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Mini Cucumbers, Winter Experiment in Kerem Shalom, Israel, 2022

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Abstract

Cucumber is a popular crop all over the world. In Israel, cucumbers are grown throughout the year, even though wintertime cold temperatures provide the main challenge for cucumber growing farmers. Growing in pots or grow-bags disconnects the roots from the isulated effects of the soil and exposes root zone to damage from ambient temperatures. Farmers using ROOTS's (Rootsssat.com) zone temperature technology and controls, can adjust and maintain root zone temperatures at an optimized range throughout the year, i.e. cooling the roots during the summer and heating them during the winter.

In this paper, we will discuss the use the ROOTS's system when growing mini cucumber plants. The experiment was conducted on 2,000 plants in a commercial greenhouse in south western Israel. The root zone heating system provided an average of 4.4°C above the control group. **Heating the roots zones contributed to a 31% increase in the average yield.**

Introduction

Cucumber (*Cucumis sativus*) is an annual summer climbing plant from the gourd family in the Cucumber genus. The cucumber does not require generous watering, and the fruit is elongated, juicy, and very rich in water. Mostly, it is green and is eaten raw, pickled in salt, or pickled in vinegar. The origin of the plant is India, where humans began to grow it about 3,000 years ago. It "migrated" into Europe in the ninth century. Today, cucumber is a very common fruit, and it is grown mostly in greenhouses or under shade nets. In 2019, 88 million tons of cucumbers were sold worldwide, with 80% of them grown in China.[1]

In Israel, greenhouse cucumbers have undergone many transformations over the years and have been established as one of Central Israel's major crops. Several important changes have made this dynamic industry serve as a stable and central source of income:

1) the improvement of agrotechnical cultivation, where the important change was the transition to growing several growing cycles in the same greenhouse and

[1] Production of cucumbers and gherkins: from pick lists, World regions/Production Quantity, FAOSTAT of the United Nations. 2019

2) by using varieties that have been adapted to the different seasons.

Until the beginning of the 1990s, only one winter cucumber strain was grown in Israel, planted in October and continuing until June or July. During the last decade, varieties have been grown according to the seasons. In the late summer/autumn season, varieties are grown with yield that continues into the beginning of winter. In the winter season, plantation begins in October-November and continues until March-April. This set of varieties allows growing three cycles a year in the same greenhouse, and therefore, it is possible to obtain a very high yield at the level of 30-40 tons per acre per year (per what greenhouse size?)

Other agrotechnical changes in cultivation have also led to an increase in crop quality, such as changes in the structure of the greenhouse and the types of cover sheets, use of nets against insects, cultivation in separated beds, water recycling, and more.[2] Growing cucumbers in the winter season poses many professional challenges to the farmer: dealing with unpredictable and sometimes extreme climate conditions, typical root and landscape diseases, grow house operating challenges, adjusting an optimal supply of water and fertilizer, choosing suitable varieties for the season, growing conditions on the farm, and more.[3]

Some of these major challenges that Israeli cucumber farmers face in the winter months can be solved by heating of the root zone area of each plant. ROOTS Sustainable Agricultural Technologies Ltd. developed a unified system for cooling and heating roots zones. The system is constructed in closed water circulation. By regulating the water temperature in the system, it creates a heat source to control the micro-climate inside the root zone and eliminate the temperature variation during the day and night. The system also contributes to eliminating the growth-inhibiting impacts of extreme temperatures (Figure 1).

Preliminary experiments and commercial installations demonstrated the economic and agronomic[4] benefits of heating and cooling roots for the following reasons:
A) increasing yield,
B) increasing the quality of the crop,

[2] Nabil Ghanahim, Israeli Agronomic Services, Ministry of Agriculture, Israel. 2004
[3] Yigal Meron, Israeli Agronomic Services, Ministry of Agriculture, Israel.
[4] Sasaki, Kozi, and Tositaka ITAGI. "Effect of root cooling treatment of nutrient solution on growth and yield of tomato, cucumber and melon." Environment Control in Biology 27.3 (1989): 89-95.

C) shortening the growing cycle, and

D) energy saving (in crops with r air cooling or heating.

A major advantage of the system is that cooling and heating can be performed by the same system.

In addition, cooling and heating systems are usually operated in closed greenhouses. In this experiment, part of its purpose was to determine if there would be agronomic effects as a result of heating mini cucumbers roots. Previous experiments in cucumber using ROOTS system showed very good efficiency (over 38% increase in yield) in normal greenhouse cucumbers.

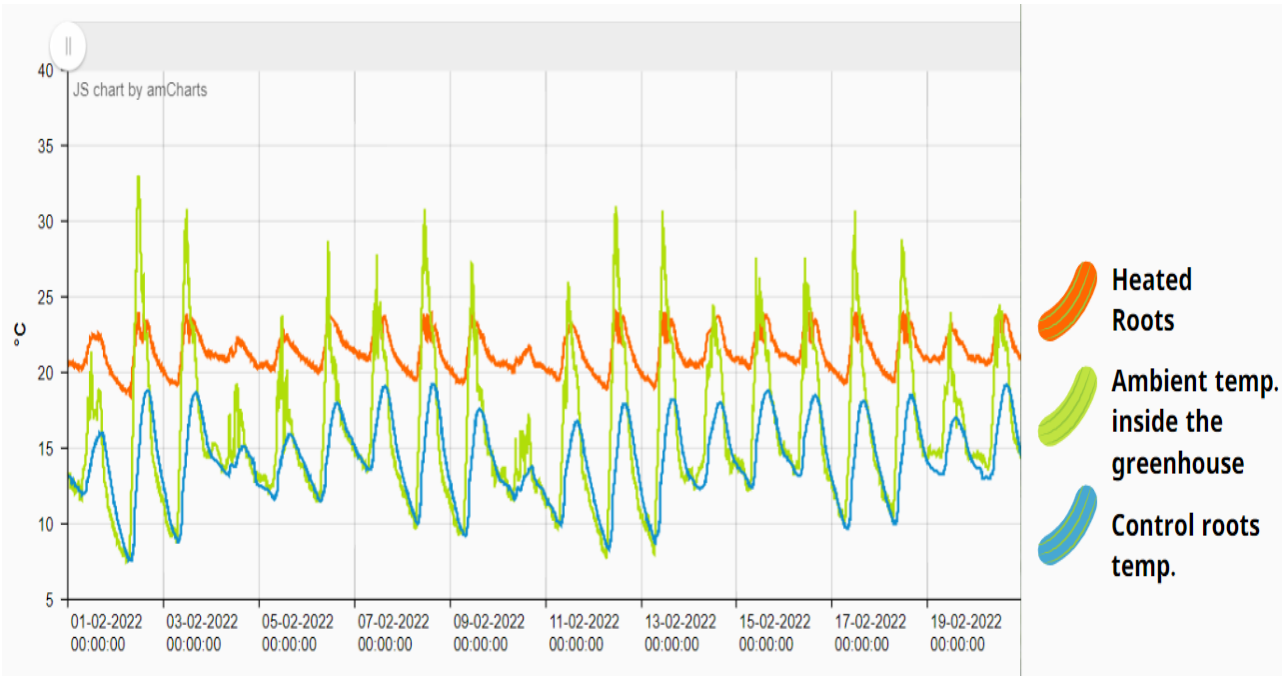

Figure 1: A typical configuration of the operation of the ROOTS system during heating. In orange, the regulated temperature of the ROOTS heating system maintains a constant and desirable temperature (19°C -24°C). In green, the ambient temperature in the greenhouse air. In blue, the control temperature in the roots zone.

Methods

The test was carried out in an agricultural field in January 2022, in Kerem Shalom in the south of Israel, by a commercial and experienced farmer who purchased a POC system that was installed in one of the growing greenhouses. The system provided controlled heating for 500 pots of 15 liters (two plants per pot), utilizing a 12kw heat pump. The heat exchange to the substrate was carried out using the ROOTS system HEP (Heat Exchange Prob) (Pictures 1& 2). The control was 500 pots

in the same greenhouse and conditions. No changes were made in fertilization and watering protocol during the experiment compared to the standard protocol of the grower.

The target root temperature as well as all the measurements published in this report were monitored and collected by the grower. **The experiment was also monitored by the Israeli Ministry of Agriculture Agronomic Advising Service.**

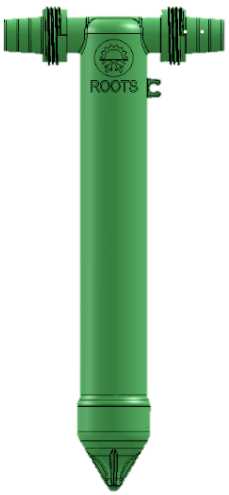

Photo 1 and Photo 2: On the left, a row of pots with HEPs in the test array in Kerem Shalom. On the right, the ROOTS HEP system.

Results

Substrate Temperature

The average temperature difference was 4.4°C for the heating system plants versus the control, where the average temperature in the treatment group was 22.2°C compared to 17.8°C in the control (Figure 3, Photo 3). The farmer in the field manually measured the temperatures, taking them in the center of the pot at 10 cm depth.

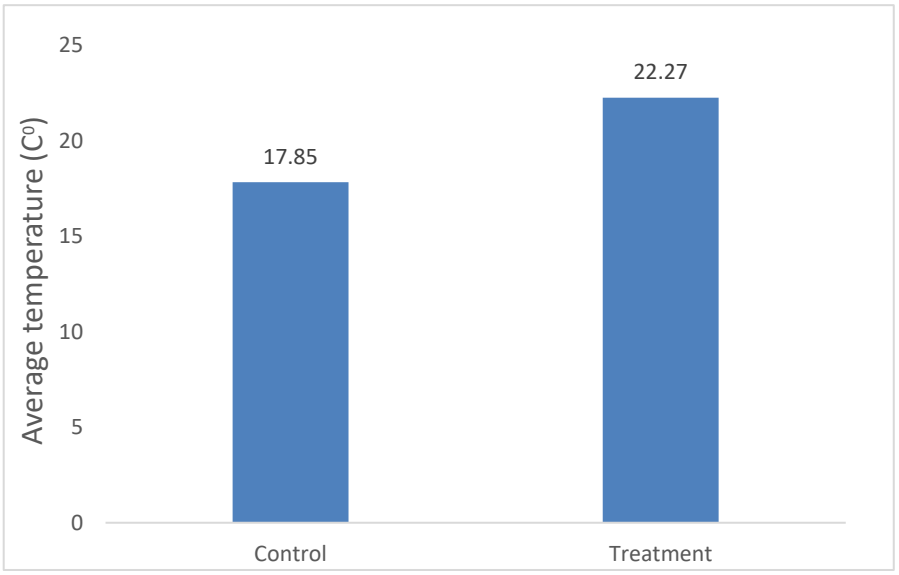

Figure 3: On the left, the average temperature in the control pots. On the right, the average temperature in the ROOTS heating system

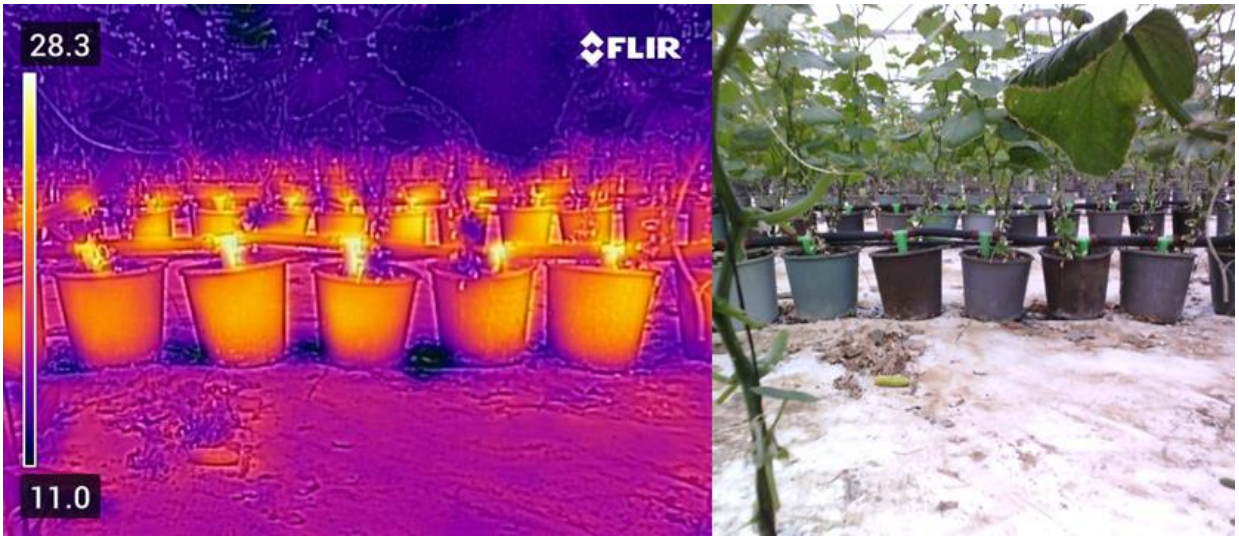

Photo 3: On the left, a photo taken with a thermal sensor which detects heat (yellow shades indicate heat, blue shades indicate cold), showing the treated pots and the system piping are very warm compared to the relatively cold environment. On the right, a photo taken with a regular sensor.

Yield

The first picking was carried out on 24.1.2022, and the last winter growth cycle picking was carried out on 22.3.2022, with a total of 29 pickings throughout the period. The harvest was collected and weighed by the grower from 1,000 treatment plants and 1,000 control plants (1,000 pots in total). The average yield between the treatment and the control was 31% in favor of the treatment (Figure 4). The difference is statistically significant using paired T-test for means (P>0.001).

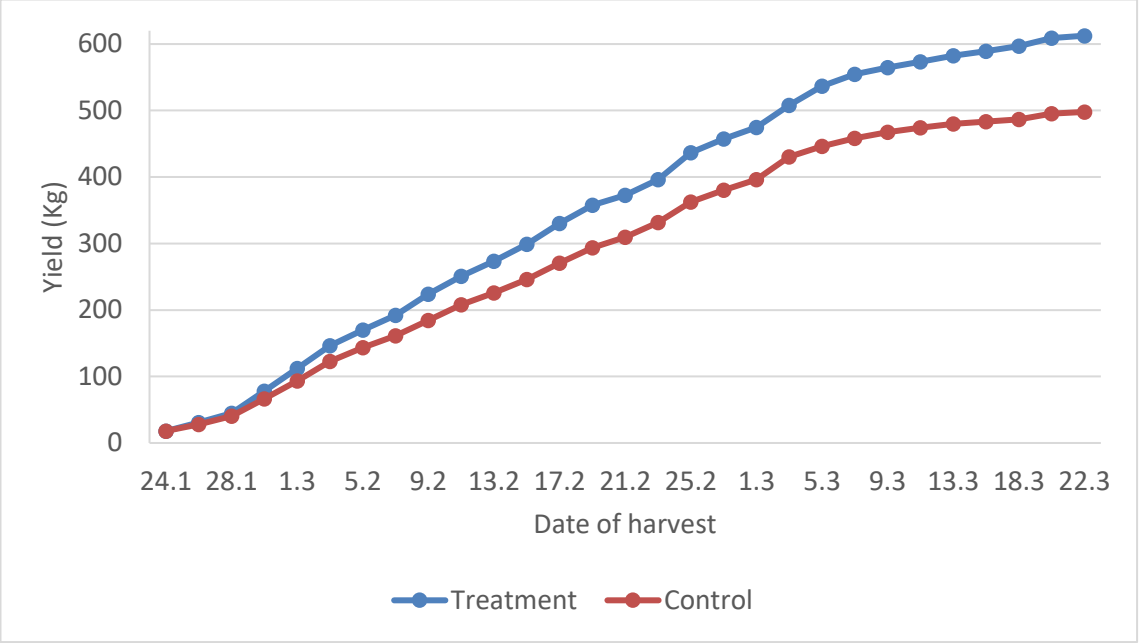

Figure 4: The difference in kilograms measured between the treatment and the control throughout the days of the experiment. The average difference was 31% in favor of the root heating treatment. The differences are statistically significant (p>0.001).

Summary and Conclusions

Heating root zones has proven to be a factor influencing the growth of cucumbers. Winter crop increase is critical to farmers. The results show that cucumbers can not only be grown in the winter using the ROOTS technology, but the system can also increase a harvest and create a more stable crop throughout the cold season. The effect of heating on the crop increase is unequivocal, and its economic derivatives are positive.

It should be noted that the ROOTS system that operated in this experiment is not a full system. A ROOTS system that has even more stabilized temperature and control options will be used as this

current experiment continues to the next stage this summer. The effects of temperature regulation in mini cucumbers in the hot season will also be examined.

Thanks

Cooperation with the farmer is critical in any ROOTS experiments and pilots; the effort and commitment are crucial when carrying out studies on commercial growing sites. Without Edward's dedication and professional interest, the experiment could not have been carried out as is. Thanks to the Israeli Agronomic Services and the Ministry of Agriculture guides who accompanied the experiment throughout, Lior Avraham and Nir Barholtz. After Edward's experience with the system, he bought a full system with a subsidy from the Ministry of Agriculture in Israel.