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TAILORED HI-GROW TABLETOP SYSTEM FOR ADVANCED STRAWBERRY CULTIVATION

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Abstract

There is a continuous interest in developing experimental technologies that can be further transferred to small producers or house fields with limited soil surface area. The aim of this study was to implement a hi-grow tabletop technology for strawberry in the USAMV of Bucharest experimental open field. This growing technology will allow experimentation with different fertilization treatments and strawberry cultivars as well as an evaluation of abiotic and biotic stress on plant growth. 'Albion' variety used as the day-neutral strawberry cultivar bore fruit from June to the end of October. In the first year the plants developed well, despite various stress factors (heat, pests, diseases). This study will continue with the implementation of a shading system to protect the plants from direct solar radiation, reduce the temperature, and prevent the sunburn of the fruits.

Key words*: Fragaria x ananassa Duch., growing technology, hi-grow tabletop system, 'Albion' cultivar.*

INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is a globally grown plant (Oğuz et al., 2022). It is even considered the most widely cultivated crop, covering almost all continents (Hanif & Budiyati, 2011; Oğuz et al., 2022).

Strawberries are appreciated for their biochemical composition, taste and flavour and they are some of the most popular summer fruits in European countries (Kahu et al., 2010). Strawberry production has a clear upward trend; according to data from the FAO in 2020, strawberry production reached almost 8.9 million tons and the world area harvested reached more than 380 thousand tons. According to UN Department of Economic and Social Affairs, Population Division (2022), the global population will reach 8 billion on 15 November 2022 and it is forecast to exceed 9.5 billion in 2050. Correlated with population growth, space and resources are becoming more and more limited, therefore the need to produce more strawberry crops at lower costs, by using new production techniques, is increasing (Bălan et al., 2015; Defterli et al., 2015; Lelieveld, 2015; Rusu et al., 2015; Schmidt et al., 2017; Vizitiu et al., 2017; Oğuz et al., 2022). Despite the population growth, labour force has become harder to find and more expensive, which leads to development of optimized plant cultivation technologies to ensure the highest productivity on the smallest possible area (Koufiotis et al., 2016; Asănică et al., 2017).

There are many technologies that can be used for strawberry cultivation, with the most used being classic raised-beds mulched using plastic or straws (Lille et al., 2003; Uselis et al., 2008), for both conventional and organic crops. Organically cultivated strawberries showed better fruit quality and improved stress tolerance compared to conventionally grown ones (Tõnutare et al., 2009; Reganold et al., 2010).

High tunnels are frequently encountered, being a standard for countries like Spain, the United

Kingdom, Mexico (Lantz et al., 2021). The high tunnel system is one of the choices of small farmers to practice season extension. It extended the strawberry fruit production by up to 5 weeks in USA, using increased temperatures in winter and early spring (Gu et al., 2017). The use of low tunnels cannot be disregarded and may have some advantages such as extending the harvest period (Lewers et al., 2017) with increasing fruit yield and attempts are being made to study their effect on early season production (Laugale et al., 2017; Fernandez et al., 2021).

Hydroponics, vertical farming, and horizontal systems are technologies that have many advantages, but the initial cost of investment is quite high. These modern technologies have been the subject of many studies (Hanif & Budiyati, 2011; Ramírez-Gómeza et al., 2012; Borrero, 2021; Oğuz et al., 2022).

Cultivar choice is the most important factor for conventional/organic strawberry production (Kahu et al., 2010). In Romania several popular local and foreign varieties are widely used in strawberry growing technology, such as: 'Coral', 'Premial', 'Real', 'Magic' 'Onebor', 'Clery', 'Alba' (originated from Italy), 'Benton', and 'Mira' (originated from Canada). Newer varieties, *e.g.*, 'Albion', 'San Andreas', and 'Benicia' (USA), have been taken into study (Tudor et al., 2014) in a plasticulture system considering the pedo-climatic conditions of Bucharest.

'Albion' is a day-neutral (everbearing) cultivar (Shi et al., 2021). It was released in 2006 by University of California and its parents are the cultivar 'Diamante' and the advanced selection Cal 94.16-1, varieties crossed in 1997 (Teklić et al., 2010).

Compared with short day cultivars, day-neutral strawberry varieties present better performance in areas with highland climate (Polat et al., 2016), because perpetual flowering genotypes are not affected by photoperiod and produce flowers and fruits regularly, allowing year-round harvesting in closed systems and from spring to late autumn in conventional systems (Hossain et al., 2019).

Given the multitude of technologies for strawberry growing systems, nutrition requirements will be determined according to variety necessities.

Strawberry plants require a high amount of nitrogen (N) in order to be able to sustain a good production. The total amounts of N, phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) accumulated by plants can gradually increase as growth stages progress.

However, due to environmental pressures related to excess fertilizer use, a more optimal fertilization strategy is required (Yoon et al., 2014). There are different types of fertilization techniques, including foliar fertilisation (Valentinuzzi et al., 2018), fertigation (Yoon et al., 2014) or classic fertilization using organic fertilizers, *e.g.*, compost, manure (Gaskell et al., 2009).

The aim of this study was to implement a tailored hi-grow tabletop technology for strawberry in the USAMV of Bucharest experimental open field. This growing technology will allow experimentation with different fertilization treatments and strawberry cultivars as well as an evaluation of abiotic and biotic stress on plant growth.

IMPLEMENTING THE GROWING TECHNOLOGY

The experimental field within the Faculty of Horticulture, USAMV of Bucharest - 44.4708° N and 26.0662° E (Asănică et al., 2017), was established in spring 2022, with a single cultivar ('Albion') in 2 rows. The stages of hi-grow tabletop technology for strawberries are presented below.

Tabletop strawberry growing system

Prior to the construction of the support for the tabletop system, the ground was leveled in order to have a uniform distribution of the pillar height (Figure 1).

The iron pillars supporting the tabletop system had a height of 2 m and a diameter of 50 mm. They were coated with zinc to provide them a better durability. The pillars were fixed in the ground at about 50 cm in order to support the consoles for the irrigation drains. The metallic consoles with a rectangular profile had 70 cm length and were coated with zinc. The irrigation drains were made of anti-corrosive sheet metal, painted white, with a thickness of 0.6 mm (Figure 1a). The planting distance was of 0.25 m between the 2 rows and 0.20 m between the plants in the same row. Each pot (48 cm × 18 cm × 16.3 cm) hosted 2 strawberry plants. The pots were made of UV-resistant treated plastic material to resist direct sunlight. They were fixed at a point in the irrigation drains so that they can resist high wind speed and other meteorological phenomena that may occur in the open field (Figure 1b). Each row had a length of 62 m and a total of 124 pots. Accordingly, 496 strawberry plants were cultivated in 2 rows. A distance of 2 cm was left between the pots and the irrigation drain to allow the irrigation water to flow easily from the pots.

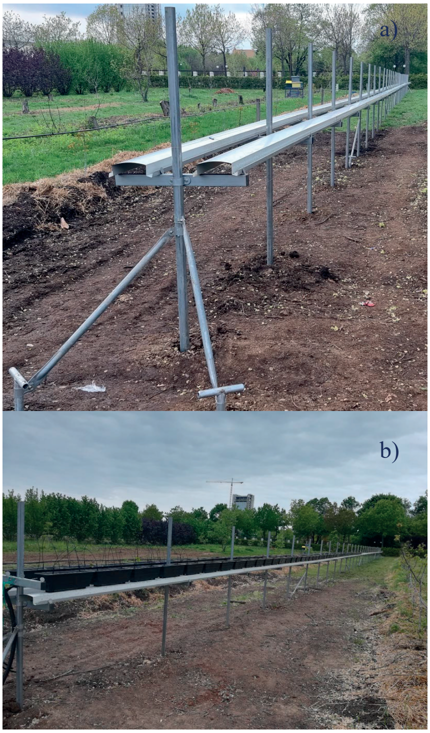

Figure 1. Tabletop growing system: a) structure for supporting the pots; b) pots placed on irrigation drains

Preparing the substrate for strawberry cultivation

A substrate based on sphagnum peat (OPM 540 W, Kekkilä-BVB, Finland) was selected for the strawberry cultivar. The sphagnum peat contained limestone in order to decrease the pH at a value of 5.9 and had a NPK concentration of 1 kg/m^3. The required volume of sphagnum peat substrate for all 248 pots was 1.98 m^3. Before filling the containers, the sphagnum peat was crushed by hand, so that it was as loose as possible to facilitate the spread of the roots throughout the substrate (Figure 2).

Figure 2. Filling pots with peat:
a) crushing the peat; b) pots with crushed peat

Selecting the seedling material

'Albion' variety is a typical day-neutral strawberry cultivar and produces fruit regardless of day length when treated appropriately (Shaw et al., 2006). Because of their small dimensions (15-40 cm), the strawberries could be grown successfully in pots, greenhouses or in large outdoors spaces (Tudor et al., 2014).

Preparing and planting the strawberry plants

Dormant cold-stored plants of the 'Albion' cultivar were obtained from a commercial nursery (SC Strawberry Plants SRL, Tămășeu, Bihor, Romania). Before planting, the plants were kept at 1°C in plastic bags, firmly closed at the top to prevent mold and premature development of the strawberry leaf rosette. The roots were shortened to a length of about 10 cm, spread by hand to support their development, and immersed in a mixture of water and peat to prepare them for planting (Figure 3). After preparing the plants, they were planted in the pots and irrigated throughout the day.

Figure 3. Preparing and planting the strawberry plants in the experimental field

Irrigation system installation

For strawberry, overhead and/or trickle (drip) irrigation systems are used in both conventional and organic growing technologies. A drip irrigation system (Figure 4) was used in this study. Drip irrigation involves dripping water onto the soil at very low flow rates (2-20 L/h) from a system of small diameter plastic pipes (emitters). The irrigation system consisted of a main pipe, branched into 2 pipe of 16 mm diameter each, and arrow drip emitters attached to each strawberry plant (as seen in Figure 4). The irrigation system was first set-up to fill the peat with enough water to plant the strawberry plants. After planting, the irrigation system was set to water 4 times a day to facilitate plants growth under optimal conditions.

Fertilization requirements

Strawberry plants were fertilized according to their requirements and development of phenophases. The general recommendation for N-P_2O_5-K_2O application rate is about 155-104-283 kg/ha for a high yield production (Haifa Group, 2022). Being an experimental field, different fertilization methods were applied considering the nitrogen requirements for optimal plant growth and development.

Diseases and pest control

To ensure a good protection of the strawberry field, it is usually necessary to perform several treatments to combat diseases and pests. According to Hoza (2000), 3 treatments should be applied, *i.e.*, one against foliar diseases and fruit rottenness, one against pests, and one against fungi. Depending on the type of cultivation chosen (organic or conventional), different substances and products can be selected and applied.

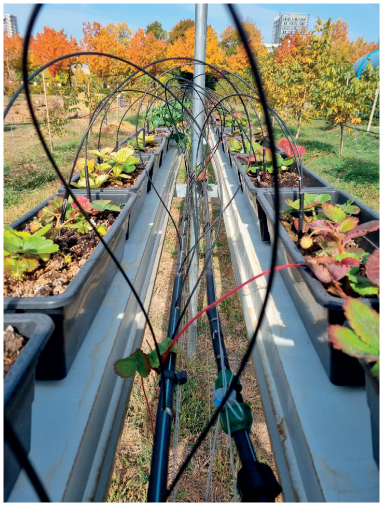

Figure 4. Drip irrigation system

FIRST YEAR PRELIMINARY RESULTS

After the first year of experiment, the tailored growing system successfully resisted the weather variations, proving its durability and the possibility of its use in future research.
The irrigation scheme (Figure 4) proved to be effective, providing the plants with the necessary water. Moreover, it reduced water loss, being environmentally friendly and also decreasing the costs.
'Albion' strawberry plants were successfully grown in pots (Figure 5), they developed vigorously and bore fruit throughout the experiment. The fruit production obtained using this growing technology was in accordance with the data specified by the producer of 'Albion' variety. Regarding the

percentage of plant rooting, in the first days after planting, 98.5% of the plants survived and started to develop. At the end of the season, 81.4% of the plants had grown and developed.
The plants began to bear fruit in June 2022 (2 months after planting), with a production peak in autumn (September 2022), but fruiting continued even at lower temperatures (November 2022). In this experimental climate, the main stress factors were the high temperatures during the summer (when the substrate temperature exceeded 30ºC) and direct solar radiation. The solutions to these problems can be the optimization of the amount of irrigation water (depending on plant phenological stages and climate conditions) and the implementation of a shading system (to protect the plants from direct solar radiation, reduce the temperature in the pot, and prevent the sunburn of the fruits). Another advantage of the system is the presence of pollinating insects, more insects being near the pots than at ground level.

Figure 5. Strawberry plants development and fructification (06.06.2022-27.06.2022)

For an ecological approach, different plant species (*e.g.*, asparagus, beans, peas, spinach, lettuce, garlic, onion, horseradish, rhubarb) can be sown under the raised beds, which can improve soil fertility by fixing nitrogen. Companion plants (flower strips, trap plants or cover crops) are sources of nectar for antagonists and living mulches. These plants can increase biodiversity and strawberry crop productivity by minimizing the development of pests in the field, attracting beneficial entomophagists, for example pollinators or predators. Even if the implementation of the growing system can be more expensive than that of the conventional systems, this technology can be very profitable due to the reduction of costs corresponding to water and fertilizer consumption, human resources, etc.

CONCLUSIONS

This study successfully implemented a tailored hi-grow tabletop technology for strawberry in the USAMV of Bucharest experimental open field. Based on the developed technology, the 'Albion' strawberry plants grew vigorously and bore fruit throughout the experiment. This growing technology will allow experimentation with different fertilization treatments and strawberry cultivars as well as an evaluation of abiotic and biotic stress on plant growth. Fertilizers obtained from marine residual materials, *i.e.*, residues of fish, rockweed (*Ascophyllum nodosum*), and organic blue mussels (*Mytilus edulis*), will be tested to grow strawberries. The technology can be easily adapted for other crops, *e.g.*, salad, spinach, aromatic plants. Future research will be conducted to improve the technology with a shading system, which will increase the efficiency and production.

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