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EVALUATION OF THE PERFORMANCE OF GREENHOUSE TOMATO SEEDLINGS GROWN WITH DIFFERENT CULTIVATION TECHNIQUES

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Abstract

The present study was conducted to evaluate the effects of two different seedling production systems (floating and traditional) on earliness, growth, development, yield and some quality parameters of Töre F_1 tomatoes (*Solanum lycopersicum,* L.) grown under greenhouse conditions. Results revealed increased plant height (cm), plant diameter (mm), number of leaves, number of clusters, number of fruits per cluster, fruit diameter, fruit weight and yield values with floating seedling production treatments. Earliest harvesting period (27.45 day) and fruit set (30.70 day) were found in floating system. Seedling treatments had significant effects on earliness, growth, development, yield and quality of tomatoes ($p \leq 0.05$).

Introduction

For a healthy plant growth and improved quality and yield per unit area, seedlings should be produced from high-quality seeds, environmental conditions should properly be arranged, production techniques should be well-selected and cultural practices throughout the growth period should properly be implemented. In greenhouse vegetable production, plug seedlings are preferred rather than direct seeding to minimize the risks in production processes. Therefore, seedling quality is a significant factor in a healthy and sustainable growth. The success in seedling production starts with the procurement of seedlings with a balanced dry matter distribution throughout plant organs and a well-developed root system (Şeniz 1992, Özer 2006, Tüzel *et al.* 2015).

Planting is followed by a rapid growth and development stages. Since the seedlings with a balanced dry matter distribution throughout plant organs and a well-developed root system can exhibit well-adaptation to their actual growth media, their growth, development and yield parameters will then be positively influenced. In case where entire development factors are sufficiently and steadily supplied, plants exhibit a normal development throughout the entire life cycle and form proportionate root, stem, leaf, fruit and seed. It is impossible to expect high yields from poorly developed plants (Uzun 1996).

Seedling production system is a technical process and exhibits a rapid development throughout the world. Such developments are also encountered in Turkey and today more than 100 companies are producing around 3.5 billion ready-to-plant seedlings. Tomato seedlings constitute the greatest portion of annual seedling production of Turkey (41.2%, 991.317.123) (Tüzel *et al.* 2015). Turkish seedling companies either use soil or without soil cultures for seedling production. But, in recent years, a special attention has been paid to floating systems worldwide in seedling production practices (Hensley and Fowlkes 2002, Miceli *et al.* 2003, Demir 2004, Titiz 2004, Tüzel and Özçelik 2004, Özer 2006). Floating system technology is used extensively to produce tobacco seedlings in greenhouses but is rarely used for horticultural crops (Biernbaum 1992, Carter 2002, Hensley and Fowlkes 2002, Bilalis *et al.* 2009). One of the important advantages of

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this system compared to standard seedling production systems is that it is less harmful to the environment. Because of the advantages over traditional methods, such as being less harmful to environment, not required potting, traying, mixture preparation and sterilization, such systems are rapidly widespread throughout the world (Miller 1998, Hensley and Fowlkes 2002, Miceli *et al.* 2003, Demir 2004, Bilalis *et al.* 2009).

Therefore, the present study was conducted to investigate the effects of organic tomato seedlings produced traditionally and with floating systems on plant development and yield when they were transplanted into their original places in greenhouses.

Materials and Methods

The present study was conducted at greenhouses of Ondokuz Mayıs University Agricultural Faculty Horticulture Department from June to October cultivation period. Experimental greenhouses are 12 m wide and 20 m long (240 m^2). The side walls are 3 m high and the greenhouse is covered with anti-fog, antivirus, infrared and ultraviolet supplemented PE cover. The greenhouses have natural ventilation from one long side and arc roof. Commonly grown early and pole type Töre F_1 tomato cultivar was used as the plant material of the experiments. Biofarm (Commercial organic, İzmir, Turkey) were used as organic fertilizers.

The floating tray beds were made of wood measuring 140 cm (length) × 70 cm (width) × 20 cm (depth). Seed tray had 204 cells (3.1 × 3.1 cm) and each tray measured of 69.5 cm (length) × 46 cm (width) × 6 cm (depth) for seed sowing. Silver gray PE (1.30 m wide, 0.03 mm thick) mulching material was used to cover the transplanting beds in greenhouses.

Forest ground surface soil, peat and manure (cattle) were used at a ratio of 1 : 1 : 1 as seedling production medium. This medium was filled to seed trays (204 cells). Seed were sown to these trays. Wooden water beds were constructed in order to place seed trays. Each water bed was filled with 127 litre water and three trays were placed into water bed. Organic fertilizers were added to the water beds after 50% germination of seeds. Commercial organic fertilizer (0.5 litre) accounting for 0.4% of the total water bed volume was added to bed. Aeration was performed once a week in water beds. Inner sides of water beds were lined with polyethylene plastic trays. Ten days after addition of organic fertilizers to water beds, some of the nutrients (total nitrogen, P, Ca, Mg and K), pH and EC (second measurement for EC was done 30 days after first measurement) of organic fertilizer solutions were determined (Table 1).

After seed germination, half of the seedlings (at the stage of the first true leaf appearance) in each tray were transplanted into pots (9 × 9 cm) in each application (as traditional system). Seedling production medium was also used in pots. The other half was not transplanted (floating system).

Planting places (raised beds) were prepared in measuring 20 m (length) × 1 m (width) × 30 cm (depth) in the greenhouse. Prepared raised beds were mixed with farm manure (2 kg m^{-2}) to the upper part of the 5 - 10 cm depth. Any other supplementary fertilization was not performed throughout the cultivation period. Seedlings in floating and traditional systems which were at 4 true-leaves stage, were planted to the raised beds according to the double row planting system (50 × 50 × 90 cm) in plastic greenhouse.

Following the planting, regular observations were made to determine the initial plant height (cm), diameter (mm), number of leaves and second cluster and number of fruits. In order to determine the effects of cations on plant development in greenhouse; first inflorescence (days from planting to the appearance of the first flowers in cluster) and fruit set (days from planting to the appearance of the first fruit in cluster) dates were recorded.

Weight (g) and diameter (mm) of fruits harvested from the first to last harvest were measured with a precise balance (± 0.1 g) and a digital caliper. Resultant fresh fruit weights were used to determine the yield per plant. Then, the yield per plant values were multiplied with the number of plants per decar to get the total yield in kg/da.

Experiments were conducted in RBD. Resultant data were assessed through Microsoft Excel 2010 and SPSS 17.0 software. Means were compared with DMRT at $p < 0.05$.

Results and Discussion

The effects of traditional and floating systems on post-planting plant height (cm), stem diameter (mm) and number of leaves of organically grown tomato plants were found to be significant ($p < 0.05$) (Table 2). The average plant height (158.7 cm), average stem diameter (14.26 mm) and number of leaves per plant (22.37) were obtained highest from the seedlings grown in floating system. The increase in stem diameter was resulted from the balanced growth between the vegetative and generative organs of the plants. The key in plant production is to provide a balanced growth (Kandemir 2005, Kandemir *et al.* 2009, Özer and Uzun 2013). Current results revealed that the seedlings grown in floating system showed higher stem diameter and plant height values than the seedlings grown in traditional system and such a case indicated a balanced growth in floating system. Previous studies also reported that the highest yields and stem diameters were obtained from plants with an optimum height (Çinkılıç 2008, Özer 2012). Leaves are the most significant factors of photosynthesis. They are also significant parameters for the yields of plants (Kandemir 2005, Taiz and Zeiger 2008). In this study, it was observed that the highest yield was obtained from plants with highest number of leaves and obtained from the seedlings grown in floating system (Fig. 3, Table 2).

Table 1. Nutrients, pH and EC of floating system organic fertilizer solutions.

Floating system (commercial organic fertilizer)							
Total nitrogen (%)	P (%)	Ca (ppm)	Mg (ppm)	K (ppm)	pH	EC ds/m	
						First measurement	Second measurement
0.01186	0.003	61.243	15.731	80	7.2	0.87	0.86

Table 2. The effects of different seedling production systems and organic fertilizers on average plant height (cm), average stem diameter (mm) and number of leaves per plant.

	Average plant height (cm)	Average stem diameter (mm)	Number of leaves/Plant
Floating system	158,70 **a***	14,26 **a**	22,37 **a**
Traditional system	135,27 **b**	11,32 **b**	18,15 **b**
			***p < 0.05**

Ripening duration is among the most significant factors affecting the yields of plants. Such durations are closely related to initiation of flowering. Formation and appearance of the first flower bud are also significant factor for the yield and earliness of the plants (Atherton and Haris 1986, Özer 2012). The number of days from planting to first flowering and fruit set (Fig. 1) revealed that the seedlings of floating system had the earliest flowering period (27.45 day) and fruit set (30.7 day). Effects of treatments (traditional or floating system) on flowering and fruit set were also found to be significant in this study ($p < 0.05$).

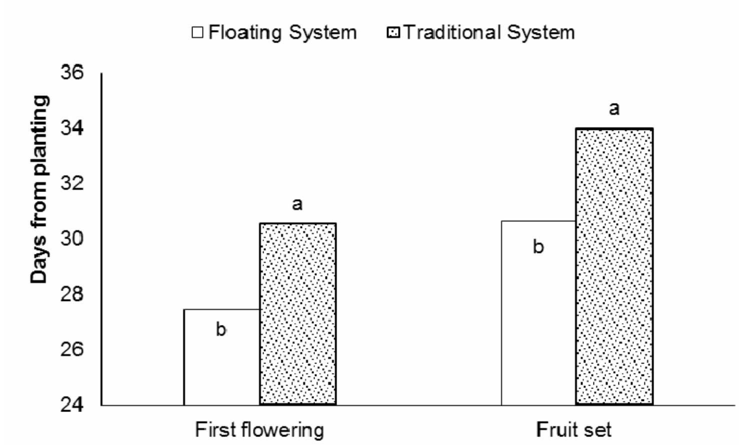

Fig. 1. The effects of different seedling production systems on days from planting to first flowering and fruit set. Different letters above the bars indicate significant differences at $p < 0.05$.

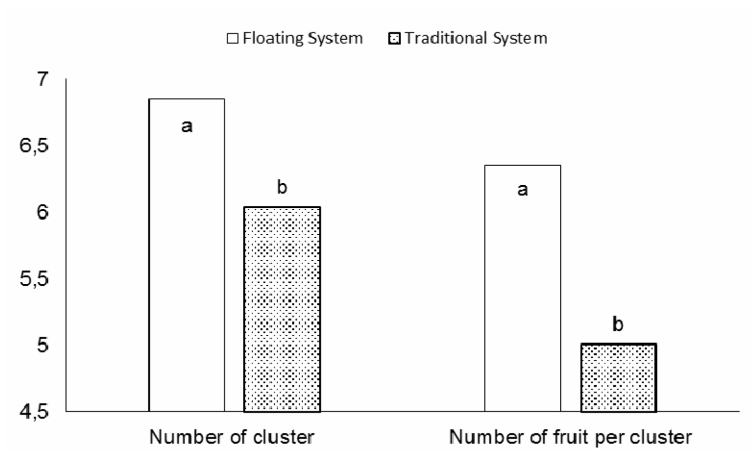

Fig. 2. The effects of different seedling production systems on number of clusters and number of fruits per cluster. Different letters above the bars indicate significant differences according to DMRT at $p < 0.05$.

Number of clusters and number of fruits per cluster are commonly used to estimate the potential yields. Effects of different seedling growing systems on number of clusters and number of fruits per cluster were found to be significant ($p < 0.05$). The highest number of clusters (6.84) was obtained from the plants grown from the seedlings of floating system and the least number of clusters (6.03) was obtained from the plants grown from the seedlings of traditional system. With regard to number of fruits per cluster, the seedling of floating system showed higher performance (6.35) than the seedlings of traditional system (Fig. 2).

Fruits are harvested when they reached to harvest ripening levels in size and color. In this way, higher dry matter accumulation and thus higher yields are obtained. Fruit weight and diameter are the significant quality indicators of tomatoes. The average fruit weight (122.02 g) and the average fruit diameter (56.77 mm) were obtained highest from the seedlings of floating system

(Fig. 3). Number of leaves per plant also increased with floating system (Table 2). Increased number of leaves increase the amount of light intersected by the leaves (Taiz and Zeiger 2008). Then, increased light intensity linearly increase the fruit weights (Pearson *et al.* 1993, Uzun 1996). Higher number of leaves in seedlings of floating system also increased the amount of light intersected by the leaves and ultimately such increased light intensitiy levels increased fruit weights and diameters.

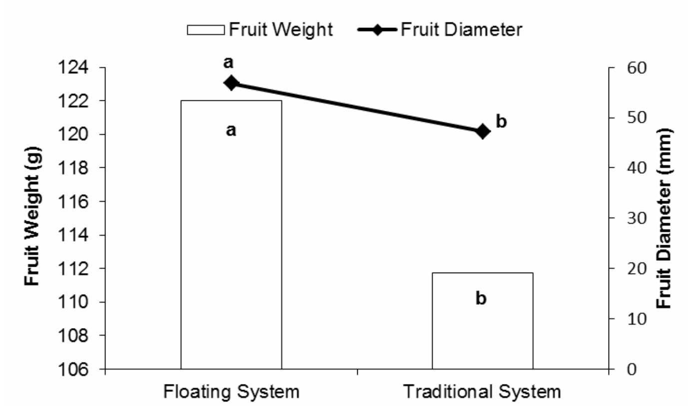

Fig. 3. The effects of different seedling production systems and organic fertilizers on average fruit weight (g) and fruit diameter (mm). Different letters above the bars indicate significant differences at $p < 0.05$.

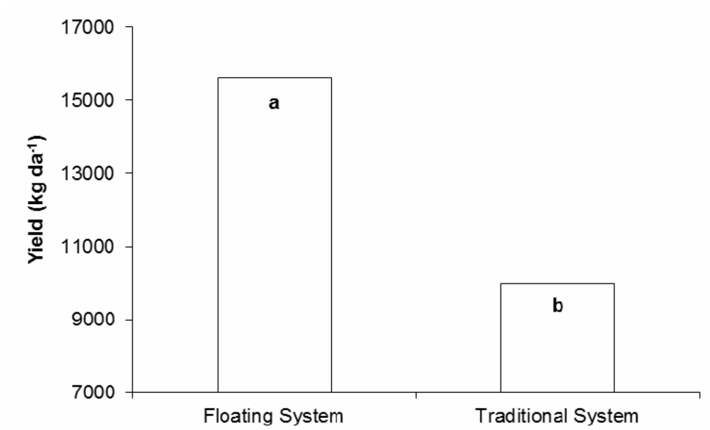

Fig. 4. The effects of different seedling production systems and organic fertilizers on yield (kg da^{-1}). Different letters above the bars indicate significant differences at $p < 0.05$.

Yield is the most significant indicator of success in vegetable culture. Although light intensity exposed by the leaves and temperature are among the most significant factors effecting the yields, proper and timely practice of irrigation, fertilization and pruning-like cultural activities also play significant roles in yields (Uzun 2000). Besides all these factors, the success in vegetable culture is primarily depending on strong and healthy seedlings grown from high quality seeds (Özer 2006, Tüzel *et al.* 2015). Starting tomato culture with quality seedlings will significantly improve the resultant yields (Markovic *et al.* 1997).

Current findings revealed that seedling quality significantly affected the yield levels ($p < 0.05$). The highest yield (15.638 kg da^{-1}) was obtained from the plants grown from the seedlings of floating system and the lowest yield (9.977 kg da^{-1}) was obtained from the plants grown from the seedlings of traditional system (Fig. 4).

In greenhouse vegetable culture, plug seedlings are commonly used instead of direct seeding to minimize the risks and improve the success. Just because of various advantages, ready-to-plant seedling production is rapidly increasing throughout the world. However, seedling production companies commonly produce seedlings in viols or containers with small cells just to improve their profitability. Such intensive production systems together with the use of growth regulators may result in a stress on seedlings when they were transplanted into their original places. Resultant stress exerted over the seedling may then result in serious yield losses. In this study, two different organic seedling growth systems were compared and it was concluded that seedling production systems had significant effects on earliness, yield and quality parameters of tomato ($p < 0.05$). Thus, found that floating system used in production of tomato seedlings had significant impacts on success of vegetable culture.

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