Changing the environment of microgreens to increase net primary productivity

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Introduction

Chickens at Grand View Farm have been showing a decrease in egg quality over winter. Chickens were able to freely graze on grass and insects during the summer, however winter conditions are inhospitable for the chickens and inhibits plant growth, leading to a lack of nutrients. As the existing grain feed is not replicating the grazing nutrients, this project is meant to facilitate the growth of microgreens during winter to supplement the chickens' diet. To do so, multiple tests with changing conditions were used to find what results in maximum yield. Conditions such as light intensity, watering quantity and frequency, seed density, and germination time were modified to promote growth of the microgreens (Table 1). Light intensity has been shown to increase growth over all conditions (Jones-Braumgart et al., 2019). Net primary productivity, or NPP, is the amount of carbon that plants absorb from the atmosphere (measured in grams of carbon per square meter per day) and is a measurement for growth of the wheat. The NPP of winter wheat grown under varying conditions was used to show the effectiveness of the conditions. One major obstacle in growing greens in winter is that there was not traditional heating in the greenhouse which affects winter wheat growth negatively (He et al., 2020). This was solved using a geothermal heating system that exchanges heat with the ground. This allows the temperature of the greenhouse, shown in figure 2, to remain stable throughout the year.

Materials and Methods

For the geothermal greenhouse, three pipes were placed 6' underground with air flowing through the pipes into the greenhouse. Two of the pipes were laid in a long U-shape, and one was coiled underneath the greenhouse. The final greenhouse is shown in figure 2.

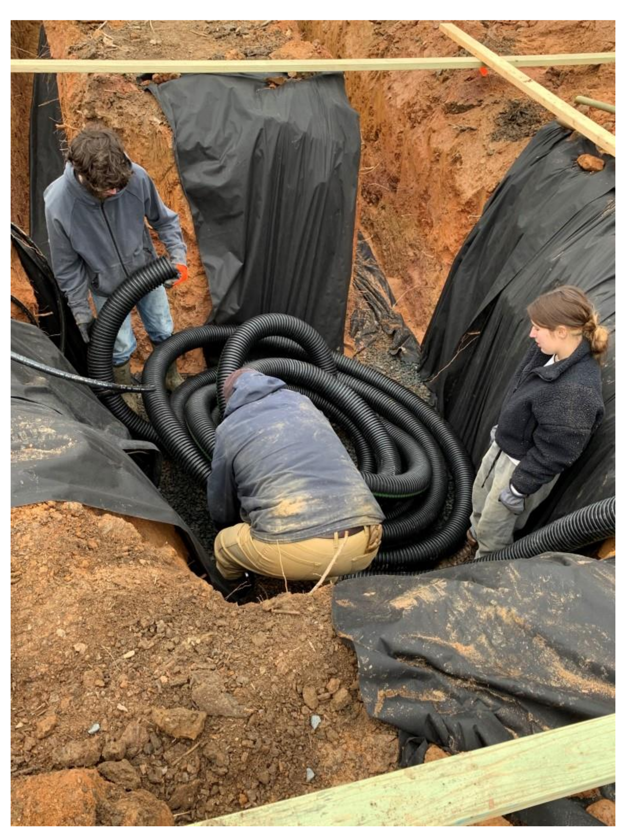


Figure 1 (above): Pipe being laid in a coil for the geothermal heating. Pipes are 3" in diameter and 100' long.

Five tests were set up comparing the NPP of various environmental conditions. Plastic trays (13.5 cm × 20.5 cm × 2 cm) were used to test conditions. In table one, variations in tests are explained. The highest NPP value from the previous test was then applied to the next test. Each test was completed over a 14-day period and then harvested, dried and massed. Microgreens were dried using lab ovens to remove the extra weight from water. The dried microgreen's NPP was compared to the original mass of the seed to find the amount the mass increased.

Materials and Methods (cont.)

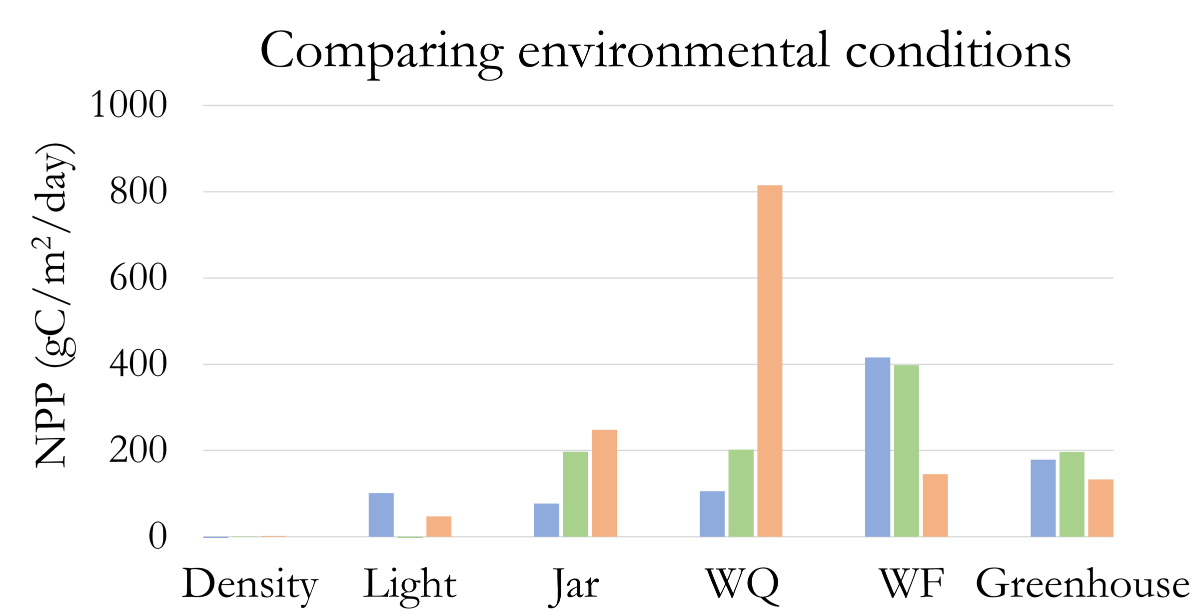
Test	Conditions	Results	Dates
Density	1101, 2202, and 3299 g/m^2 of dry seed.	High density showed more growth	3 January–4 February
Light	Now using a density of 3613 g/m^2 of seed. Trays positioned two, one, and zero feet from directly under the grow light to change intensity	Some trays exposed to sunlight, greatly increasing growth.	8–22 February
Jar	Seeds germinated for zero, one, and two days before being placed in trays.	Germinating for two days yielded highest NPP	22 February–7 March
Water quantity (WQ)	Microgreens were sprayed with 20, 40, and 60 ml of water per day and covered with plastic wrap to simulate a greenhouse.	Seeds need at least 0.4 mL/g seed/day	7–21 March
Water frequency (WF)	Trays were given equal amounts of water one, three, or six times per day. Highest frequency of water given per day contained a mat to see if it would reduce mold.	Mat did not reduce mold, and decreased NPP. Other results had similar NPP	21 March–4 April

Table 1 (above): Conditions of each test in greater detail. Results determined conditions for next test.

Figure 2 (below): Greenhouse used for final test. Greenhouse is 12' L × 10' W × 10' H

Figure 3 (above): Microgreens growing in a tray after 14 days.

Results



Graph 1 (left): NPP of microgreens under varying conditions, displayed in the order stated in table 1. There was a large increase in NPP from the density test to the light test, and again when water was controlled.

Results (cont.)

As shown in table one, tests and conditions were based on the outcome of previous tests. For example, seeds germinated in jars for two days produced significantly higher NPP (248 $gC/m^2/day$) than not in jars (77 $gC/m^2/day$), so this condition was used for the rest of the tests. As shown in graph 1, the NPP increased with each subsequent test. The most productive light test condition was 101 $gC/m^2/day$, and the most productive WQ test condition was 815 $gC/m^2/day$. The most productive jar test had a 246% higher NPP than the highest NPP light test. It was determined that two days of germination in a jar, exposure to direct sunlight, and watering with at least 0.4 mL/g seed/day is the most ideal set of conditions for growing microgreens. These conditions were verified as successful when repeated in the greenhouse, with an average NPP of 170 $gC/m^2/day$ (see graph 1).

Discussion

The purpose of this project was to determine how to maximize the NPP of winter wheat by changing the conditions of the growing environment. This goal was achieved as the NPP of the winter wheat increased as testing continued, more so than would be expected just from the change in seasons. Light, water, and seed density were shown to result in the greatest increases in NPP, making them crucial conditions to consider in growing microgreens over winter. Tests were done to determine if a mat would decrease mold growth and increase the NPP of the microgreens, but both times the roots grew into the mat preventing collection. Higher density was used for the microgreens after the first tests even though there was little difference between the NPP, this could have been because of decomposition, as the highest density was massed three days after others and still had the highest NPP. In addition, there may be an outlier in the water quantity test caused by incomplete drying. When verifying the conditions, the lowered average NPP compared to the indoor water frequency test is likely because of the temperature difference between the house and the greenhouse. Future research is recommended to test more variables. Examples of this include increasing light intensity past ambient light levels, changing container size, or changing the airflow within the greenhouse.

References

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Jones-Baumgardt, C., Llewellyn, D., Ying, Q., Zheng, Y. (2019). Intensity of sole-source light-emitting diodes affects growth, yield, and quality of Brassicaceae microgreens. *HortScience*, *54*(7), 1168–1174. https://doi.org/10.21273/hortsci13788-18