Optimizing Corn Growth: Fertilizer, Soil Temperature, and Plant Health

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Introduction

For many years, corn (*Zea mays*), has held a crucial position in the realm of global agriculture and food production. Numerous studies have revealed the pivotal role of fertilizers in enhancing corn plant performance. Specifically, research has shown the positive correlation between fertilizer application and the concentration of critical pigments such as chlorophyll and anthocyanin in corn plants (Li et al., 2009 and Yamuangmorn et al., 2018). These pigments play an important role in photosynthesis and overall plant health, ultimately resulting in improved growth and vigor. In addition to the influence of fertilizers, the temperature of the soil in which corn plants grow is another important environmental factor. Soil temperature can significantly impact the health, growth, and physiological processes of corn plants (Stoll and Saab 2013).

This research study is aimed at delving deeper into the multifaceted dynamics of corn cultivation. Specifically, this study seeks to unravel the extent to which fertilizers contribute to corn's growth. With these objectives in mind, the data collection of this study was guided by the following research questions:

1. **To what extent does fertilizer influence the growth of corn plants?**
2. **What are the differences between corn plants that receive fertilizer and those that do not?**
3. **How critical is the role of fertilizer in maintaining the overall health of corn plants?**
4. **How does soil temperature affect the physiological processes and growth of corn plants?**

Methods

Fertilizer Experiment:

The fertilizer experiment had 4 treatment groups with 8 replicates. The fertilizer used in this study was composed of 24% Nitrogen (N), 8% Potassium (K), and 16% Sodium (Na). To prepare the fertilizer solution, 2.05 grams of the fertilizer was dissolved in approximately 2 liters of water, creating a homogenous mixture. In this experiment, four groups were studied. The Control Group received watering only, serving as the baseline. The YY Treatment Group (YY) received both water and fertilizer to assess their combined impact on plant growth. The FN Treatment Group (FN) received fertilizer without extra watering, examining the effect of fertilizer alone. Meanwhile, the NN Treatment Group (NN) received minimal water without fertilizer, investigating reduced water availability's impact on plant growth.

Experimental Timeline: The primary experiment spanned four weeks and the plants were treated every two days.

- Initial Two Weeks: During this period, the control group received 20 ml of water, the YY group was provided with 10 ml of water and 10 ml of the fertilizer solution, the FN group received 10 ml of the fertilizer solution, and the NN group was given 10 ml of water.
- Final Two Weeks: In the latter half of the experiment, the control group received 40 ml of water, the YY group was given 20 ml of water and 20 ml of the fertilizer solution, the FN group received 20 ml of the fertilizer solution, and the NN group was provided with 20 ml of water.

High Temperature Experiment: Additionally, a temperature experiment was conducted, involving a single treatment group and a control group. The control group consisted of the same eight control corn plants utilized in the fertilizer experiment. The treatment group, denoted as "Hcontrol," comprised eight corn plants placed on a heating mat and treated in a manner identical to the control group from the primary experiment. The high temperature experiment was carried out over the same four-week duration as the primary experiment, with the treated corn plants remaining on the heating mat throughout the entire period.

Data Collection: On the last day of the four-week treatment period, comprehensive data were collected from each corn plant. The following measurements were taken:

- Node Height: The height of the final node on each plant was measured.
- Overall Height: The total height of each plant was recorded.
- Photosystem Efficiency (PE): Photosystem efficiency was assessed using a fluorometer device to understand the photosynthetic performance of the corn plants.
- Chlorophyll Content Index (CCI): The chlorophyll content of the leaves was measured using a chlorophyll concentration meter device.
- Anthocyanin Content Index (ACI): The anthocyanin content of the leaves was determined using an anthocyanin concentration meter device.

Statistical Analysis: To evaluate the significance of the observed differences among the control and treatment groups, a one-way analysis of variance (ANOVA) test was conducted using the program JMP (vs. 4.0.4 SAS). This statistical analysis was employed to assess whether there were statistically significant variations in the measured parameters among the different experimental groups.

Acknowledgements

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Results

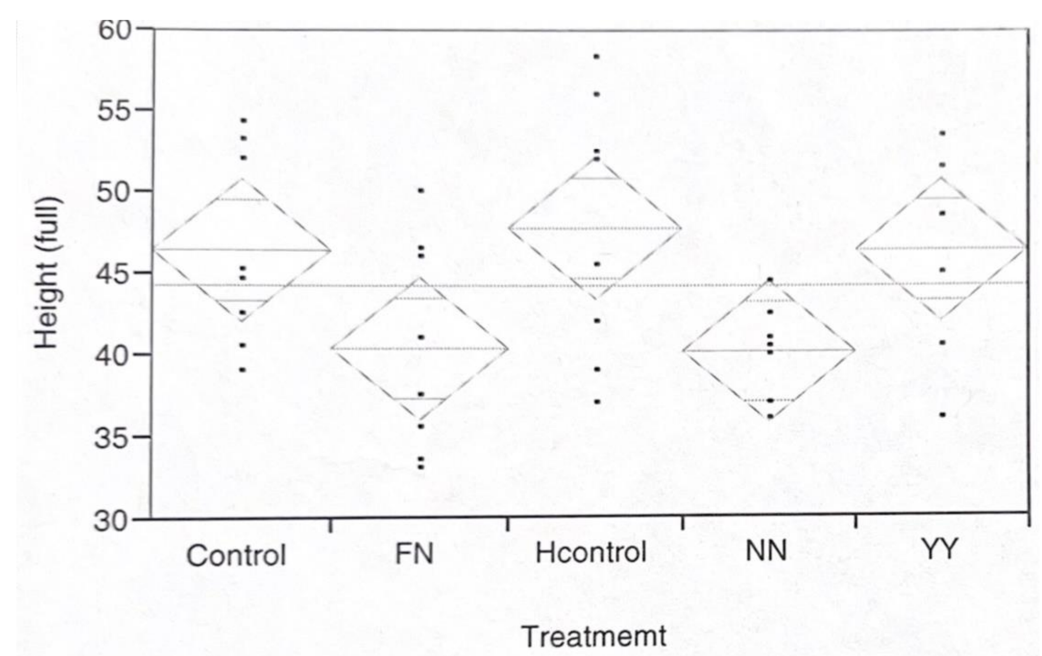

Figure 1. Plant Height (full) by Treatment, significant effect of fertilizer ($F = 2.8766$; $P = 0.0369$).

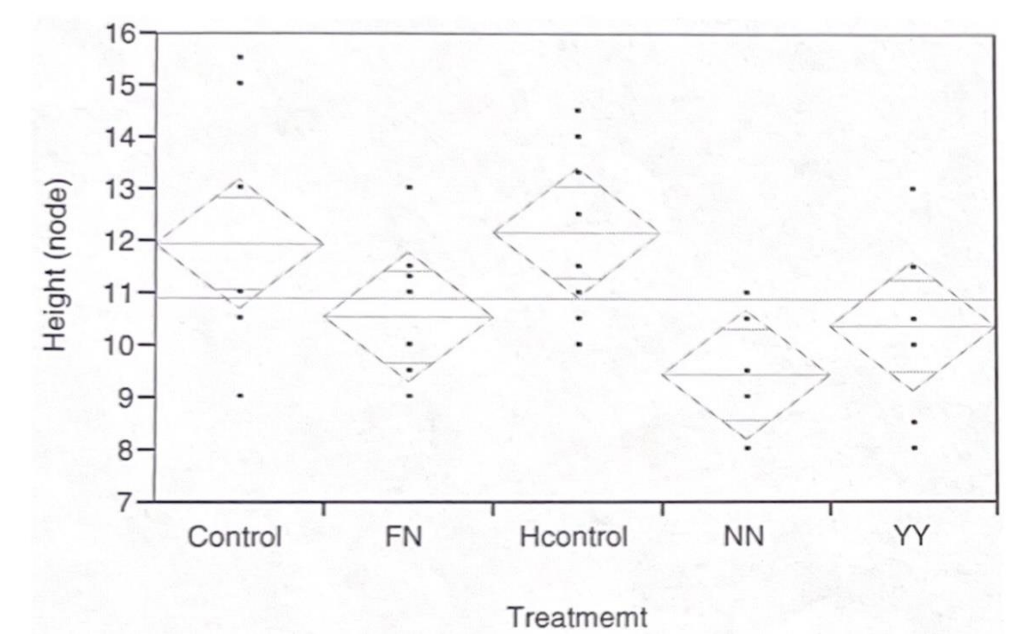

Figure 2. Plant Height (to the node) by Treatment, significant effect of fertilizer ($F = 3.4715$; $P = 0.0172$).

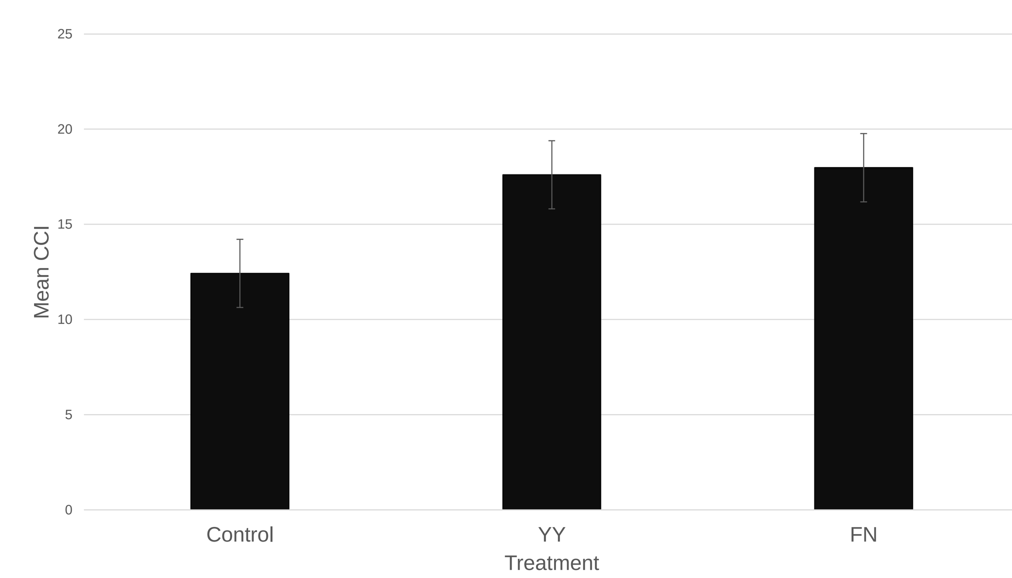

Figure 3. Mean Chlorophyll content index (CCI), significant effect of fertilizer YY treatment group ($F = 8.4953$; $df = 14$; $P = 0.0113$). Significant effect of fertilizer on FN treatment group ($F = 8.7904$; $df = 14$; $P = 0.0102$).

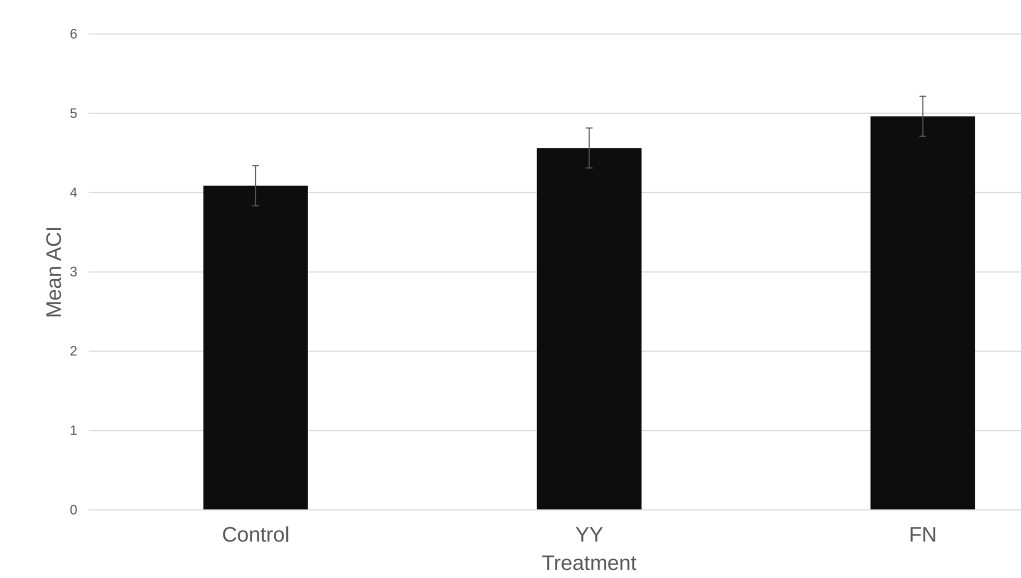

Figure 4. Mean Anthocyanin content index (ACI), significant effect of fertilizer on FN treatment group ($F = 7.1369$; $df = 14$; $P = 0.0182$). Non significant effect of fertilizer on YY treatment group.

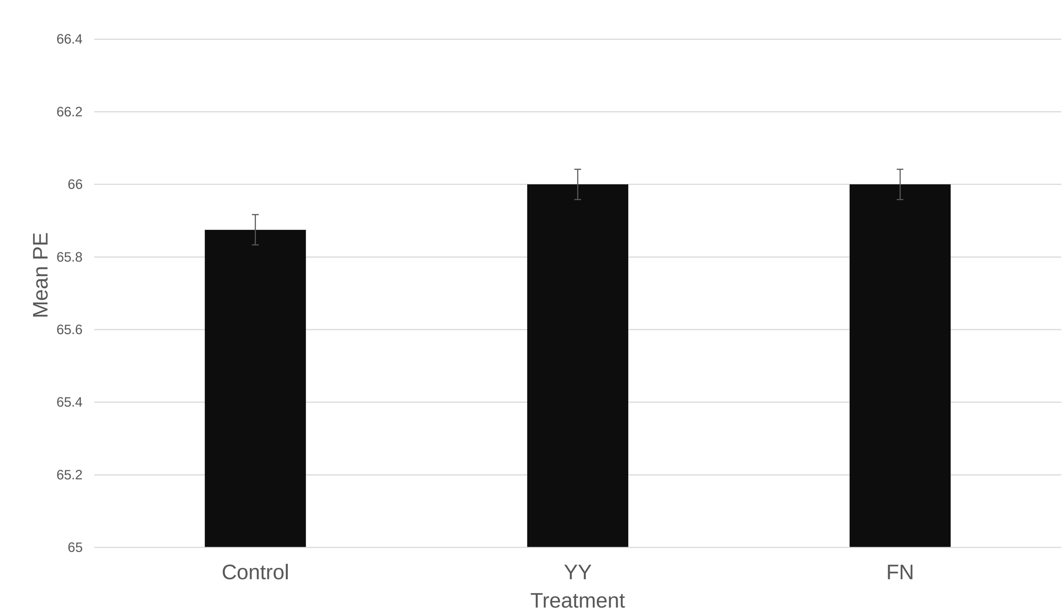

Figure 5. Mean Photosystem Efficiency (PE), non significant effect of fertilizer on YY and FN treatment.

Table 1. Oneway Anova test between control and heated control treatments

Control vs. Hcontrol	F-ratio	df	p-value
CCI	0.0360	14	**0.8523**
ACI	2.5743	14	**0.1309**
PE	2.8354	14	**0.1144**

Treatment Key

YY: water + fertilizer
FN: only fertilizer solution
NN: minimal water + no fertilizer
Hcontrol: heated control

Discussion

1. **To what extent does fertilizer influence the growth of corn plants?**

This study provided evidence of the significant positive impact of fertilizer on the growth of corn plants. Specifically, we observed that the treatments had a significant effect on full corn plant height (Figure 1) and corn plant node height (Figure 2). These findings suggest that the proper application of fertilizer and water can improve the growth and physiological performance of corn plants. This aligns with previous research findings that demonstrated the positive impact of nitrogen fertilizer on the yield and quality of corn (Omar et al., 2022).

2. What are the differences between corn plants that receive fertilizer and those that do not?

The results demonstrate significant effects of fertilizer application on key physiological traits: chlorophyll content index (CCI) and anthocyanin content index (ACI). The second treatment group (FN) had significantly higher CCI and ACI than the control (Figure 3 and Figure 4) and the first treatment group (YY) had significantly higher CCI than the control (Figure 1). Additionally, the third treatment group (NN) did not exhibit any significant differences in CCI and ACI compared to the control. These data might indicate that fertilizing corn plants significantly increases their chlorophyll and anthocyanin concentration compared to simply watering them. The increased concentration of both ACI and CCI could be attributed to the increased nitrogen in the fertilized plants, as both pigments contain nitrogen in their molecular makeup.

3. How critical is the role of fertilizer in maintaining the overall health of corn plants?

Concerning the critical role of fertilizer in plant health, the results suggest that fertilizer can positively influence specific physiological attributes of corn plants. While the data did not find significant differences in photosystem efficiency (PE) among the treatment groups (Figure 5), this lack of significance may be attributed to the relatively young age of the corn plants in our study. Photosystem efficiency can vary with plant age (Bielczynski et al., 2017), and our focus was on young corn plants. Therefore, the immediate impact of fertilizer on PE remains a potential area for further investigation.

4. How does soil temperature affect the physiological processes and growth of corn plants?

The results of this study shows that increased soil temperature, induced by heating mats, did not result in any significant differences in CCI, ACI, and PE compared to the control treatment (Table 1). However, since previous research has shown that soil temperature can be really important for plants (Stoll and Saab 2013), it is possible that soil temperature may have influenced other plant processes such as root growth that wasn't immediately reflected in the measured traits.

Conclusions & Implications

This study offers valuable insights into how fertilizer, water, and soil temperature affect young corn plants. Fertilization significantly boosted corn plant growth, evident in their increased height, while also leading to higher chlorophyll and anthocyanin levels. These findings hint at improved photosynthesis and stress tolerance. The findings also suggest that the the increase in fertilizer primarily increases the amount of nitrogen, phosphorus, and potassium in corn plants. However, to gain a complete understanding, further research should explore the long-term effects of fertilizer on photosystem efficiency as corn plants mature. Additionally, studying the precise mechanisms through which soil temperature influences corn plant physiology and growth can provide deeper insights.

These discoveries contribute to optimizing corn cultivation in agriculture. Farmers can benefit from adopting well-timed and balanced fertilizer application strategies to enhance crop productivity. Future research could investigate different fertilizer concentrations, application schedules, and how various environmental factors like light, temperature, and soil quality interact to further enhance corn plant growth and performance. This study serves as a stepping stone for ongoing research aimed at improving agricultural practices and increasing crop yields in corn cultivation.

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