Effects of nitrogen fertilizer on drought-affected corn (*Zea mays*)

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Abstract

This project explored the effects of nitrogen fertilizer on droughted corn plants. It aimed to investigate whether the amount of fertilizer would affect the rate at which the plant underwent photosynthesis. The hypothesis was that nitrogen would have little or reduced effect on a droughted plant, due to the requirement of water to undergo photosynthesis. To test this, three nitrogen treatments (zero, low, and high concentrations) and two water treatments (well-watered and droughted) were used on corn plants. Chlorophyll concentration, height, stomatal conductance, internal CO_2, and photosynthesis were measured for eight weeks of treatment. Increased water primarily had an effect on the height of the plant, while the nitrogen treatments primarily affected chlorophyll content and photosynthetic rates. This suggests that while plants experience stunted growth when droughted, they do not experience a significant change in photosynthetic rates, which are decided by the nitrogen content of the soil rather than the water content.

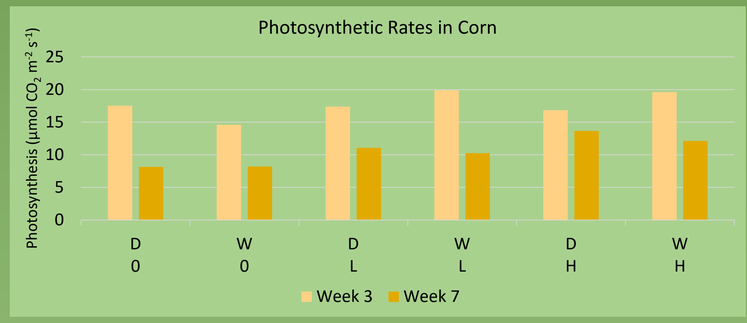

Figure 1. Average photosynthetic rate of corn in drought and nitrogen treatments at Week 3 and Week 7, as measured by a LiCor 6400XT Portable Photosynthesis System. D stands for drought, W for well-watered. 0, L, and H stand for zero nitrogen, low nitrogen, and high nitrogen, respectively.

Introduction

Plants experience a myriad of environmental stresses. High soil salinity or pH, overexposure to sunlight, or pathogens all target plants in a variety of ways. One of the most prevalent afflictions, however, is drought – a deficit in water availability to the plant. Drought can cause a number of acclimatizing responses, such as the shedding of leaves or the inhibition of growth, to minimize the amount of water expended (Chaves et al., 2008). Other responses, such as the closing of stomates to lessen the amount of water lost through them, can indirectly affect the process of photosynthesis, the principal food-making process in plants.

Fertilizer, conversely, is meant to help aid in a plant's growth and promote various processes, including photosynthesis. The most prevalent and commonly-used fertilizers for crop plants are nitrogen-based. Nitrogen-based fertilizers are commonly employed to promote growth and nitrogen is also integral to many light-capturing compounds such as chlorophyll, which is vital for the photosynthetic process. Such fertilizers have been noted to have influence on the chlorophyll content of leaves in corn (Ma & Biswas, 2016). Due to these known facts, it was hypothesized that nitrogen would affect a plant less if it was droughted.

Methods

This experiment was conducted in the FHSU greenhouse (Hays, KS). Plants were grown in 11 cm x 11 cm pots, in which three nitrogen treatments were established: zero, low, and high nitrogen. These treatments were based on common nitrogen-based fertilizer applications of 0, 50, and 150 pounds of nitrogen per acre. The fertilizer used was a common all-purpose plant fertilizer (6-10-10), and it was weighed to introduce the appropriate amount of nitrogen.

Two water treatments were established: droughted and well-watered. The drought treatment was established by watering the plants to capacity only once they had become dry, while the well-watered treatment was watered twice per week regardless of whether they had dried or not.

Three seeds were planted per pot, each pot filled to approximately two-thirds capacity with field soil from a nearby site. Plants were then given three weeks to germinate and sprout, at which point the initial height and chlorophyll content measurements were taken ("Week 0" on graphs) and they were subjected to their treatments. Height and chlorophyll measurements were taken weekly for each plant within each pot, whereas photosynthesis measurements were taken every four weeks starting with Week 3 and used the "best" (most well-developed/green plant) plant from each pot.

Figure 2. Measuring chlorophyll concentration using a SPAD meter.

Figure 3. Measuring plant height using a standard meter stick.

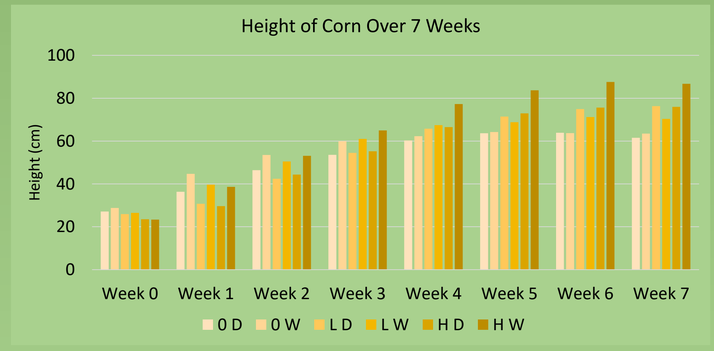

Figure 4. Average heights of corn in drought and nitrogen treatments over the course of eight weeks. D stands for drought, W for well-watered. 0, L, and H stand for zero nitrogen, low nitrogen and high nitrogen, respectively.

Results & Discussion

Over the course of the experiment, plants under well-watered conditions tended to be taller, but there were no differences between the two water treatments in terms of chlorophyll content or photosynthetic rates, which defied the initial hypothesis. There was also a significant effect from nitrogen on both photosynthesis and chlorophyll content. More nitrogen meant both higher photosynthetic rates and higher chlorophyll concentration, which was expected. The difference was greatest between the control and high nitrogen treatments; high nitrogen treatments had significantly higher photosynthetic rates and chlorophyll content compared to the control treatments.

Stomatal conductance mirrored this trend – higher nitrogen treatments showed higher stomatal conductance, whereas those with zero nitrogen showed lower stomatal conductance, even despite the drought treatments. Droughted plants normally close stomates to minimize water lost due to transpiration. However, it can also be concluded that the higher stomatal conductance did not have an effect on photosynthetic activity, as the internal CO_2 – the *other* factor controlled by stomatal conductance, which most directly affects photosynthetic activity – was not significantly affected by any of our treatments.

Overall, while there were some aspects that should be revised for further experimentation, the data gathered yields interesting insights – water is a vital part of the photosynthetic process, but subjecting our corn to drought had only marginal effect on their photosynthetic rates. In fact, the only factor that truly had a significant effect on photosynthesis or chlorophyll content was nitrogen. Future experiments will yield more data.

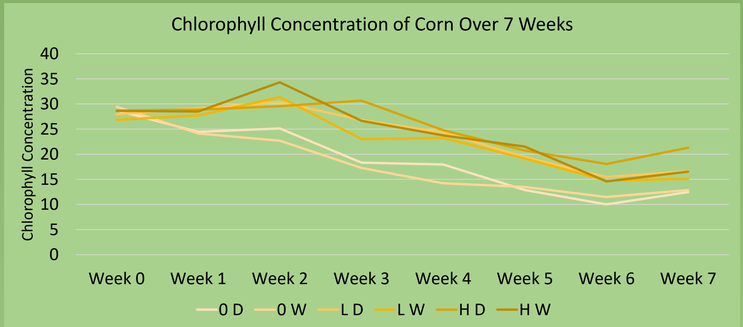

Figure 5. Chlorophyll content of corn in drought and nitrogen treatments over the course of eight weeks, as measured by a SPAD 502 Plus meter. D stands for drought, W for well-watered. 0, L, and H stand for zero nitrogen, low nitrogen and high nitrogen, respectively.

References

Ma, B.-L., Biswas, D.K. (2016). Effect of nitrogen rate and fertilizer nitrogen source on physiology, yield, grain quality, and nitrogen use efficiency in corn. *Canadian Journal of Plant Science*, *96*, 392-403.

Chaves, M. M., Flexas, J., and Pinheiro, C. (2008). Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. *Annals of Botany*, *103*, 551-560.