stages. In this way, the greening period of tomato plants that complete their development is prolonged, and an increase in photosynthesis abilities in a more extended period results an increase yield. In the study by Özer (2017), in which similar results were expressed, maximum yield was achieved by shading and prolonging the greening time of tomato plants.

Yücel (2006) reported that the best results (total emergence rates, stem diameter, stem and root length, number of leaves, seedling fresh and dry weight) were obtained in 100 mg kg^{-1} humic acid applied to peat media in cucumber and tomato seedlings. They also observed that their application increased the essential plant nutrient (NPK) uptake of tomato and cucumber seedlings. While different humic acid doses (0, 30, 60, 90 and 120 ppm) applied in beans plants did not have a significant effect on dry matter accumulation in plants, it was reported that it increased the uptake of elements such as N, P, Fe, Mn and Zn in the leaves (Sözüdoğru et al., 1996). In the study in which different doses of humic acid (0, 400, 800 and 1200 mg kg^{-1}) were applied to lettuce, it was determined that nitrate, total N, Ca, Cu, Zn and Mn contents of plants generally increased with increasing humic acid dose (Odabaş, 2019). One of the most important reasons why humic acid applications increase plant nutrient intake is that it provides better plant root system development (David et al., 1994; Demirtaş et al., 2014). In our study, where similar results were obtained, the highest plant nutrients N (2.75%), P (0.45%) and K (3.39%) values were obtained from peat + perlite media. When the effects of humic acid doses on plant nutrients were examined, the highest phosphorus content (0.42%) came to the fore in the 4 ml L^{-1} application, while the potassium content was measured with 2.82% in the 8 ml L^{-1} application (Table 4).

4. Conclusion

The effects of different doses of humic acid, an essential source of organic matter, and different growing media on tomato plants growth and nutrient uptake were statistically significant in this study. Intensive use of chemical fertilizers in tomatoes, especially during the seedling period, increases the inputs and pollutes the environment. Today, different commercial growing media are used in the seedling industry. Commercial growing media both increase the cost and create a serious waste problem. In our study, tomato seedlings grown in hazelnut husk, an important waste material, showed weak growth. Cocopeat and peat+perlite media came to the fore regarding seedling quality and growth. While a positive relationship was found among the increase in humic acid doses and the plant growth, root development and total plant dry weight values reached the highest at the lowest humic acid dose. While the humic acid doses did not have an effect on growth in general, the results were obtained in the relationship between the media and humic acid (cocopeat and 8 ml L^{-1}). However, humic acid doses showed significant effects on flowering (8 ml L^{-1}), fruit set (4 ml L^{-1}), fruit phosphorus content (4 ml L^{-1}) and fruit potassium content (8 ml L^{-1}). In future studies, different mixtures of different media should be examined in order to determine the full effect of the growing media. In addition, it is thought that the continuation of the application of humic acid to the plant from leaves or soil after planting may significantly affect the results.

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