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ORIGINAL PAPER

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THE EFFECTS OF DIFFERENT SEEDLING PRODUCTION SYSTEMS ON QUALITY OF TOMATO PLANTLETS

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ABSTRACT

Successful vegetable cultivation begins with quality seedlings. Some quantitative parameters such as stem diameter (g), seedling dry weight (g) and specific leaf area (cm^2 g^{-1}) are used to determine the quality of seedlings. In this study, the effects of different seedling production systems (traditional and floating system), organic fertilizers (M – manure, B – blood fertilizer from slaughterhouse and O – commercial organic fertilizer) and seed tray cell size (ST1 – 2.2 × 2.2 cm and ST2 – 3.1 × 3.1 cm) on seedling quality of tomato, were investigated. It was determined that the most effective results in applications of BST1 and MST2, were obtained in terms of leaf dry weight (0.39 g), stem dry weight (0.15–0.16 g) and root dry weight (0.10–0.11 g). At the end of the study, the big celled seed tray, blood and manure fertilizers were significantly higher ($P < 0.01$) than grown in the small celled seed tray and control plants.

Key words: floating system, organic fertilizer, seed tray cell size

INTRODUCTION

Progressive decline in the agricultural areas of the world, and rapidly increasing human population inclined the producers to choose farming systems leading to fruitful, high quality, disease and pest-resistant production materials that increase the yields per unit area. Understanding the importance of vegetables in human nutrition, vegetable farming has become a profitable branch of agriculture. In connection with this, greenhouse vegetable production has shown a rapid development in many countries [Tüzel et al. 2010, FAO 2015].

In vegetable production, having economic significance in the way of production and consumption, optimum transplant production techniques should also be determined. First of all, successful vegetable production depends on selection of suitable seed variety and production of healthy and strong transplants, accordingly. Vegetable production is also affected by environmental factors, applied techniques and cultivation processes [Demir et al. 2010].

On the other hand, transplant production is also a technological process and is a subject of fast development trends in the world. In recent years, attention to improve this issue has come into existence as a vegetable seedling production in floating systems [Hensley and Fowlkes 2002, Miceli et al. 2003, Titiz 2004, Tüzel and Özçelik 2004, Roosta and Hamidpour 2011]. One of the important advantages of this system, compared to standard seedling production systems, is the fact that it is less harmful to the environment, because traditional methods use chemicals for media sterilization that are harmful for human health and environment, while making potting, traying and mixture preparation becomes unnecessary in here proposed

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system and mixture sterilization can be excluded [Hensley and Fowlkes 2002, Miceli et al. 2003].

Hensley and Fowlkes [2002] stated that many vegetable and tobacco seedlings could be produced in floating system in greenhouses. Preferred commercial fertilizers for this system are easy dissolving and they do not plug the pumps, however organic fertilizers in terms of these properties do not show similarity, but can be used in the float systems.

Seedling production in floating system that can be accepted as an alternative to the standard methods of seedling production, increased in recent years. In 1990, while seedling production in floating system was less than 1%, it reached up to 88% in 1999 for tobacco in America and almost all of the production of tobacco seedlings is in this system [Hensley and Fowlkes 2002].

The purposes of planning the present study were the facts that seedling production is taken into consideration as a science division and gaining importance in seedling production in float system, accordingly. Therefore, the effects of seedling production systems, different organic fertilizers and seed tray cell size on seedling quality of tomato were examined and discussed in the present study.

MATERIAL AND METHODS

This study was performed in a plastic covered greenhouse (6 × 20 m, width and length). Tomato (*Solanum lycopersicum* cv. Töre F1) was used for tests.

Two different applications were carried out in the study. In the first application (traditional system), seedlings were grown in pots. In this system, called the control, seeds were sown into seed trays (styrofoam) with 345 cells (2.2 × 2.2 cm) filled with forest ground surface soil, peat and manure (cattle) used at a ratio of 1 : 1 : 1 as seedling production medium. When the seedlings were at the first true leaf growth stage, they were transplanted into plastic pots (9 × 9 cm) filled with the composted manure/garden soil mixture. Transplants were irrigated throughout the growing period to meet their water needs. No supplementary fertilizers were applied.

In the second application, seedlings were grown in floating system. This system used three different organic fertilizers (M – farmyard manure, B – blood and O – commercial organic). In this applications, seeds were sown into two different seed trays (Styrofoam; ST1 – small-cell and ST2 – big-cell) filled with the peat soil medium. The small celled seed tray had 345 cells (2.2 × 2.2 cm) and the big celled seed tray had 204 cells (3.1 × 3.1 cm) (Tab. 1). Afterwards, the seed tray was placed in water bed. The seedlings were remained here until the stage of four true leaves. Three trays were used for each cell type in the floating system. Forest ground surface soil, peat and manure (cattle) were used at a ratio of 1 : 1 : 1 as a seedling production medium. This medium was used for all the seed trays.

Three wooden water beds with dimensions of 140 × 70 × 20 cm (length, width and height) were used in order to place seed trays. Inner sides of water beds were lined with polyethylene plastic. Each water bed was filled with 127 l water and four trays were placed into each water bed. Farmyard manure (mixture of sheep and cow manure), blood fertilizer (cow blood provided from slaughterhouse) and commercial organic fertilizer (Biofarm) were used as organic fertilizers in the floating system. Organic fertilizers were added to the water beds after 50% germination of seeds. Manure (36 kg sheep + 36 kg cow manure) accounted for 36% of the total water bed volume was added to the first bed, blood (0.5 l) accounted for 0.4% of the total water bed volume was added to second and commercial organic (0.5 l) accounted for 0.4% of the total water bed volume was added to third bed. Aeration process was performed once a week in water beds. After that, 10 days after addition of organic fertilizers to water beds, some of the nutrients (total nitrogen, P, Ca, Mg and K), pH and of organic fertilizer solutions were determined and shown in Table 2.

Days from seed sowing to four true-leaf stage, seedling height, stem diameter, leaf dry weight, stem dry weight, root dry weight and specific leaf area (SLA) per seedling were determined as growth parameters at the stage of 4 true leaves of growth. Plant samples were dried at 80 °C for at least 48 h. Determination methods of specific leaf area (SLA; total leaf area (cm^2) / total leaf dry weight (g)) parameters were calculated according to Uzun [1996, 1997].

Table 1. Applications of seed productıon systems, organic fertilizers and seed cell size

	Abbreviation	Applications	Seed tray
First (traditional system)	control		
Second (floating system)	MST1	manure	small-celled
	MST2		big-celled
	BST1	blood	small-celled
	BST2		big-celled
	OST1	commercial organic	small-celled
	OST2		big-celled

Table 2. Nutrients, pH and EC of organic fertilizer solutions

Organic fertilizers	Total nitrogen (%)	P (%)	Ca (ppm)	Mg (ppm)	K (ppm)	pH	EC (dS m^{-1})	
							first	second
Farmyard manure	0.01185	0.004	30.667	8.691	330	1.79	1.09	7.6
Blood	0.0286	0.004	75.142	15.731	35	7.2	0.82	1.41
Commercial organic	0.01186	0.003	61.243	15.731	80	7.2	0.87	0.86

The experiment was carried out in a randomized block design with three blocks and 15 transplants in each replication. Data analysis and graph drawings were carried out by EXCEL 10.0, and multi comparisons for statistical significance of obtained results were performed. All data were subjected to statistical analysis software (SPSS version 17, USA).

RESULTS

The highest seedling height (19.77 cm) was determined from commercial organic fertilizer application in the small-celled seed tray (OST1). Mean seedling stem diameter for traditional system (4.71 mm) was found to be higher than seedlings from floating system. For floating system, the non-transplanted seedlings had the highest diameter (4.07 mm) from commercial organic fertilizer application in the small-celled seed tray (OST1) and the lowest diameter was found to be 2.99 mm for blood application applied to the big-celled seed tray (BST2). The differences were statistically significant between the seedling height and stem diameter of the seedlings from control, MST1, MST2, BST1, BST2, OST1 and OST2 (Fig. 1).

The highest leaf dry weight (0.394 g) was obtained from blood application in the small-celled seed tray (BST1). BST1, MST2 and OST2 had the same effect on leaf dry weight. The lowest leaf dry weight (0.329 g) was from BST2. It was also found that the highest stem dry weight (0.162 g) for floating system seedlings was obtained from MST2 application (Fig. 2). This was followed by MST1 and BST1, respectively. There was significant difference between applications. Blood fertilizer affected the lowest stem dry weight value (0.086 g) in big-celled seed tray (BST2) (Fig. 2).

As seen in Fig. 2, for seedlings of floating system, the highest root dry weight (0.112 g) was determined from blood application for the small-celled seed tray (BST1). Commercial organic fertilizer applied to the small-celled seed tray (OST1) gave the lowest seedling root dry weight (0.068 g).

For the traditional system, the specific leaf area (SLA) was determined to be higher (319.06 cm^2g^{-1}) than for floating system seedlings. However, there was significant difference between traditional and floating system. For floating systems, the highest (307.61 cm^2g^{-1}) SLA was determined from commercial organic fertilizer application in the small-celled seed tray (OST1). The lowest SLA (113.21 g) was obtained from MST1 (Fig. 3).

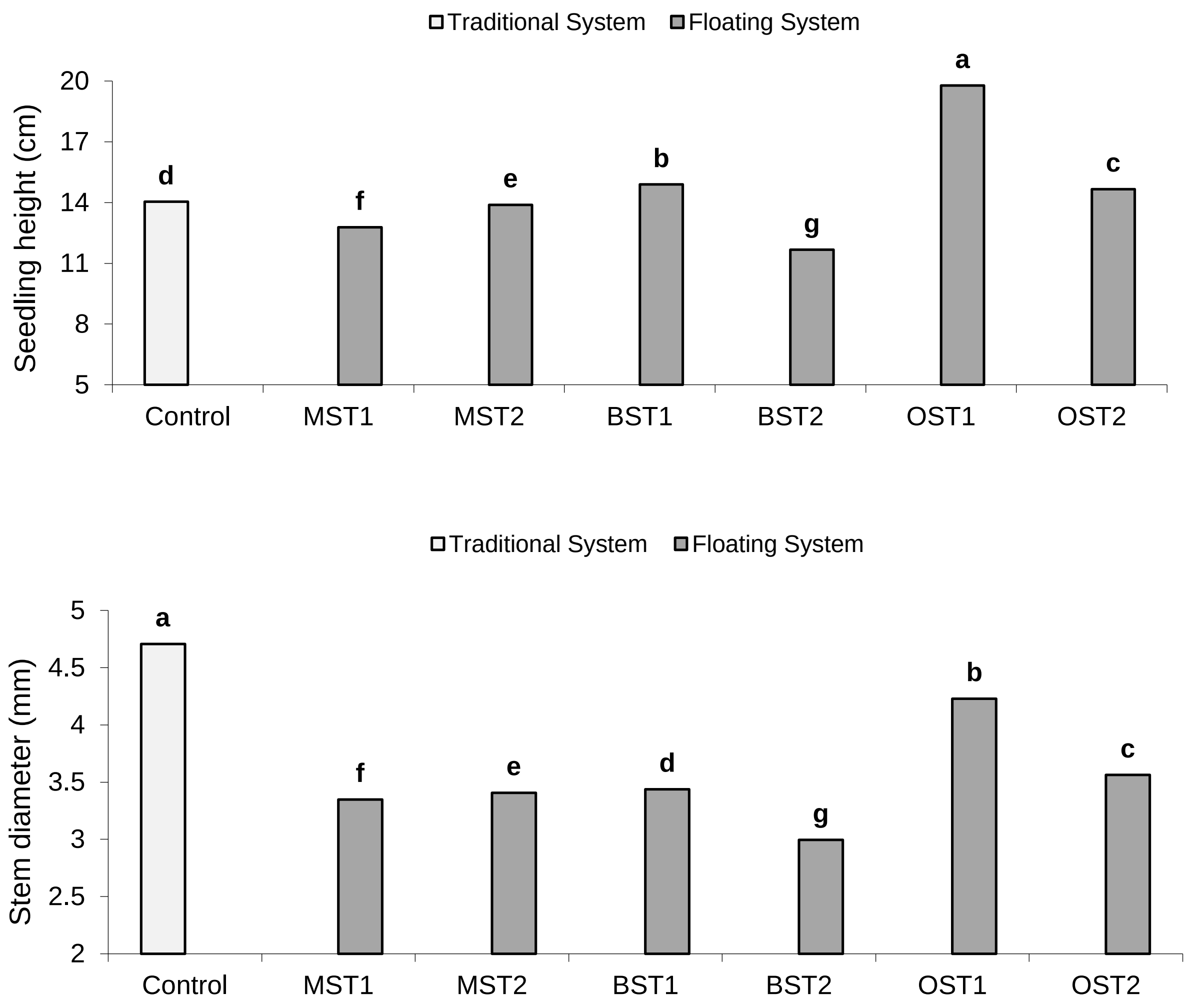

Fig. 1. The effects of different seedling production systems (traditional and floating), organic fertilizers and seed tray cell size on seedling height (cm) and stem diameter (mm). Different letters above the bars indicate significant differences according to Duncan's Multiple Range test at P < 0.01

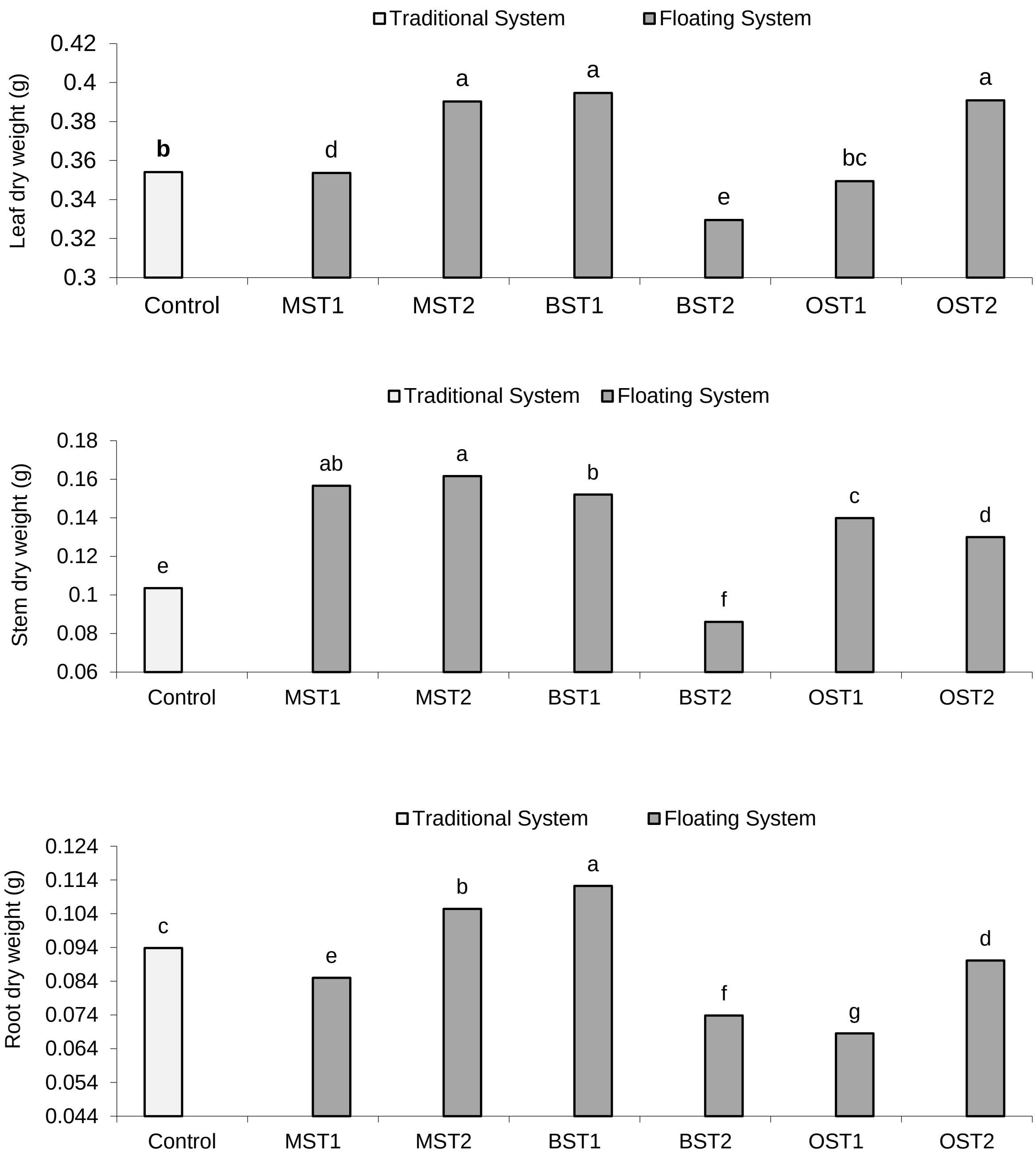

Fig. 2. The effects of different seedling production systems (traditional and floating), organic fertilizers and seed tray cell size on leaf dry weight (g), stem dry weight (g) and root dry weight (g). Different letters above the bars indicate significant differences according to Duncan's Multiple Range test at $P < 0.01$

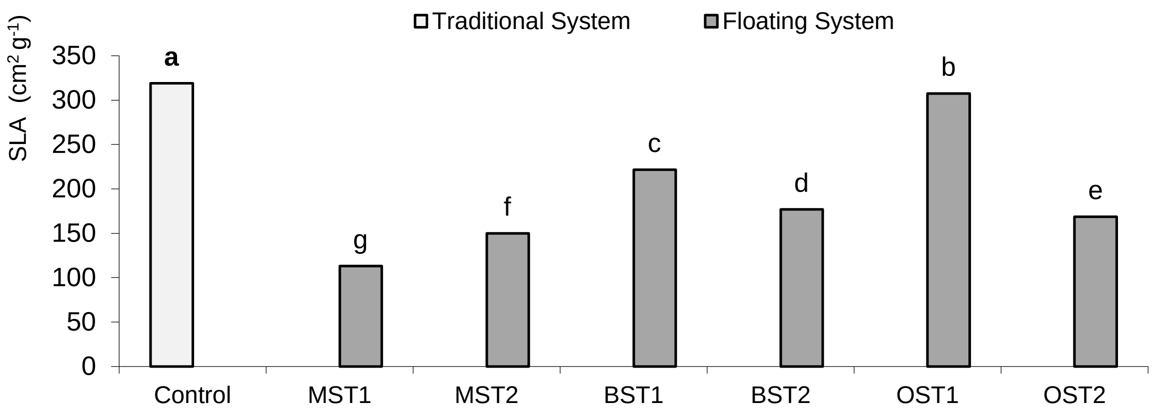

Fig. 3. The effects of different seedling production systems (traditional and floating), organic fertilizers and seed tray cell size on specific leaf area (SLA). Different letters above the bars indicate significant differences according to Duncan's Multiple Range test at $P < 0.01$

DISCUSSION

Numerous morphological attributes concerning seedling quality evaluation (seedling height, stem diameter, shoot dry weight, root dry weight, leaf dry weight, and shoot: root ratio and so on) are reported in the literature [McGilvary and Barnett 1982, Uzun 1996]. In general, stem diameter has been found to be a useful predictor of a field survival and growth [Kandemir et al. 2009]. Generally, the results are obtained from the plants with the highest yield, high stem diameter and specific optimum seedling height of plants [Özer and Kandemir 2016]. But, we know that quality seedlings are highly resistant to stress conditions. Resistance to stress conditions is also possible with the balance of root, stem and leaf dry weight. Stomata regulate the resistance of plants to stress [Taiz and Zeiger 2008]. Sarıbaş et al. [2018] reported that the stomata conductivity of seedlings having a high transplant dry weight was high. Although the maximum diameter of the stem (control and OST1) and the lowest leaf thickness of seedlings were obtained from the same applications (Fig. 3).

It is widely known that leaf chlorophyll content is an important parameter for testing the plant status. For example, chlorophyll content can be used as an indicator of the photosynthetic potential as well as plant productivity. In addition, leaf chlorophyll content increases with N levels, leaf color and leaf thickness. Higher accumulation of dry matter produced during photosynthesis for leaves and lower leaf surface area increase the leaf thickness [Taiz and Zeiger 2008].

High value of specific leaf area indicates higher leaf area, but the leaf thickness is lower. The photosynthetic activity of these type of leaves is considered to be low. In contrast, low specific leaf area shows that the leaf thickness is higher and those structures utilize photosynthetically active radiation much more than others and as a result, the amount of dry matter of these plants is expected to be high [Uzun 1997]. It is known that the increase in leaf thickness in high light and high temperature conditions is due to the increase in the amount of dry matter produced in photosynthesis due to the increase of stoma conductance in plant leaves under these conditions [Taiz and Zeiger 2008].

CONCLUSIONS

At the end of the study, it was determined that organic fertilizer applications in floating system had significant effects on seedling quality. The effect of seed tray cell size was also affected by the organic fertilizer applications. In all applications, BST1 and MST2 had higher seedling quality in floating system. We can say that these seedlings will probably have better growing potential and the yield of these plants is expected to be higher.

Floating system has got much more advantages than the traditional one; it eliminates disruptions caused by irrigation, and since seedling leaves are not in contact with water after germination, the disease problem is less experienced. As seedling roots are not limited with the cell, they grow better in the ventilated nutrient solution. This provides significant savings in time, labor, space and energy, because, seedlings in this system can be grown in a small area.

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