Spring 5-2018

The Effects of Gibberellic Acid and Auxin Hormones on Heliotropism in Sunflowers

Brandon Bernardo
Chapman University, bernardo@chapman.edu

Hagop S. Atamian
Chapman University, atamian@chapman.edu

The Effects of Gibberellic Acid and Auxin Hormones on Heliotropism in Sunflowers

Bernardo, B., Atamian, H.
Chapman University, Orange, CA

CHAPMAN UNIVERSITY
SCHMID COLLEGE OF SCIENCE AND TECHNOLOGY

SURF Summer Undergraduate Research Fellowship

Introduction

Sunflowers are one of many different plant species that are able to track and face the sun in order to optimize the amount of sunlight they are exposed to. This process of orienting towards the sun is called Heliotropism.

Sunflowers are able to effectively orient themselves towards the sun because the growth rate on the East and West side of the stem alternates depending on the time of day. At dawn, the East facing stem will grow at a faster rate than the West facing side, resulting in the flower orienting towards the West. This alternating and uneven growth is what allows the sunflower to track the sun during the day and reorient at night to face the East in preparation for sunrise.

Not much is known about the biological processes that induce heliotropism. In our study, we focused on two known growth inducing hormones in plants that are present in sunflowers, Gibberellic Acid and Auxin, and their importance to heliotropism.

Hypothesis

Because of their prevalence in sunflowers and their known ability to induce growth in plants, we hypothesized that Gibberellic Acid (GA) and an Auxin hormone, Indole-3-Acetic Acid (IAA), play a significant role in sunflower's ability to perform heliotropism.

Experimental Method

In order to test the effects of specific hormone in the sunflower's ability to track the sun during different times of the day, the following steps were executed:

- Acquire two plants prior to the development of the flower.
- Use a camera to monitor both plants for a complete day prior to applying the specific hormone we are testing.
- Apply the hormone via lanolin paste to one side of one plant, the treatment, and continue to monitor both via camera.
- Collect and analyze the pictures with ImageJ. Then, create graphs depicting any changes in orientation that occurred following the application of the hormone in comparison to the day the plant was monitored with no hormone applied.

Figure 1. An example as to how the degrees in which sunflowers move throughout the day are recorded via ImageJ and how paste containing specific hormones were applied to the plants.

Results

When GA was applied to the West side of the stem of the sunflower at dawn, the plant's ability to track the sun during the day and move from East to West was inhibited. This result is depicted in *Figure 2,* where the degree that the sunflower was able to move was significantly lower than what it was able to move prior to application of the hormone.

In *Figure 3*, GA was applied to the East side of the stem of the plant at dawn. No significant difference in movement was observed. Overall, the Treatment plants did move more directly after application of the hormone, but the standard error margin was too large to say that the findings were significant.

The application of GA to the East side of the plant at dusk, as shown in *Figure 4*, also yielded insignificant data. No significant decreases in the plants ability to reorient at night were observed. There was a slight difference in the plant's movement after the application of GA, but no significant results.

Lastly, in *Figure 5* when the second hormone that was being tested, IAA, was applied to the East side of the plants stem at dusk, a significant decrease in ability to reorient back to the East over night was observed.

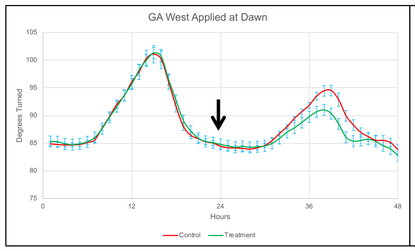

Figure 2. This graph is a depiction of when GA was applied to the West side of sunflower's stems at dawn and the hormones affect on the plants ability to perform heliotropism. Arrow indicates time of application.

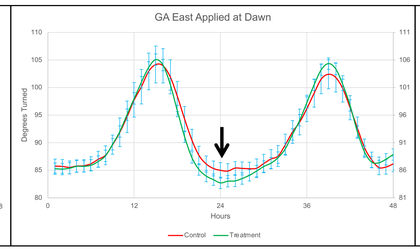

Figure 3. This graph depicts the affects GA on heliotropism when it was applied to the East side of sunflower's stems at dawn. Arrow indicates time of application

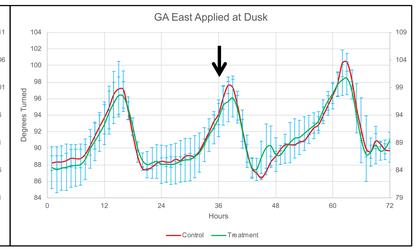

Figure 4. This graph depicts the application of GA to the East side of sunflower's stems at dusk and its affects on the plants ability to perform heliotropism. Arrow indicates time of application.

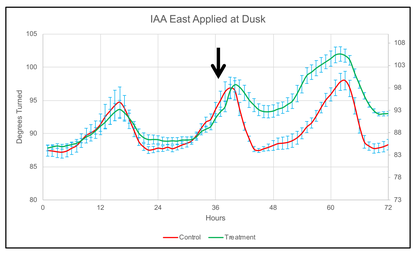

Figure 5. This graph depicts the affects of IAA on heliotropism when it was applied to the East side of the sunflower's stem at dusk. Arrow indicated time of application.

Conclusions

In the experiment in which GA was applied to the West side of the sunflowers at dawn, the unnatural surge of growth on the West side of the plant offset some of the growth that occurred on the East side and inhibited the plants ability to move from East to West during the day. This behavior is attributed to the application of GA that induced growth in the plant and is exhibited in *Figure 2*. Since the experiment was able to inhibit the plants ability to move from East to West, this result shows that GA promotes growth in sunflowers and has an important role in the function of heliotropism, which supports our hypothesis. Although the exact biological process in which GA is able to induce heliotropism is unknown, our findings show that it is an important hormone that promotes growth in the stem that allows the plant to orient and track the sun.

Figure 3 is a depiction of GA being applied to the East side of the stem at dawn. Not much significant variation was observed in the plants ability to track the sun in this experiment, as is illustrated in *Figure 3*. However, the degree of change in the morning did increase slightly after the application of the GA. This shows that the plant oriented further than it did without the GA applied, hinting that GA could also be used to enhance movement during the day if applied on the East side. Despite our observations in the field and our data, more trials need to be held to validate our hypothesis.

When GA was applied to the East at 6 pm, pictured in *Figure 4*, similar results to *Figure 3* were observed in that no significant data was collected. The main issue with this trial was that it was only replicated twice, which did not yield enough data to either support or reject our hypothesis. The expected observation was that the plants movement towards the East at night would be inhibited by the unnatural promotion of growth occurring on the East side of the plant as a result of the application of GA. However, no data that was collected supported what we expected to occur, and more trials need to be held to gather more reliable data.

In the last graph, *Figure 5*, our only experiment testing the effects of IAA on heliotropism is depicted. Data shows that when IAA was applied to the East side of plants at dusk, they were unable to orient back to the East during the night. This inability to orient back at night not only shows that IAA is an important hormone in the promotion

Conclusions (continued)

of growth in heliotropism, it is also the first time sunflower orientation at night has been successfully inhibited. More trials should be performed to reinforce our findings, but these results are a first in the study of heliotropism. These findings give insight into how heliotropism operates differently from night to day, and how orientation from West to East occurs during the night.

Future Research

For future experiments, we plan on replicating the trial that did not yield conclusive data. Past observations lead us to believe that there is a possibility that when GA is applied on the East side of the plant, both at dawn and dusk, growth is promoted. Also, because the use of IAA yielded the first data showing inhibition of movement at night and was so effective in these trials, we would like to test different combinations of the side that the IAA is applied on and the time of day it is applied on. Following up on these IAA experiments could reveal that IAA is more important to heliotropism at night, and GA is more important during the day if the proper trials are held and significant data is acquired.

Acknowledgements

Special thanks to Richard Goo, a high school student at Tustin High, who assisted us in field work, analyzing data and contributing to discussions about our experiments. Also, thanks to the UC South Coast Research and Extension Center, where our field experiments were conducted, for allowing us to use their facility.

References

Atamian, H. et al., *Science* 353, 587-590.
Briand, P.W. et al., *Journal of the Science of Food and Agriculture* 5(12).
Idris, E.E. et al., *APS Journals* 20(6), 619-626
Santner, A. et al., *Nature Chemical Biology* 5, 301-307.
Liscum, E. et al., *Plant Molecular Biology* 49(3-4), 387-400.

Figure 6. Blooming sunflower in the fields of the UC South Coast Research and Extension Center, in which our experiments were conducted.