Strawberry drip-irrigation in plastic tunnel – effects of irrigation frequency on water use, yield and fruit quality

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ABSTRACT

In 2013 a field experiment was carried out to figure out the effects of three different irrigation frequencies (twice a week, daily, several times a day) with manual or automatic irrigation systems on yield and fruit quality (fruit size, acidity, sugar, firmness) of strawberries cv. 'Clery' (*Fragaria x ananassa Duch*), as well as on water use. The results showed that with frequent irrigation the amount of water could be reduced by 35 % compared to the treatment 'irrigation twice a week' without influencing yield and fruit quality. Consequences of the three irrigation treatment on the water content at different soil layers, as well as on economic outcomes are discussed.

1 Introduction

In Switzerland, large majority of the 420 ha of strawberry crops are cultivated on plastic covered raised beds and equipped with drip irrigation. The irrigation systems are based on the monitoring of the soil moisture. Monitoring is based on the visual readings of tensiometers and combined with a manually operated irrigation system. The use of fully automatic irrigation systems with a high frequency of irrigations might help to reduce the amount of water used for irrigation and also the production costs.

The aim of this project was to evaluate the effects irrigation frequency (twice a week, daily, several times a day) with manual or automatic irrigation systems on strawberry yield, fruit quality and water use. Economic aspects of the different treatments were also estimated.

2 Material and Methods

A trial comparing three irrigation systems was conducted during 2013 at Agroscope ACW in Valais, located in the southern part of Switzerland. The strawberry variety `Clery´ was cultivated in plastic covered raised beds equipped with drip irrigation (TTape). At the end of July 2012, fresh plants were planted at a distance of 20 cm rows and 1.30 m between the rows, on sandy loam. There were 3 treatments (table 1), 6 replications per treatment and 11 strawberry plants per plot.

All three treatments combine the limit value of 20 kPa for irrigation according to the results of Krüger *et al.* (1999). This threshold value is measured in a depth of 25 cm, an area where most of the strawberry rots are located (Dierend et al. 2012). The difference between three treatments is the frequency of irrigation according the soil moisture levels and the amount of water per irrigation. The reference measurements for each irrigation treatment was taken from one replication. The irrigation of the remaining 5 replications were also based on this measurement. The fertigation was adapted in a way that all systems got the same amount of fertilizer per week.

The soil moisture levels during the irrigation time was measured separately with Watermark sensors which were connected to a data logger (WatchDog). Every hour the soil moisture was measured and saved.

Statistical differences were evaluated with a two factor analysis of variance and Tukey-Test (0,05).

Table 1: Control frequency of soil moisture, threshold value for irrigation (measured at 25 cm soil depth) and amount of water per irrigation of the three irrigation treatments.

Irrigation treatments	Control of soil moisture for irrigation		Amount of water per irrigation		
	Frequency	Threshold Value	till blossom	till fruit development	till harvest
Twice a week	2 times per week	20 kPa	3.00 l/m²	5.00 l/m²	4.00 l/m²
Daily	daily	20 kPa	1.25 l/m²	2.00 l/m²	1.60 l/m²
Several times a day	4 times per day (9am/11am/1pm/3pm)	20 kPa	0.75 l/m^2	0.75 l/m^2	0.75 l/m^2

The irrigation treatments 'twice a week' and 'daily' were based upon controlling the tensiometers twice a week, respectively daily. If the limit value of 20 kPa (median of 3 tensiometers) was reached, irrigation was activated manually. The water amount per irrigation is shown in table 1. The irrigation treatment 'several times a day' was managed with the automatic Watermark system. This automatic irrigation system was based on measurements taken from Watermark sensors (3 sensors). The sensors measured four times a day (9 am/ 11am/ 1pm/ 3pm) the soil moisture. If the limit value of 20 kPa was reached, irrigation started automatically. The amount of water per irrigation was 0,75 l/m².

3 Results and discussion

3.1 Water use

The total amount of water used was indicated in the table 2. The treatment with 'several irrigations per day' and with 'daily irrigation' showed a very similar levels of water consumption. Treatment with irrigations twice a week had a 0.6 l/m^{-2} higher water consumption than the two other systems.

Table 2: Average daily water use and number of irrigations for the three irrigation treatments.

Irrigation treatments	Total water per day per square meter [l]	Number of days with irrigations from 18 April to 21 June.	Number of irrigations from 18 April to 21 June
Twice a week	1.49	20	20
Daily	0.94	35	35
Several times a day	0.95	31	81

3.2 *Yield and fruit quality*

Different water levels for each system has statistically no influence on the yield (table 3). There was also no difference in fruit size of the 1st class fruits. The same results were observed for fruit quality. Fruit quality based on sugar, acidity and firmness showed that there is no statistical difference between the three treatments (table 4). The results show that there is no influence on yield and fruit quality between each irrigation system. Small amounts of water with frequent applications can result in good yields.

Table 3: Effects of the 3 irrigation treatments on yield, 1st class fruit yield and fruits weight. Beginning of harvest 17 May and end of harvest 21 June 2013.

Irrigation treatments	Total yield per plant [g]	1st class yield per plant [g]	Weight per fruit [g]
Twice a week	845,7	793,2	19,3
Daily	924,0	863,9	18,1
Several times a day	898,3	832,4	18,8

Table 4: Effects of the 3 irrigation treatments on fruit quality based on acidity, sugar and firmness

Irrigation treatments	Acidity [g citric acid/kg fruit juice]	Sugar [°Brix]	Firmness [g/cm²]
Twice a week	8,1	9,8	66,9
Daily	8,4	9,7	68,1
Several times a day	8,7	9,9	66,6

3.3 *Soil water levels*

The soil moisture levels in the irrigation treatment 'two times a week' showed that a continuous change of soil moisture (25 cm depth) between 0 and 20 kPa, even at a depth of 35 cm happened (Figure 1). This suggests that water percolation to lower soil depth occurred.

The curve in Figure 2 shows a similar development as Fig. 1 until mid May. From mid May, the soil moisture level could not be influenced by more than 15 kPa because of the rising temperatures. This is also reflected at the soil depth of 35 cm. There seemed to be less loss of water. The water was consumed in the top 25 cm.

Figure 3 (irrigation several times a day, Watermark) shows a continuous change in soil moisture (25 cm) between 0 and 15/20 kPa. But on 35 cm depth, the soil moisture decreased from the spring to the end of the harvest induced by a higher irrigation frequency (max. 4 times a day) and lower amounts of water per irrigation.

The soil water levels show that the Watermark system with a high irrigation frequency and with a low amount of water per application, showed less loss of water to deeper layers by percolation.

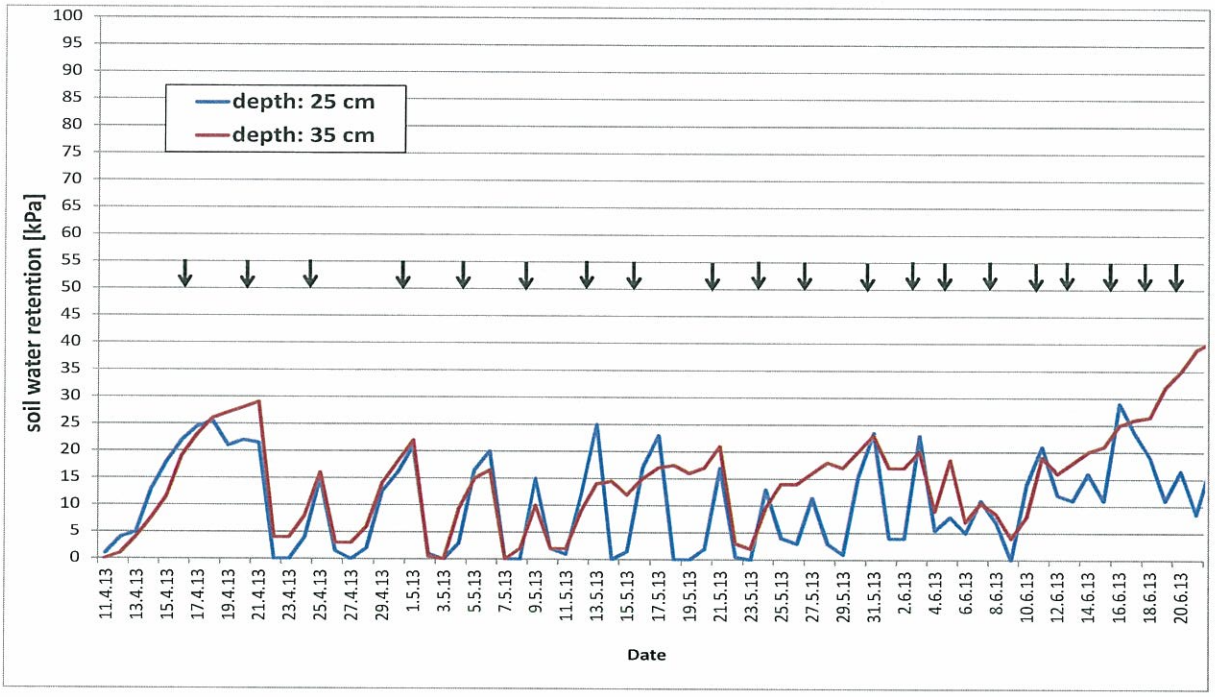

Fig. 1: Soil moisture levels in the irrigation treatment 'two times a week', measured with Watermarks (median of 3 Watermark sensors). Arrows indicate days with irrigation.

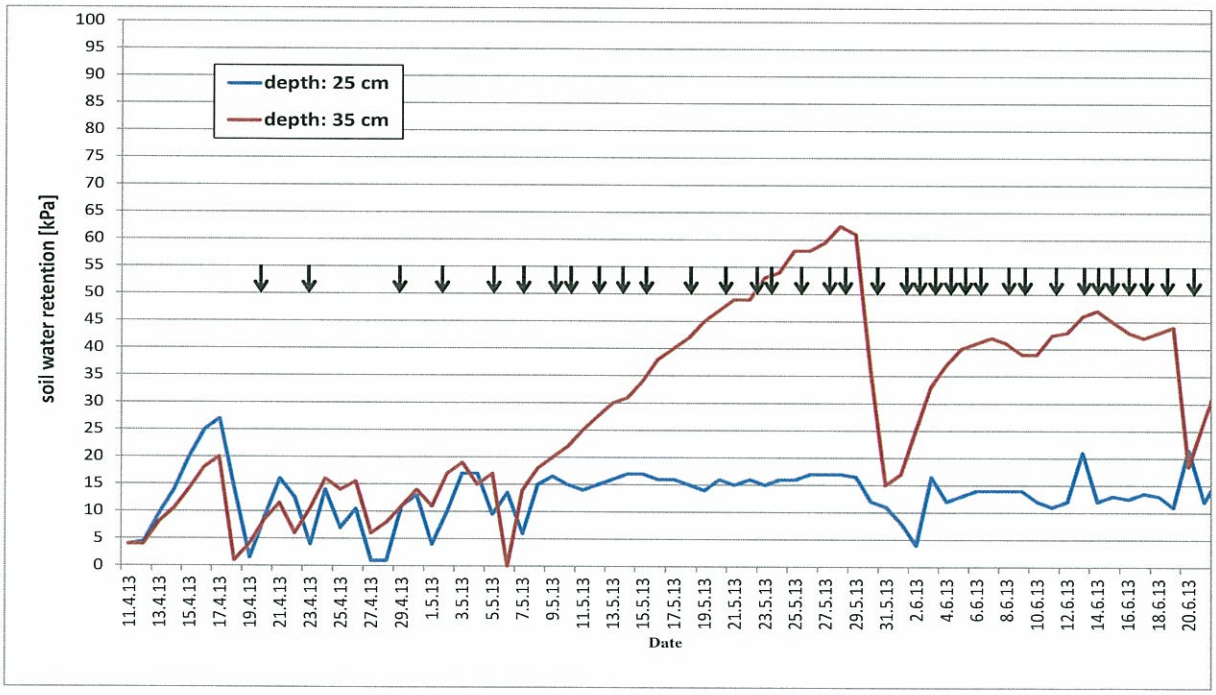

Fig. 1: Soil moisture levels in the irrigation treatment 'daily', measured with Watermarks (median of 3 Watermark sensors). Arrows indicate days with irrigation.

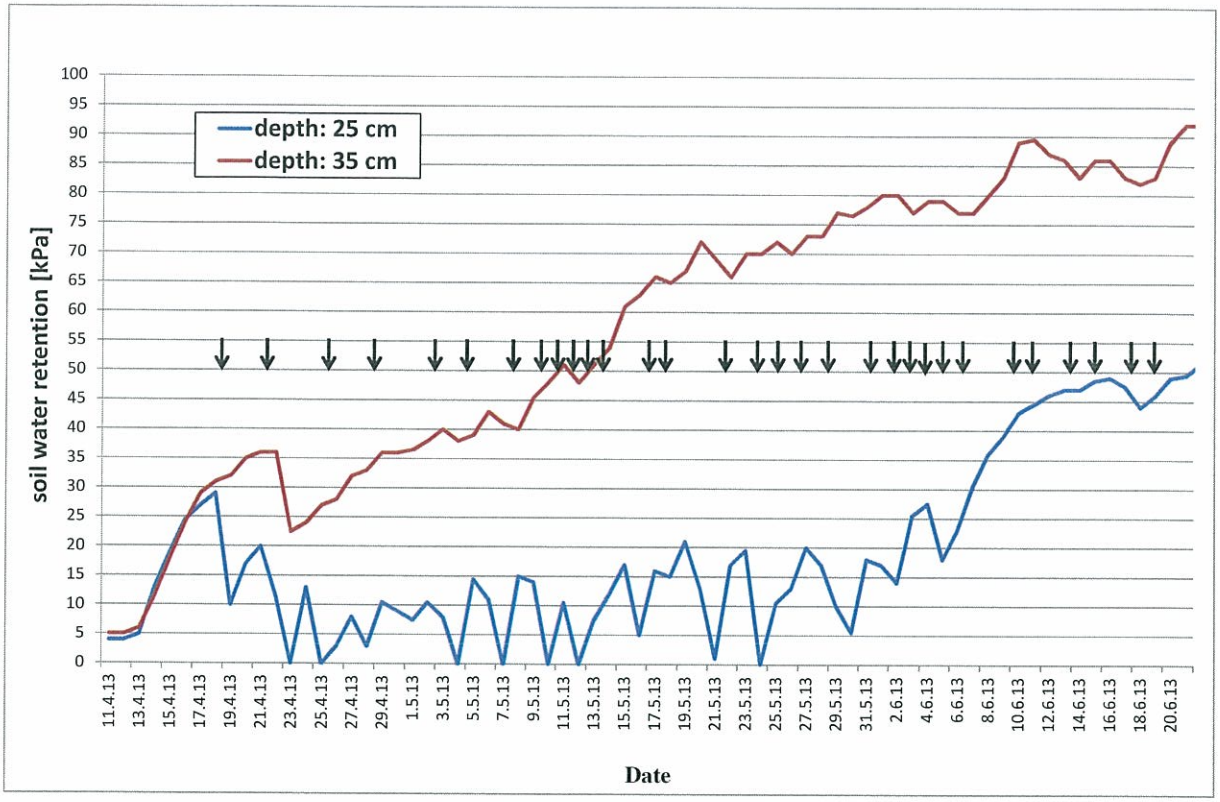

Fig. 3: Soil moisture levels in the irrigation treatment 'several times a day', measured with Watermarks (median of 3 Watermark sensors). Arrows indicate days with irrigation.

3.4 Costs of the irrigation treatments

The investment cost are relatively low compared to the labour costs. The investment costs for 3 tensiometers (225 CHF/182€) are much lower than the automatically Watermark system (781 CHF/632€). However, the labour needs were estimated at 20 hours per hectare for monitoring and irrigating with the treatment 'irrigation twice a week'. Because of the frequent monitoring of the treatment 'daily irrigation' labour needs were estimated at 40 hours per hectare. In contrast, the Watermark system works almost automatically and so the labour was calculated at only 5 hours per hectare form spring to the end of the harvest. With an automatic irrigation system the water needs and the workload is considerably lower and therefore economically interesting.

4 Conclusions

The three irrigation frequencies showed no statistically significant difference in strawberry yield and fruit quality. However, the water needs were very different. With frequent irrigation (daily or several times a day) about 35 % of water were saved compared with irrigation in maximum twice a week. With an automatic irrigation system, allowing to irrigate several times a day small amounts of water, the workload for irrigation is also considerably lower and therefore economically interesting.

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