Developing the Irrigation-Fertilizer Interface in Soilless Perlite Substrate

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BACKGROUND, DESCRIPTIONS, and OBJECTIVES

In the past ten years, there has been an increase in the frequency and level of damage observed from diseases caused by pathogens in the soil, such as nematodes, fungi, and bacteria. Consequently, many farmers have expressed interest in switching to growing tomatoes in soilless substrate. In recent years, a number of farmers in the Negev have begun to grow tomatoes in soilless substrates made of coconut in growbags at the recommendation of the Training and Professional Service (Shaham), other farmers, or companies. The farmers have encountered numerous problems, like low yield, and even the collapse of all the plants. Common complaints were collapses in the height of summer (especially during heat waves), blossom end rot, 'weak' plants, and a substantial decline in yield. Most of the studies that examined cultivation in soilless substrates were based on perlite and tuff substrate, while currently the absolute majority of tomato cultivation in soilless substrate use coconut substrate. Furthermore, most of the substrates had a different geometry (the substrate width and height) from what currently exists, which affects the optimal irrigation regime.

It is assumed that the quantity, frequency, and method of irrigation are very important in optimizing irrigation. The quantity of irrigation in soilless substrate must include the drainage quantity that washes the soilless substrate. Studies have determined that at the desirable drainage percentage, the chloride concentration in the drainage water is 20% higher than in the entry water. The quantity of drainage depends on the water quality, the quantity of the fertilizer, irrigation method, and kind of substrate. It was found that perlite substrate irrigated with

desalinated water required a drainage percentage of about 20%, but it was found that irrigation with brackish water with electrical conductivity of 1.5 decisiemens per meter needs a drainage percentage of about 40%. It was found that there are distinctions between different kinds of substrates, and it is therefore necessary to test the optimal drainage quantity for the coconut substrate as well.

The irrigation frequency is very important in an optimal drainage regime. After irrigation, the surplus water is drained from the substrate and the next irrigation should be scheduled according to the water condition in the substrate, which is mainly determined by the mature plant's water consumption. The drying process is not linear, and irrigation is therefore necessary before reaching the threshold. Another consideration for a soilless substrate is the substrate temperature; a high temperature may damage the root activity. Irrigation with cold or hot water cools or heats the substrate in the summer months, respectively, and the strength of the effect depends on the substrate volume and the frequency of the irrigation. Therefore, the timing or frequency of the irrigation should also consider the impact on the temperature.

Coconut substrate is relatively inert, and thus easily manipulated. A study in Spain found that irrigation with desalinated water with electrical conductivity of ~0.5 decisiemens per meter, which was salted by fertilizer to an electrical conductivity of ~2.5 decisiemens per meter, increased the tomato quality (especially Brix) without effecting the yield. These tomatoes are intended for the premium/niche market, because of their high quality. Ramat Hanegev R&D showed that irrigation with desalinated water, mixed with brackish water to an electrical conductivity of ~3 decisiemens per meter, increased the tomato quality (especially Brix) but damaged the crop. Salt build-up by fertilizer instead of using brackish water will increase the price of cultivation (the price of the water and fertilizer). If the fertilization salt build-up does not affect the quantity of the yield and improve the quality of the crop, we believe that this solution will be financially worthwhile for premium/niche tomatoes.

Main Study Objectives:

1—Development of a protocol for growing premium/taste tomatoes (Whitney, 582, Honey Drop, Lobello, Novella) in a soilless substrate that is irrigated with water salted by fertilizer to an electrical conductivity of ~2.5 decisiemens per meter.

2—Development of a protocol for growing acceptable tomatoes adequate for commercial cultivation in the region (Whitney) in soilless substrate. The following sub-targets are necessary to develop the protocol:

- *Find the ratio between the drainage percentage and the accumulated chloride, sodium, and nitrate, which will prevent salt build-up.* The ratio will give us the quantity of irrigation needed for obtaining the desired drainage percentage.
- *Find the substrate drying rate and reach the post-irrigation threshold value in the different growth stages and atmospheric requirements.* The bigger the plant, the faster the drying of the substrate. In addition to the temperature and radiation variations during the growing season, there is a difference in the plant's daily needs. For example, at the start of the day, the plant will have fewer needs, and the drying rate will be slower than at midday, when the plant is at peak photosynthesis activity and the atmospheric need is higher.

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- *Find the substrate heating rate and reach the threshold temperature after irrigation.* Increasing the irrigation frequency may prevent reaching a high roots temperature that harms their activity.
- *Find the substrate volume that will enable optimal growth.* In general, a larger substrate volume offers better growth conditions but has higher costs.

COURSE OF STUDY AND WORK METHODS (PLANNING VERSES PERFORMANCE)

Winter Growing Season: The seedlings were planted in September 2020. Due to an error at the nursery, seedlings of other varieties were supplied, which were not separated from the Whitney variety. Consequently, four treatments were stopped: substrate size 11, high frequency, substrate size 27 with two branches, and 10% drainage.

Summer Growing Season: The main problem with growing tomatoes in soilless substrate in summer is the substrate temperature. It was shown that for peppers, a growbag substrate heats up more than a perlite substrate. To verify the results and check the mechanism causing the difference in temperature, tomatoes were grown in the following substrates:

1—Coconut substrate in an 18-liter growbag

2—Coconut substrate in a 27-liter growbag

3—Perlite substrate in a 27-liter geotextile sleeve

4—Coconut substrate in a 27-liter geotextile sleeve

Also, two irrigation frequencies (low-standard and high) were applied, in order to study the effect of the irrigation frequencies on the substrate temperature. For this purpose, the different substrate temperatures at the different irrigation frequencies were monitored.

There were only two replications for each treatment (kind of substrate and irrigation frequency), so these results are considered as observations, because it is not possible to carry out a statistical analysis due to the limited number of tests.

Interim Results: The plants were planted on April 21, 2021, and grown according to the standard, except for the kind of substrate and irrigation frequency. In general, we see a trend in which the high frequency of irrigation increased the yield compared with the low irrigation frequency standard (Figure 1). We also see a positive effect of using sleeves compared with growbag or perlite of the same size. In contrast, an 18-size growbag with high irrigation frequency also showed an increase in yield. It should be emphasized that the trial was carried out with two replications, and we cannot therefore reach conclusions before a full trial.

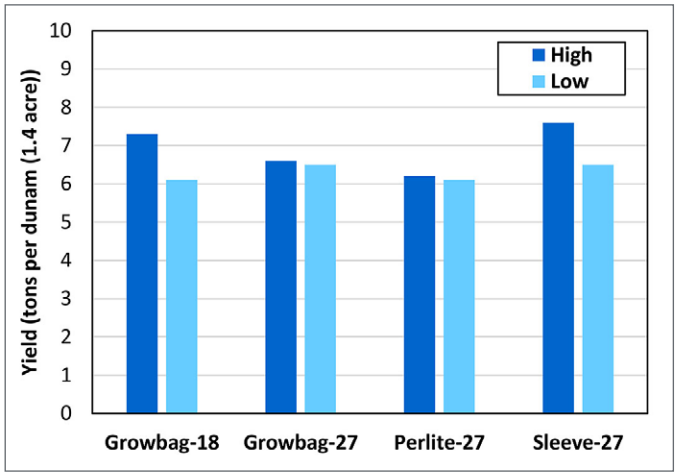


Figure 1 • Summer crop yield in different kinds of substrates and at different irrigation frequencies.

FIG 2 • Daily Temperature: STANDARD Irrigation Frequency

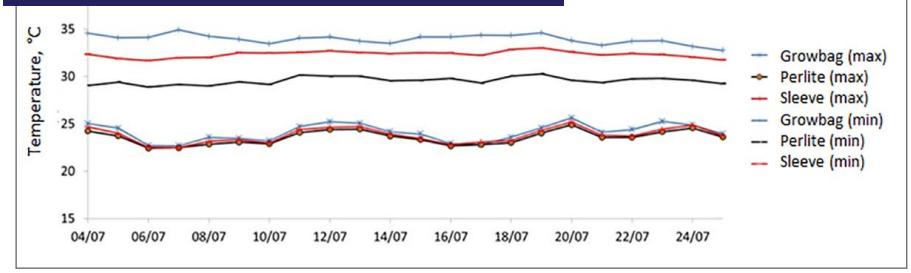
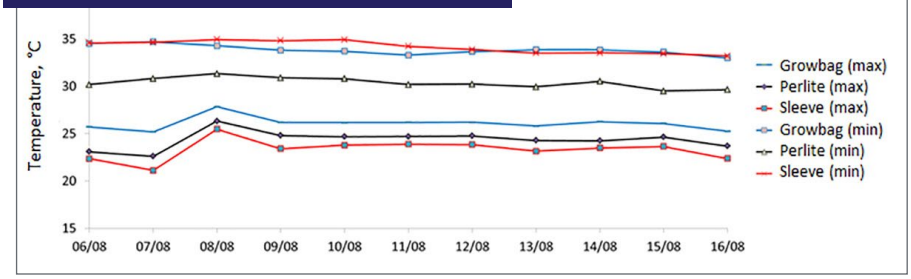


FIG 3 • Daily Temperature: HIGH Irrigation Frequency



CONCLUSIONS

1—The frequency of irrigation and the type of soilless substrate yield affect the results of the tomatoes grown in summer. Increasing the frequency had no cooling effect on the sleeve substrate compared with the growbag, because of the fairly high-water temperature.

2—During the summer period, the substrate consisting of perlite presented the lowest maximum temperature by more than 2.5 °C compared to the growbag and sleeve either under standard or high irrigation frequency.

3—Measurement taken on an hourly basis showed that the lowest substrate temperature was achieved with perlite throughout the day.

4—The irrigation water temperature controls the substrate temperature; thus, it is suggested to protect the water hoses from the sun through burying.

Figure 2 and Figure 3 present minimum and maximum daily temperature in different substrates under standard and high irrigation frequency, respectively. Under standard irrigation frequency, the substrates' minimum daily temperature was fairly similar, but the maximum temperature varied between the substrates. The perlite substrate had the lowest temperature, and the growbag had the highest, with the sleeve being intermediate. Similar are the observations when high irrigation frequency was applied.

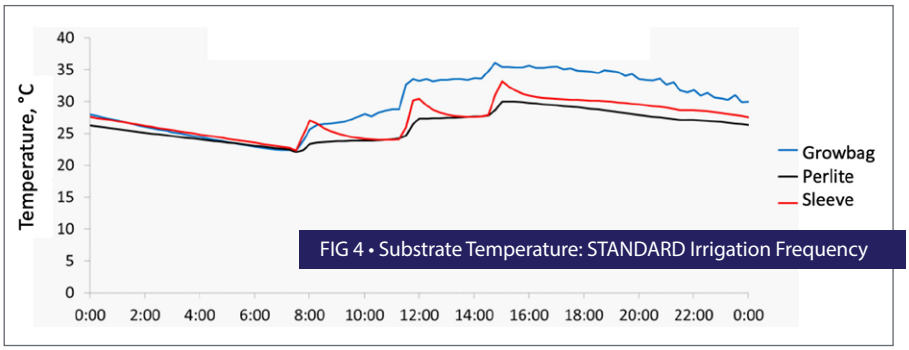


FIG 4 • Substrate Temperature: STANDARD Irrigation Frequency

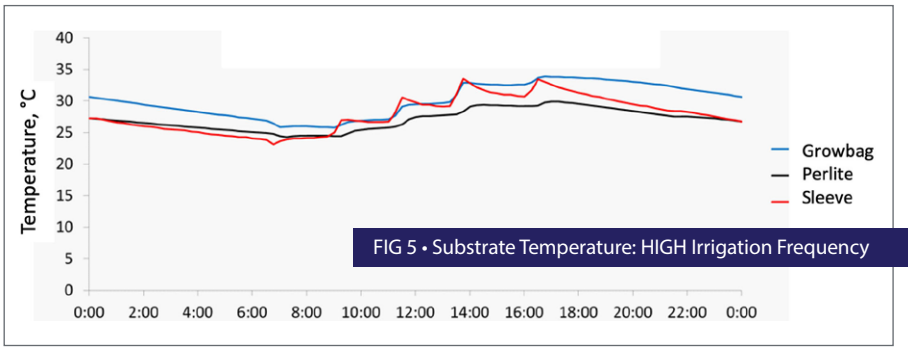


FIG 5 • Substrate Temperature: HIGH Irrigation Frequency

Figure 4 and Figure 5 present the substrate temperature throughout a day under standard and high irrigation frequency, respectively. Close observation of the graphs reveals that irrigation temporarily raises the substrate temperature. This is apparently because the irrigation hoses were not buried, thus exposed to the sun and heated up. This was especially prominent in the sleeve, which had a temperature similar to the perlite before irrigation but had a higher temperature afterwards.

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