RESULTS OF PRELIMINARY EXPERIMENTS CONDUCTED ON TOMATO GROWN IN SMALL-SCALE AIMING THE REUSE OF MINERAL WOOL

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Abstract. *The goal of our research is to determine how the incorporation of mineral wool originated from hydroponics impacts the yield and main industrial processing parameters of tomato. The experiment aims the examination of mineral wood used in the forcing of plants from the aspect of reusability. As far as we know, nobody has ever examined the possibility of mineral wool incorporation in Hungary. The research has been implemented within the framework of EFOP-3.6.1-16-2016-00016 and has been supported by NAIK ZÖKO (Vegetable Crop Research Department of National Agricultural Research and Innovation Centre). We consider this research as a preliminary experiment taking into account the small scale on whish it has been realised. The experiment was conducted in Kalocsa, using Unorosso F1 tomato variety grown on poor quality, slightly alkaline alluvial soil. Prior to planting mineral wool has been incorporated in the soil. Trickle irrigation has been applied in the involved parcels after themain flowering using 50% of the total water demand of the plants. They received nutrients necessary for their development according to the preliminarily implemented soil analysis. In the vegetation period 70% of the total nutrient requirements (nitrogen: 38 g/m^2; phosphorous: 8 g/m^2; potassium: 55 g/m^2) has been dispensed until the main flowering. The remaining amount has been provided during the fruit growing and ripening phase with the prevalence of potassium. Bands were created for the experiment with four repetitions. The trickle irrigation system was the reason for this pattern, since it was a less labour-intensive task to dispense the exact amount of water and nutrients. Water supply has been determined by tensiometers and the specific water demand. Water meters attached to the irrigation system measured the amount of water used. Beside the parcels with incorporated mineral wool other oneswere observed as control. In these parcels no mineral wool has been used, the irrigation was 0%, 50% or 100% of the water demand. Seedlings were planted later than usual. Harvest started in the beginning of September. We tried to simulate machine harvesting conditions. Berries were shaken off the cut plants and were sorted by colour: ripened, burgeoned, green and unhealthy ones were separated. Precipitation was extremely high in Kalocsa following the main flowering period.The amount of rain exceeds 30 mm in five occasions. Thus, water was not a limiting factor. No considerable differences were observed regarding the effects of the different treatments, although it can be stated that the mineral wool provided more balanced water supply for the plants. The colour-based classification of berries indicated that good water supply can increase the number of burgeoned and green products. When growing plants outdoor, the effects of the given vintage cannot be excluded. Since it remarkably influences our current and future results the continuation of this experiment is justified. Mineral wool used in this preliminary experiment has an impact on the structure and mineral content of soil, too. It is important to examine mineral wool as a horticultural by-product to reveal the consequences of its use regarding plants, soils and the creatures living in them.*

Keywords: *tomato, mineral wool, irrigation, yield*

INTRODUCTION

Global climate change challenges arable crop production in an increasing manner. Weather extremities become more and more frequent which rises the risks connected to production. The area of Danube-Tisza Interfluve is prone to aridity. Growing industrial-scale tomato without irrigation is turning to be uneconomic. Considerable share of the soils in these areas have reduced water retention capacity due to their structural characteristics. The use of mineral wool originated from hydroponics can be suitable for improving the water retention of soil. It also provides a method for reusing this material. Currently mineral wool applied in plant forcing is considered as waste in Hungary. Its excellent water holding capacity as well as nutrients and plant residues accumulated in it endow mineral wool with a soil-improving and yield-increasing effect in some poorer quality fields. After removing the forced plants considerable amount of organic matter and different micro- and macro-nutrients remain. In case the mineral wool containsneitherheavy metals nor other environmentally harmful substances, it can be utilised in agricultural production. We want to collect valid information so that we can set up an experiment regarding the use of hydroponic waste materials. The objective of our research is to determine how the incorporation of mineral wool originated from hydroponics impacts the yield and main industrial processing parameters of tomato. The experiment is conducted usingthe slightly alkaline and hard soil of Kalocsa. This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIE Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production, has been implemented in the Kalocsaestablishment of National Agricultural Research and Innovation Centre by Schmidtné Szantner Barbara Ildikó.

LITERATURE REVIEW

Both the production and consumption of tomato, either fresh or processed, show a constantly increasing trend worldwide. Based on FAO statistical data the total tomato production was 151.8 million tons considering the average of yields between 2008 and 2011. Out of this amount 21.5 million tons were produced in Europe, 30% of which was grown for industrial purposes. Average Hungarian production was 174,000 tons regarding the above-mentioned four years. It represents approximately 0.8% of the total European yield (FAOSTAT, 2015; HELYES 2015). New investments in processing industry prospect the increase of the amount of tomato produced in Hungary.Large amount of raw material with outstanding nutrient content is needed for domestic processingin order to create high quality tomato products. They can also be suitable for improving average quality concentrates (HELYES, 2015). In case of countries with relatively arid climate optimal for outdoor tomato growing average yield can be expected around 100 to 130 t/ha. According to Hungarian data the 100 t/ha production is achievable with the use of intensive field production technology and several highly productive tomato hybrids (HELYES, 2013.)

The Vegetable Crop Research Department (ZÖKO) of National Agricultural Research and Innovation Centre (NAIK) and its predecessors have been conducting successful researches related to the improvement and selection of tomatoes, including industrial varieties, for decades (ALGEIER, 2013). Depending on the production conditions, tomato berries are developed and ripened in 7 to 8 weeks following pollination (VARGA ET AL, 2005). Several factors influence dry matter content, such as variety, ripeness of the berry, nutrient and water supply of the plants (MAHAKUN ET AL, 1979) as well as other environmental parameters (HELYES ET AL. 2008b). Yield of a unit area is determined by the size and number of berries grown in a plant. It is inversely proportional with dry matter content (LAPUSHNER ET AL., 1990; HELYES ET AL., 2008A; PÉK ET AL., 2014).Brix°is used for indicating soluble dry matter content; its value usually variesbetween 4 and 6.5 and is influenced by numerous factors

(VARGA 1983; VARGA 1988; CSELŐTEI 1988, HELYES 1999).Large part of soluble dry matter content (Brix°) consists of reducing sugars: this value is between 50 and 70% according to DAVIS AND HOBSON (1981) AND HELYES (1999), WHILE HELYES ET AL. (2008b) set this value at 60 to 70%.

Development type, berry size andthe number of set fruits fundamentally determine the productivity of tomatoes, although the method of production and the technology applied play important roles, too (HO, 2003). According to the research of MACUA ET AL. (2003) the amount of irrigation water significantly influences the living conditions of plants. CAHN (2003) et al. claim that the more water a plant receives during the phase of crop formation, the lower the Brix° will be. The weather of last weeks before harvesting considerably influences harmonised ripening and dry matter content of industrial tomato varieties. Larger rains can remarkably deteriorate the Brix value. In some years the acceleration of ripening is unavoidable (HELYES ET AL, 2006) one way of which can be the ceasing of irrigation (HELYES ET AL, 2008a).Water withdrawal in the last 3 to 4 weeks before harvesting (cut-off method) has not provided unambiguous results in Hungarian experiments, thus water deficit irrigation might be the solution for ensuring adequate Brix value without suffering considerable yield loss (JOHNSTONE ET AL, 2005).

MATERIAL AND METHODS

The experiment has been conducted between May and September 2018. Grodanmineral wool originated from hydroponics was dispensed in outdoor parcels of industrial tomato varieties (altogether 58 m^2) and evenly incorporated into the upper layer (15 to 20 cm) of the soil by using a rotary cultivator.The used medium cam from 50 m^2 of hydroponics. The six-week-old tomato seedlings were planted outdoor later than usual, in the first week of June. Planting and row distance was 22 cmand 130 cm, respectively; as a result the density of the plantation was 3.5 plants/m^2. We planned a four-repetition banded experiment. Each parcel contained 51 plants in three rows (17 plants per row). A trickle irrigation system has been installed. Bands were separated by paths two metres wide. The space between two rows was covered by geotextile in order to prevent weed growth.Non-irrigated parcels as well as ones with 50% and 100% water supply were observed as control beside the parcels where mineral wool was incorporated in the soil and the level of irrigation was 50%.

The plant nutrition plan was elaborated by soil analysis. According to these calculations 38 g N, 8 g P and 55 g K active substance have been provided for each square meter. 25% of the required nutrients were dispensed and incorporated into the soil using an NPK fertiliser prior to the planting. Ferticare 15-30-15 starter fertiliser was used to promote root development at the time of planting. 70% of the total nutrients has been administered by the time of main flowering (i.e. mid-July).Ferticare 24-8-16, Ferticare 14-11-25, Calcinitand Krista K Plus were applied. The remaining 30% was mainly given by the form of Krista K Plus ésCalcinit fertilisers in the period from main flowering to harvesting. All parcels participating in the experiment received the same treatment (i.e. amount of water and nutrients).until main flowering.

The irrigation experiment has been conducted between 16 July and 27 August. Based on the guidelines of Helyes and Vargawater demand of the plants has been determined in mm as one-fifth of the daily mean temperature. As an addition to it a tensiometer was installed in the row of plants 25 cm deep in the soil. Data collection occurred between 16 July and 31

August on Mondays, Wednesdays and Fridays prior to the planned irrigation. The plants were given water onMondays, Wednesdays and Fridays. There were heavy rains in the Kalocsa area within this period that made the implementation of the experiment temporarily impossible for several days. High proportion (15%) of the plants were infected by Stolbur Phytoplasma in the beginning of August. As a result of this disease the total yield has been reduced.

Harvest started in 4 September. The three rows were scheduled for picking one week apart from each other. Plants were cut, all the berries shaken off and classified under four categories (red, burgeoned, green and unhealthy). Fruits were counted and weighted.A sample consisting of 10 berries were taken from each parcel. These samples were pressed by a juicer. We checked the Brix% (by a Hanna digital refractometer) and the colour (by a Hunterlabcolorimeter) of the crushed berries.

RESULTS AND DISCUSSION

Average yields were calculated from the four repetitions per treatment, while the average refractions were determined by the four repetitions per harvest date. As it can be seen in Figure 2 the most ripened berries came from the non-irrigated parcels. Proportion of green and burgeoned fruits increased as a result of improved water supply. The highest share of diseased berries was observed in non-irrigated parcels.

As regards of main qualities the highest yields and the biggest average weight of berries were received when water supply had beenthe best (see Table 1). Highest dry matter content came from non-irrigated parcels, while the best colour value was connected to parcels with mineral wool and 50% of water supply.

As it can be seen in Figure 1 the amount of water fluctuated the most in the non-irrigated parcels where considerable water deficit has been measured by the end of the vegetation period. As for parcels with 100% irrigation the amount of water was critically high in some cases. As a result of mineral wool incorporation data were less extreme, the line was flattened around a middle value. It can be observed that refraction averages are lower in parcels with sufficient water supply and higher in areas under water stress. In case of taking all average yields into consideration (Table 1) the tendency shows that the better water supply a parcel has, the more yield it will produce. As a conclusion it can be stated that there is a negative correlation between Brix° and the yield.

Table 1

Changes of main quality attributes of industrial tomato due to the different treatments

	total yield		average berry weight	average refraction	colour
	db/m^2	kg/m^2	g	Brix%	a/b
non-irrigated	191,98	9,57	55,64	4,32	2,65
50% irrigation	205,27	10,74	58,33	4,22	2,67
50% irrigation+ mineral wool	211,84	10,96	56,82	4,25	2,67
100% irrigation	229,58	12,60	61,36	4,17	2,61

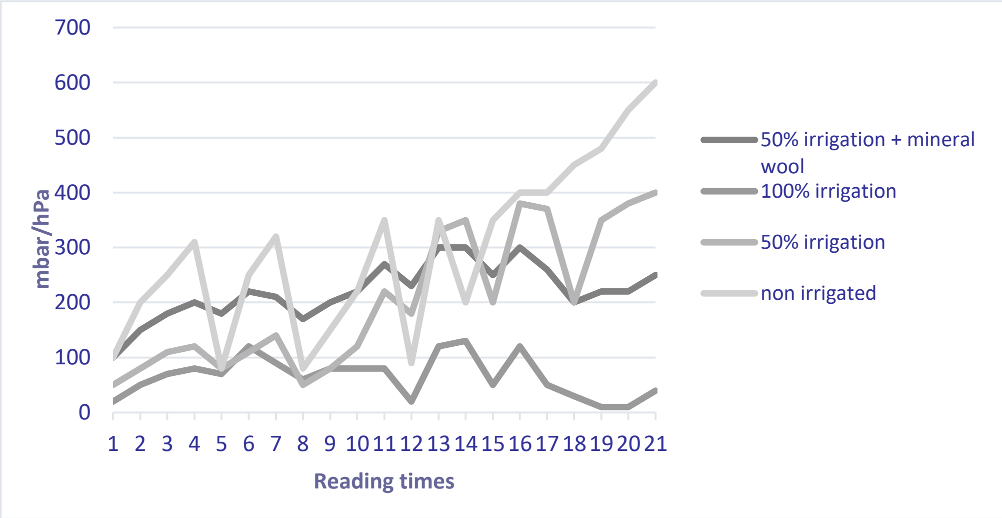

Figure 1: Read data of tensiometers

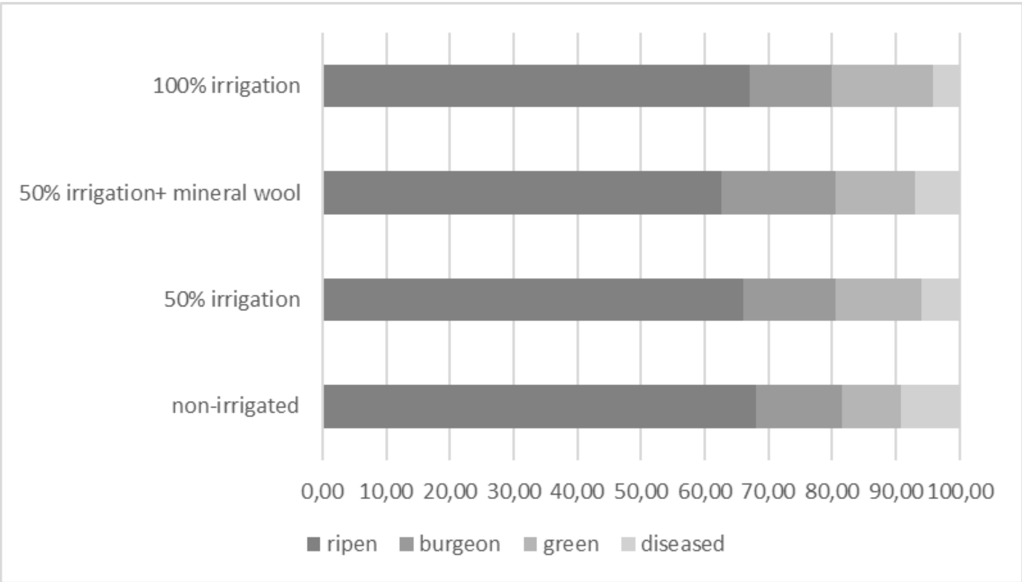

Figure 2: Share of fractions regarding harvested berries (%)

CONCLUSIONS

It can be concluded that in this year parcels treated with mineral wool produced approximately the same result as the untreated control areas. It shows us that water supply is a really important factor in growing industrial tomato. Due to the large amount of natural precipitation water has not become a limiting agent, thus the incorporation of mineral wool potentially influencing water supply have not resulted significant differences in the examined quality and quantity attributes. Lower Brix values can be the consequence of repeated and heavy rains (five times over 30 mm). According to the data recorded by the tensiometers it can be said that the application of mineral wool provided more balanced moisture content in the soil during the whole vegetation period.It has also been noted that the results of treatments were hectic depending on the amount of precipitation.

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