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The effect of drip irrigation on zucchini cultivar 'Soraya' yielding

Wpływ nawadniania kroplowego na plonowanie odmiany cukinii 'Soraya'

Summary. The effect of irrigation during different growth phases on yielding of zucchini 'Soraya' cultivar was evaluated in the research. During the conducted experiments different variants of plants irrigation were applied: irrigation during a whole cultivation period, irrigation during vegetative growth till setting fruitlets without irrigation during yielding, not irrigating during vegetative growth till phase of setting fruitlets and irrigating during yielding and not irrigating during cultivation (soil water coming only from natural rainfall). Drip irrigation was used with drip line with emitters efficiency of 4.0 $l \cdot h^{-1}$. The term of irrigation was estimated with the use of tensiometers, starting irrigation when the soil water potential was not lower than -40 kPa. Single doses of water were 3–4 mm, every 1–3 days, it was 25–55 irrigation doses depending of years. Different influence of irrigation was observed on the zucchini yielding. Irrigation during whole cultivation period and during intensive vegetative growth phase increased yield and number of fruits per plant. The biggest positive influence on yielding was obtained when plants were irrigated during a whole period, when shortage of falls were the biggest. Optimizing humidity conditions during intensive growth of zucchini, from planting seedlings into the field till the beginning of fruiting, it was possible to obtain the biggest yield of fruits as well as hasten and extend the harvest.

Key words: *Cucurbita pepo* L., drip irrigation, harvest, stage of growth

INTRODUCTION

A zucchini (*Cucurbita pepo* L.) is an annual plant of a big commercial importance. It is a high yield vegetable that provides a valuable raw material for processing industry.

A considerable development of zucchini cultivation in Poland has been observed in the last few years. Big popularity of zucchini cultivation results from big progress in it's

breeding, providing new big assortment of valuable cultivars and mainly thanks to describing a flowering biology of this plant [Mancini and Calabrese 1999]. The optimal period for female flowers development is in the conditions of a short day and low temperatures and optimal conditions of soil humidity [NeSmith *et al*. 1994]. Most cultivars react to increase of temperature to 30°C initiating male flowers [Suleiman and Suwwan 1990]. Flowers differentiation is usually finished before the plant forms two true leaves [Hume and Novell 1983].

In zucchini cultivation very significant inhibition of growth of plants at insufficient water supply has been observed [Dweikat and Kostewicz 1989]. Requirement and consumption of water during growth is different. Depending on the length of period of water shortage different reactions of plants can be observed. The first symptom is wilting resulting from turgor decrease what causes lowering intensity of photosynthesis. This phenomena often appears in summer when, due to high sunlight and hot wind gusts in the afternoon hours, transpiration is higher than water absorption [Khalil *et al.* 1996]. Zucchini has the biggest water requirements during setting and growing of fruits – the humidity of soil should not decrease below 80–85% of field water capacity [Kaniszewski 2005]. In experiments relating to irrigation of *Cucurbitaceae* plants the increase of yield and high effectiveness of both drip irrigation and micro-sprinkling were proven [Kaniszewski and Elkner 2002, Kaniszewski 2005]. The yield of zucchini increased on average by 85% due to irrigation, while for *Cucurbita maxima* L. it increased on average by 61% with drip irrigation and by 73% with micro-sprinkling [Rolbiecki and Rolbiecki 2005, Rolbiecki *et al.* 2005].

The aim of the work was the evaluation of irrigation effect applied in different phases of growth on zucchini cultivar ‘Soraya’ yielding.

MATERIAL AND METHODS

The research was undertaken in the years 2009–2011 as a strict field experiment on a zucchini plantation of the area of 1 ha in Mentów (Lublin region).

The field experiment was established in a randomized blocks arrangement in four replications with 20 plants per each replication. The spacing was 1.0 × 0.8 m, the area of each plot was 16 m^2. Different types of irrigation of zucchini plants of ‘Soraya’ cultivar were applied. Plants were cultivated in a following layout: object irrigated during a whole cultivation period, irrigated during vegetative growth till setting fruitlets and not irrigated during yielding, not irrigated during a whole vegetative period and irrigated during yielding from the phase of fruits setting and not irrigated during cultivation (shortage of water was supplemented only by precipitation).

The seedlings were planted into the ground in the second decade of May. In order to produce seedlings for 15^{th} of April the seeds were sown in the heated tunnel into the multi-pots filled with peat substrate (cubic content of single pot was 90 cm^3).

In the cultivation there was a drip irrigation used with drip line with efficiency with emitters of 4.0 $l \cdot h^{-1}$. The date of irrigation was established with the use of tensiometer, irrigation was started when the soil water potential was not lower than -40 kPa. Single doses of water were 3–4 mm, every 1–3 days, it was 25–55 irrigation doses depending of years.

Plants were cultivated on a loess soil (good wheat complex). On the basis of results the contents of macro nutrients were supplemented to the level of: 120 mg N · dm^{-3} ($N\text{-}NO_3$), 32 mg P · dm^{-3}, 140 mg K · dm^{-3}, 50 mg Mg · dm^{-3}. Doses of mineral fertilization were used before planting seedlings into the field with the use of triple superphosphate, potassium sulphate, ammonium saltpeter and magnesite. During vegetation plants were fertilized twice with lime saltpeter in fourth and eighth week after planting of seedlings.

Harvests of fruits were done successively as they grown. It was assumed that fruits 15–20 cm long constitute yield. Dates of first and last harvests were noted and the yield and number of fruits per plant were estimated.

Statistical analysis of obtained results was done with the use of non-parametric Kruskal-Wallis test ($p < 0.05$) with the use of SAS software (version 9.1).

RESULTS AND DISCUSSION

The effect of zucchini plants irrigation during different growth phases on yield and number of fruits per plant is shown in Table 1 and 2. Significantly higher mean yield of fruits was obtained when plants were irrigated during a whole cultivation (mean 42.6 t · · ha^{-1}) and irrigated till setting fruits on plants (mean 42.2 t · ha^{-1}). Significantly smaller yield was obtained from plants not irrigated (26.4 t · ha^{-1}) and when irrigation was preceded by drought stress (35.1 t · ha^{-1}). In the climate of Poland definitely higher yield of zucchini was obtained when growth conditions were improved with moulding of soil and flat covering of plants [Kołota and Adamczewska-Sowińska 2011].

Table 1. The effect of irrigation on yield of zucchini fruits
Tabela 1. Wpływ nawadniania roślin na plon owoców cukinii

Treatments Zabiegi	Yield (t · ha^{-1}) Plon (t · ha^{-1})			
	2009	2010	2011	Mean Średnia
Irrigated Nawadniane	45.5 ±4.5[a]*	36.9 ±3.3[b]	48.5 ±5.4[a]	42.6a
Irrigated and non irrigated Nawadniane i nienawadniane	38.9 ±3.1[b]	46.8 ±5.2[a]	41.0 ±2.6[b]	42.2a
Non irrigated and irrigated Nienawadniane i nawadniane	33.4 ±2.8[b]	36.4 ±2.8[b]	35.5 ±2.9[c]	35.1b
Non irrigated Nienawadniane	24.7 ±3.3[b]	27.0 ±2.1[c]	27.5 ±2.1[d]	26.4c

*mean values with standard deviations/wartości średnie z odchyleniami standardowymi
[a, b, c, d]statistically homogenous groups at $p \leq 0.05$/grupy jednorodne statystycznie przy $p \leq 0,05$

Depending on the length of water shortage in the years of cultivation different reactions of plants were observed. During intensive vegetative growth of zucchini in the year 2010 temperatures were much higher than many years mean (especially in June – by 1.8°C, July – by 3.8°C and August – by 3.1°C), while the sum of rainfalls in June and

July was similar to the many years one (Fig. 1). The option with the optimal amount of water during vegetative growth of plants, till phase of setting fruits, provided higher yield in comparison to irrigating during a whole cultivation season. Abundant falls exceeding by 64.2 mm monthly mean occurred in August, that is why the yield amount of fruits were similar both in option with optimal soil humidity and with drought stress at the beginning of cultivation. In earlier works of Wien *et al.* [2004] it was observed that if the shortage of water in plant is not supplemented the turgor decreases. When the water shortage lasts longer the reactions occur in plants which cause decrease of osmotic potential of root cells leading to reduction of water potential of these cells enabling water assimilation.

Table 2. The effect of irrigation on number of zucchini fruits
Tabela 2. Wpływ nawadniania roślin na liczbę owoców cukinii

Treatments Zabiegi	Number of fruits per plant Liczba owoców (szt.·rośl.$^{-1}$)			
	2009	2010	2011	Mean Średnia
Irrigated Nawadniane	26.6 ±1.2^{a}*	26.7 ±1.3^{a}	27.2 ±1.3^{a}	26.8a
Irrigated and non irrigated Nawadniane i nienawadniane	20.6 ±1.1^{b}	22.4 ±1.1^{b}	22.6 ±1.2^{b}	21.8a
Non irrigated and irrigated Nienawadniane i nawadniane	19.5 ±1.1^{b}	13.6 ±1.0^{d}	13.6 ±1.0^{d}	15.5b
Non irrigated Nienawadniane	20.1 ±1.2^{b}	15.2 ±1.1^{c}	18.6 ±1.1^{c}	17.9b

*mean values with standard deviations/wartości średnie z odchyleniami standardowymi
$^{a, b, c, d}$statistically homogenous groups at $p \leq 0.05$/grupy jednorodne statystycznie przy $p \leq 0,05$

In the years 2009 and 2011 higher yield of fruits was ensured with optimal plants irrigation during a whole zucchini cultivation period. Yield of zucchini fruits from irrigated plants were higher in comparison to other cultivation variants: irrigated and not irrigated by 7.5 in the year 2011 and 6.6 t · ha^{-1} in the year 2009; not irrigated and irrigated by 13.0 (2011) and 12.1 t · ha^{-1} (2009); not irrigated by 21.5 (2011) and 20.8 t · ha^{-1} (2009). It results probably from the fact that in the years 2009 and 2011 during vegetative growth of plants the sum of rainfalls noted from May to June was similar to the average one. When the shortage of water was noted the effect of irrigation was higher. According to Loy [2004] in the conditions of small precipitation and low temperatures zucchini plants do not develop well and the yield obtained is smaller and of lower quality.
Differentiated humidity conditions in the years of research had influence on the number of fruits formed on plants (Tab. 2). In the years 2009–2011, of high air temperature, plants irrigated in the early period of cultivation formed more fruits than not irrigated ones. Both in the year 2010 and 2011 less fruits (mean 13.6 per plant) formed plants which were irrigated only in the vegetative growth phase. Plants which were not irrigated during a whole cultivation formed in the year 2009 on average 20.1 fruits per plant, in the year 2010 on average 15.2 fruits per plant and in the year 2011 it was 18.6 fruits per plant.

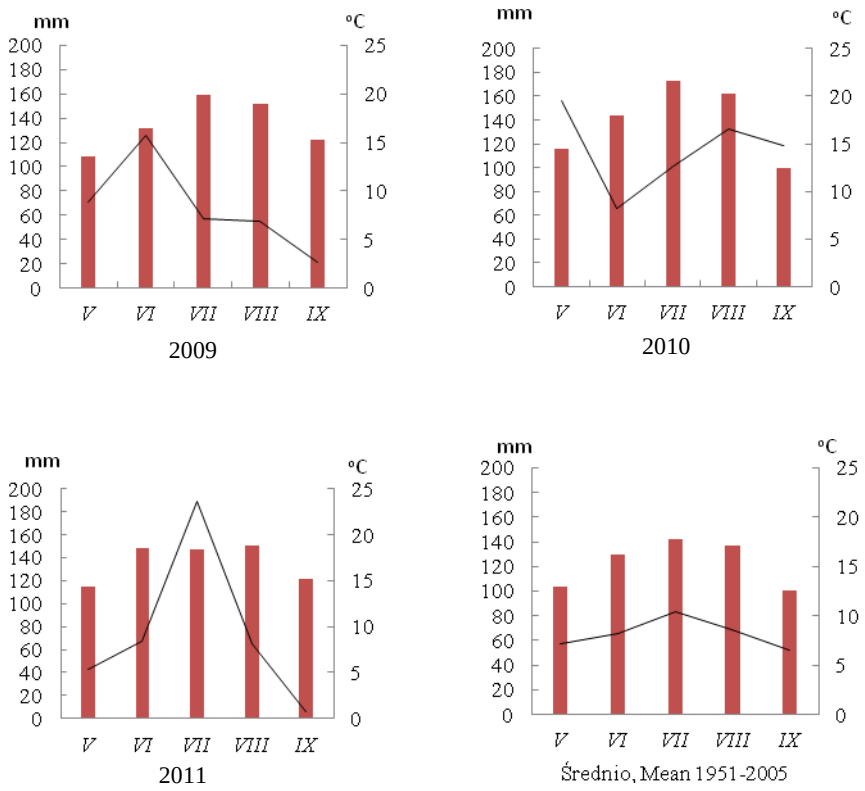

Fig 1. The total decade and monthly rainfall and average air temperature during research, according to Felin Meteorological Station University of Life Science in Lublin
Rys. 1. Dekadowe i miesięczne sumy opadów oraz średnie wartości temperatury powietrza w okresie badań wg danych Stacji Meteorologicznej Felin Uniwersytetu Przyrodniczego w Lublinie

There is an opinion, that in case of *Cucurbitaceae* lower soil humidity in the period from settling of seedlings till the beginning of fruits setting favours growth of roots and inhibits too lush growth of shoots what positively influences yielding [Loy 2004].

The course of harvest of zucchini fruits in particular years of research depending on irrigation of plants variants used is shown on Figure 2. In case of plants that were cultivated in the optimal humidity conditions (irrigated) in the years 2009 and 2011 the first harvest of fruits started after 74 days from planting seedlings into the field and lasted till the 15th of September in the year 2010 and 5 days shorter in the years 2009 and 2011. The harvest of fruits was spread in time because in the year 2010 the harvests of fruits were conducted 23 times and in the years 2009 and 2011–20 times. The highest yield was obtained on the 4th of August in the year 2010 (after 84 days from the date of planting seedlings) and on the 18th of August in the years 2009 and 2011 (102 days after planting seedlings).

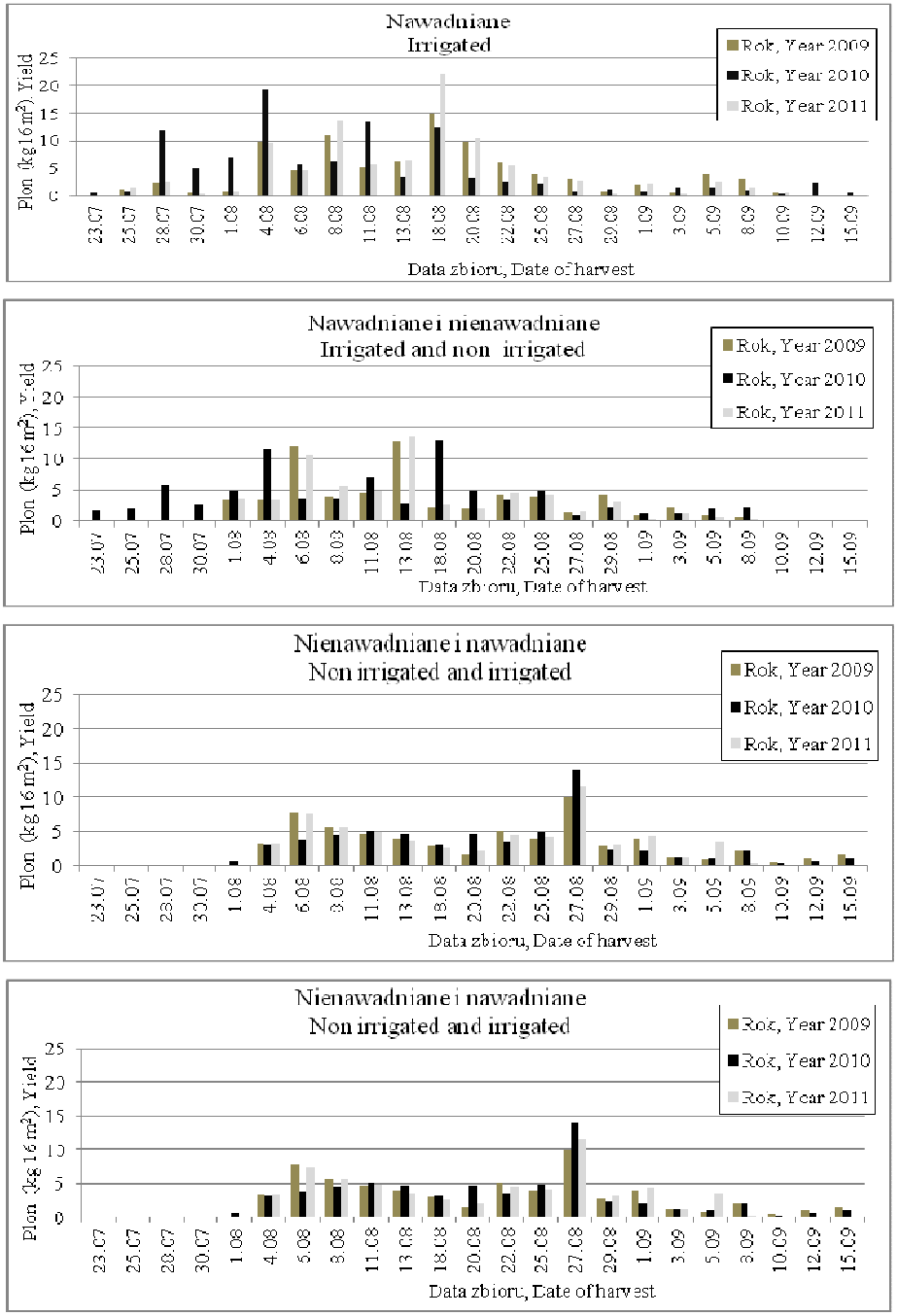

Fig. 2. The course of zucchini fruits harvest depending on the plants irrigation method
Rys. 2. Przebieg zbioru owoców cukinii w zależności od sposobu nawadniania roślin

Harvest of fruits from plants irrigated in the vegetative growth phase and not irrigated during yielding started after 73 days in the year 2010 and after 81 days after planting seedlings into the field in the years 2009 and 2011. In this variant of cultivation the most fruits were harvested from plants in the first and second decade of August.

In case of plants irrigated during yielding, which proceeded period of drought stress, as well as plants not irrigated, harvest of fruits started later, after 84 days from the date of planting seedlings into the ground. In both variants of cultivation plants characterised with shorter yielding period, as there were 19 harvests done in the year 2010 and 15 in the years 2009 and 2011. The highest yield of fruits was obtained on the 27th of August (111 days after planting seedlings) in the variant without irrigation during vegetative growth and with irrigation during yielding and on the 18th of August (102 days after planting seedlings into the field) for plants cultivated without irrigation during a whole cultivation period.

Differences in course of yielding of zucchini plants between years could result from different soil humidity levels. On the basis of our observations it can be stated that, regardless of different weather condition in the years, zucchini plants which were cultivated in optimal conditions of soil humidity (irrigated during vegetative growth phase) started yielding 7–10 days earlier in comparison to plants not irrigated during that period. Intensive vegetative growth of plants irrigated from the beginning of cultivation extended harvesting period and increased the frequency of harvests. In the option without irrigation till the moment of fruiting worse branching, later fruits setting, shorter period of yielding and yielding spread in time were observed.

CONCLUSIONS

Effectiveness of irrigation depended on the growth phase of plant. Plants used irrigation doses more effectively in the period from planting seedlings into field till appearing first fruitlets.

In the conditions of undertaken research there were observed bigger differentiation of morphological features and smaller one in developmental phases of zucchini plants.

System of drip irrigation used in the whole period of zucchini cultivation favoured earlier yielding and extending time of harvest.

Use of irrigation in a whole zucchini cultivation period and during vegetative growth of plants increased yield and number of fruits per plant.

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Streszczenie. W pracy oceniono wpływ nawadniania kroplowego w różnym okresie wzrostu roślin na plonowanie cukinii odmiany ‘Soraya’. W doświadczeniu zastosowano różne warianty nawadniania roślin: nawadnianie w całym okresie uprawy oraz w okresie wzrostu wegetatywnego do wykształcania zawiązków owoców i nienawadniane w okresie plonowania, oraz w okresie wzrostu wegetatywnego do fazy wykształcania przez rośliny zawiązków owoców i nawadnianie w okresie plonowania oraz nienawadnianie w okresie uprawy (woda w glebie pochodziła tylko z opadu naturalnego). W uprawie zastosowano nawadnianie kroplowe linią kroplującą o wydajności emiterów 4,0 $l \cdot h^{-1}$. Termin nawadniania ustalano za pomocą tensjometrów, rozpoczynając nawanianie przy potencjale wodnym gleby nie niższym niż -40 kPa. Jednorazowe dawki wody wynosiły 3–4 mm co 1–3 dni, w zależności od lat liczba dawek polewowych wynosiła 25–55. Stwierdzono różnorodny wpływ nawadniania roślin na plonowanie cukinii. Nawadnianie prowadzone w całym okresie uprawy oraz nawadnianie w fazie intensywnego wzrostu wegetatywnego spowodowało wzrost plonu i liczby owoców z rośliny. Największy efekt plonotwórczy uzyskano w przypadku nawadniania roślin w okresie, w którym niedobory opadów były największe. Optymalizując warunki wilgotnościowe w okresie intensywnego wzrostu cukinii, od posadzenia rozsady na polu do początku owocowania, uzyskano większy plon owoców, przyspieszono i jednocześnie wydłużono okres przeprowadzanych zbiorów.

Słowa kluczowe: cukinia, nawadnianie kroplowe, plon, etap wzrostu