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TWO YEARS RESOULTS FOR WATER DEFICIT IRRIGATION IN PROCESSING TOMATO ON SANDY SOIL

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Abstract

Both the production and consumption of tomato, show a constantly increasing trend worldwide. The greatest growing areas in the World to raise Brix applied the water „cut off" method 3-4 weeks before harvest. In Hungary, we cannot successfully use this method. The target of our examination is to find out if the "deficit irrigation" method can be successfully applied on the sandy soil of Kecskemét. We have found differences in the measured parameters between non-irrigated and highly irrigated plots. The year effect on the open field is very high, which influenced our results.

Keywords

tomato, irrigation, brix, lycopene, potassium

Introduction

New investments in processing industry prospect the increase of the amount of tomato produced in Hungary. A large amount of raw material with outstanding nutrient content is needed for domestic processing in order to create high-quality tomato products. One of the biggest facilities processing industrial tomato is situated in Kecskemét. The area of Danube-Tisza Interfluve is prone to aridity, so growing industrial-scale tomato without irrigation is turning to be uncertain. The majority of soils around Kecskemét are sandy. A considerable share of the soils in these areas have reduced water retention capacity due to their structural characteristics.

The greatest growing areas in the World (e.g.: California, Italy) to raise Brix and other quality parameters without notable yield loss the water „cut off" method is generally applied 3-4 weeks before harvest. In Hungary, we cannot successfully apply the „cut off" method. In the majority of the seasons, during the main harvest period (10th August to 15th September) and 3-4 weeks before that, rains can disturb the ripening process. Hungary already has deficit irrigation researches in other soil types.

The goal of our research is to determine how yields and Brix values as the main industrial processing parameters, the colour and some HPLC crop nutrition data of industrial tomato alter as a result of water deficit irrigation and different levels of potassium replenishment. In our experiment conducted in sandy soil near Kecskemét we examined Unorosso F1 industrial tomato hybrid both in 2016 and 2017.

We have found in both years differences in the total amount of ripened fruits, in Brix %, and in the amount of lycopene and in the antioxidant capacity between non-irrigated and highly irrigated plots. Results of water deficit treatments for yield were proportionate between the extremes. The year effect on the open field is very high, which influenced our results now and in the future, so we need to continue our experiments.

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 179.7 million tons considering the average of yields between 2015 and 2017. Out of this amount 24.4 million tons were produced in Europe, average Hungarian production was 195,000 tons. It represents approximately 0.8% of the total European yield [1]. 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 [2]. 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 [3].

Depending on the production conditions, tomato berries are developed and ripened in 7 to 8 weeks following pollination [4]. Several factors influence dry matter content, such as variety, ripeness of the berry, nutrient and water supply of the plants [5] as well as other environmental parameters [5-6]. The 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 [5-7]. Brix° is used for indicating soluble dry matter content; its value usually varies between 4 and 6.5 and is influenced by numerous factors [8-11]. Large part of soluble dry matter content (Brix°) consists of reducing sugars: this value is between 50 and 70% [12-15].

Refraction constantly changes in the berries during the different phases of ripening [16-17]. The case of using harvesting machines the ripeness of the fruits is not completely homogeneous; thus, average Brix values are calculated by using representative samples. An industrial sampler or adequate sampling methods shall be used for this purpose [18]. The case of experiments conducted in small parcels changes in Brix can be identified by frequent sampling and a seasonal average can be set. Refraction values of samples are usually higher in August than in September [19]. The proportion of green and burgeoned fruits can increase as a result of improved water supply. This phenomenon reduces economic efficiency [20]. Producers demand the development of such cultivation practices and strategies by which high dry matter content can be ensured beside higher yields, too.

Development type, berry size and the number of set fruits fundamentally determine the productivity of tomatoes, although the method of production and the technology applied to play important roles, too [20]. According to other research [21] the amount of irrigation water significantly influences the living conditions of plants. Cahn (2003) et al. [21] 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 [22] one way of which can be the ceasing of irrigation [23]. 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 [23].

Material and methods

The plant stand representing the subject of the examinations was planted in Kecskemét, using the experimental field of the National Agricultural Research and Innovation Centre Vegetable Crop Research Department. The tomatoes were put in loose sandy soil (KA: 31) in 2016 and 2017. Following the soil analysis a nutrient supplementing plan has been elaborated by taking the specific nutrient demands of industrial tomato into account. The case of 80 t/ha yield the active substance requirements are as follows: 280 kg N; 120 kg P and 352 kg K.

Unorosso F1 variety has been used in the experiment. Seedlings were grown in heated greenhouse using KITE trays. During the five-week-long seedling production phase Ferticare (24-8-16) growing solution has been applied. The tomatoes were planted in 19 and 20 May in 2016. In 2017 the planting dates were 18 and 19 May. Complex granulated NPK fertiliser (15-15-15) and granulated poultry manure (Orgevit) was dispensed during the spring machine spading. Ferticare (15-30-15) starter fertiliser was used to promote root development at the time of planting.

Our experiment has 16 treatments (4 irrigation and 4 potassium level and their combinations), each in 4 repetitions, wich means 64 small parcels. Each parcel contained 51 plants. Planting and row distance was 22 cm and 130 cm, respectively. The space between two rows was covered by 120 cm wide geotextile in order to prevent weed growth. We used drip irrigation, therefore the experiment was 4 banded. A tensiometer was put into each band of the experiment to determine the time of irrigation with sufficient accuracy. Two-metre-wide spacings were left between the bands to avoid the mingling of the treatments and their effects.

The uniform water and nutrient supply was ceased five weeks prior to the planned date of the harvest. Tomatoes had adequate leaf area by then, flowering has been finished, and fruits were developed. The first berries were about to reach their final size. To this point was 70% of the full amount of potassium given to the planting area. After this turning point plants were irrigated using three different amounts (100%; 75% and 50%) of water, together with three levels (100%; 75% and 50%) of potassium. The fourth parcel was the non-irrigated control group. The amount of irrigation water has been determined based on the data received from the tensiometers and the specific water demand of the plants (one-fifth of the daily mean temperature in mm).

Harvest was carried out in three different dates starting in 23 August and 21 August in 2016 and 2017, respectively. Each 64 parcel (51 plant) stands from 3 rows (17 plant in a row). We harvested weakly one row from each parcels. Machine harvest was imitated: plants were cut, all the berries shaken off and classified under four categories (ripe, burgeoned, green and unhealthy/cull). Fruits were also counted and weighted. Red and orange, evenly coloured fruits fell into the ripe category. A berry was considered burgeoned if it contained orange and green patches in varying proportions. Uniformly coloured green tomatoes belonged to the green category. All those tomatoes were considered as unhealthy which showed the signs of bacterial or fungal infections, sun-damage or Ca spots.

A sample consisting of 20 ripened berries were taken from each parcel. These samples were pressed by a juicer. From the juice we checked the Brix value by a portable automatic refractometer (Hanna HI96801). We measured the colour from the raw juice in L.a.b system by a spectrophotometer (Hunter D25). We collected another 20 ripened berries samples to measure the lycopene and antioxidant capacity in the Food Science Research Institute (NAIK ÉKI).

Results

Average yields were calculated from the four repetitions per treatment, while the average refractions were determined by the four repetitions per harvest date. Considerable difference can be observed as regards of unhealthy berries between the two years. Temperature reached, in several times, 40 °C in 2017. In spite of frequent irrigation the number of berries with Ca spots increased, thus raising the share of cull fruits. Right before harvest large amount of rain fell repeatedly balancing the effects of the applied treatments. It can be concluded that the largest amount of ripened tomatoes were harvested from parcels affected by irrigation deficit in both years (see Figure 1). Proportion of green and burgeoned categories increased as a result of better water supply, while the share of unhealthy fruits remained unchanged under the different treatments.

Figure 1. Distribution of fruit categories in 2016 and 2017

In case of total yield remarkable differences were detected as a result of the treatments in 2016. Highest yield was reached in the category “100% water, 50% potassium”, while the lowest value was observed in the “50% water, 0% potassium” group. The harvested mass of tomato increased proportionally to the water supply. Differences among the results of the treatments became much less articulated in 2017. Largest yield was reached in case of “50% water, 75% potassium”, while the lowest amount was harvested in group “0% water, 0% potassium”. Although generally speaking better water supply meant higher yields, no linear correlation could be observed. Similar tendencies were identified for refraction, too. Parcels subjected to water stress showed higher Brix values compared to areas with good water supply in 2016. The highest and lowest numbers are detected at “50% water, 100% potassium” and “100% water, 50% potassium”, respectively. No such tendencies were justified in 2017: medium-supply parcels resulted lower Brix values, while the two extremities led to similar, higher refraction averages. “0% water, 100% potassium” resulted the highest Brix, while the lowest was measured at “75% water, 50% potassium” (see Figure 2).

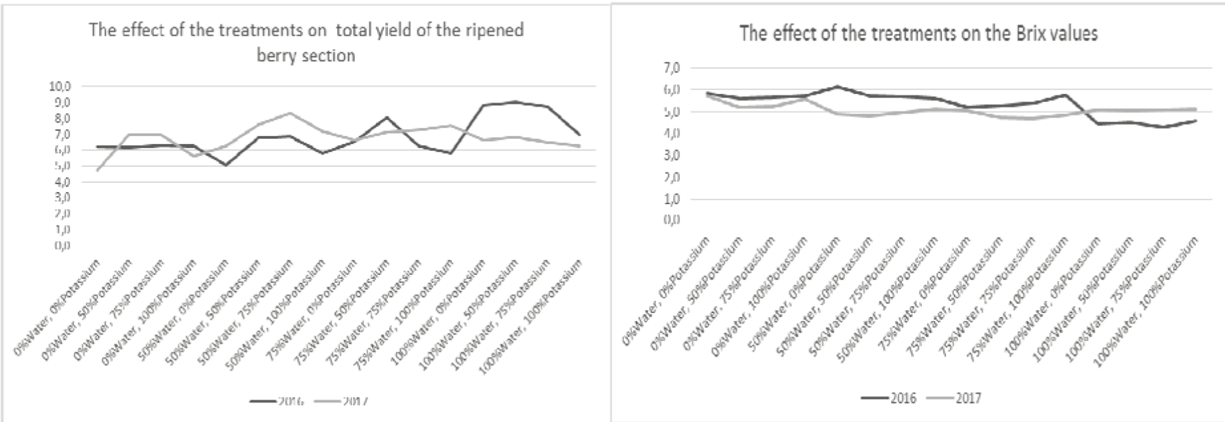

Figure 2. The effect of the treatments on the total yield of the ripened berries and on the brix values in 2016 and 2017

In case of the nutrients (lycopene and antioxidant capacity) remarkable differences were detected as a result of the treatments in 2016. We measured the highest lycopene quantity by the “50% Water, 100% Potassium” treatment and the lowest amount was by the “75% Water, 0% Potassium” treatment. We haven’t got any sample in 2016 from the “0% Water, 0%Potassium” treatment. We detected the highest antioxidant capacity by the “0%Water, 50%Potassium” treatment, and the lowest by the effect of the “75%Water, 0%Potassium” treatment. Differences among the results of the treatments became much less articulated in 2017. We realised from lycopene the highest value by the “0%Water, 50%Potassium” group, and the lowest by the ”75%Water, 50%Potassium” treatment. In the case of the antioxidant capacity we have found the highest amount by the treatment of “100% Water, 0%Potassium”, and the lowest by the “75%Water, 100%Potassium” group. (see Figure 3).

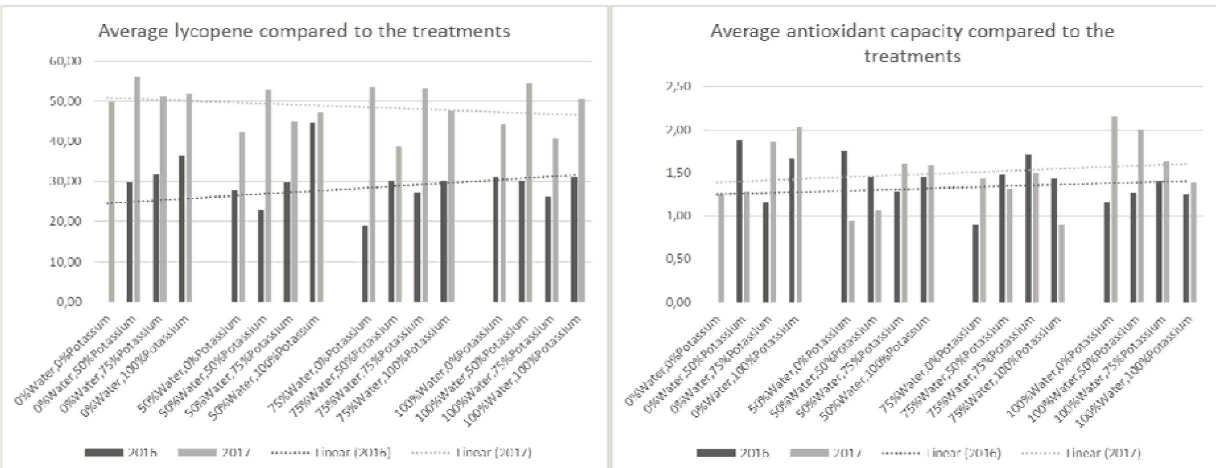

Figure 3: The average of lycopene and antioxidant capacity in 2016 and 2017 compared to the treatments

Conclusions

During the set-up of the experiments we aimed to reduce the annual fluctuation of yield and Brix value. Based on our results it can be said that the seasonal environmental effect influenced both the yields and Brix values more considerably than the applied treatments. It is important to highlight that optimal yields and dry matter contents were reached in water deficit treatments. Water supply levels induced larger differences in productivity and in the level of water-soluble dry matter content than potassium supply. 100% water supply – calculated by the specific water demand – resulted outstanding total yield, but the amount of marketable yield increased in a smaller extent. Harvested yields increased directly proportionally to water supply level. Higher Brix values were measured in parcels subjected to water stress than in ones with good water supply. In case of severe water stress the same correlation was observed in 2016 and 2017. However, at higher levels of water supply these borderlines mainly vanished in 2017. The impacts of different potassium levels are not unambiguous. In case of lycopene in 2016 it can be say that the most of the highest amounts were in water stressed parcels. The potassium top dressing has an influence of the amount of lycopene. In the amount of lycopene in 2017 and by the antioxidant capacity (in 2016 and 2017) the definite effect of the treatments was not detectable, however we have in both case significant differences. Based on our results it can be said that in case of industrial tomato the seasonal climatic effect influenced both the yields and Brix values more considerably than the applied treatments. As a conclusion it can be said that determining the optimal level of irrigation and potassium supply regarding yields and refraction can only be done for one year.

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