Cory Hofstad

UGR294

Mini Research Rough Draft

**Abstract**

Research is being conducted by Undergraduate Students of North Seattle College in the fields of Ion Chromatography. In conducting this research, we learn to use the LICOR 6800 Ion Chromatography Device and collect data on plant assimilation via photosynthesis. As a research question involving Ion Chromatography, our group has decided to collect data from samples of local plant life before and after being damaged via herbivore feeding or from artificial methods of removing an area with a known diameter.

In readings conducted during this experiment, data shows that our sample plant shows high efficiency areas of assimilation when submitted to specific intensities of light from our Ion Chromatography Device. When submitted to artificial leaf damage in the form of a removal of a 6mm area via 1-hole punch, Ion Chromatography data shows that immediately after damage is inflicted, the measured section of leaf with a hole loses all ability to use light as a stimulant for photosynthesis.

The control data from this research can be used as a resource in maximizing efficiency of photosynthesis of our sample plant species using specific light intensities. Further research can be carried out in the field of plant damage to answer questions about recovery times, recovery methods and possible plant adaptation to damaged or missing sections with regard to photosynthesis efficiency.

**Our team**

Our Undergraduate Research team consists of students of UGR 294 who have decided to participate in Ion Chromatography research as our Mini Undergraduate Research project for Fall 2017. After brainstorming throughout multiple UGR classes, we have decided to collect Ion Chromatography data on leaves which have been recently damaged by herbivore threat. Our team is comprised of students with various scientific field experience and interests, which allows us to collaborate with a combined skillset which is very complementize of this research project.

During our research and throughout the process of learning how to use and manipulate the LICOR Ion Chromatography device we are assisted by our instructor Ann Murkowsky. Our Instructor Ann assisted in preparing and programming the LICOR device during the process of our readings of plants within our campus watershed.

Our group is utilizing Google Docs to share data, drafts, tables and research materials between researchers. Through document sharing we are able to utilize the most out of our time in working together online to add portions of research as individuals which we can use as a group to put together a complete research project.

**Introduction**

The plants in the wetland areas located on the north-east end of the North Seattle College Campus produce oxygen which can be measured by using Ion Chromatography. The assimilation of CO2 into oxygen can be measured for a variety of light levels, CO2 levels and humidity levels. We can then learn how individual plants react under various conditions and how assimilation is affected by these conditions.

Our team is doing research to determine if damage to a leaf effects the assimilation rates of the surrounding leaf surface on a dogwood plant within our local water table. Leaf damage can occur in situations in which herbivore predators damage sections of leaves, or when leaves are damaged by animals or breakage. The team has decided to use mealworms to test for natural damage and a standard one-hole punch used to remove a (magnitude) section of leaf.

Control readings are taken from a sample leaf without any previous leaf damage to determine a baseline of assimilation rates from a LICOR testing series which uses various light ranges to determine assimilation rates of a sample plant under normal conditions.

Tests need to be conducted on damaged leaves, so multiple leaf samples are subjected to herbivore trauma or the one-hole punch method of creating surface damage on a plant leaf.

The section of leaf is allowed time to react to the damage for 1 minute before Ion Chromatography testing is conducted using the LICOR system. Calculations are made to the LICOR system to account for the missing (damaged) leaf section.

The LICOR testing series is repeated on damaged leaf samples. Data from control readings and data from post damage readings can then be compared. Our team is then able to look for relations and/or patterns in Ion Chromatography data which provides readings on plant data including assimilation readings.

Our team is then able to compare data and come up with new questions……

**Methods**

The study was conducted in the wetland area of North Seattle College (GPS HERE), on the north-east side of campus. An attempt to take readings was made on Thursday October 19th, 2017 between 14:00-16:00, but testing was scrubbed after multiple equipment shutdowns due to excess condensation from heavy rain and weather conditions. Successful Ion Chromatography readings were taken on Tuesday October 24th, 2017 @ 14:43. These readings were taken during dry conditions which allowed for LICOR readings of plant data without equipment shutdowns during the 10+ minute readings intervals.

A group of plants was selected from a grouping of ground level plants with 10 – 20 leaves and average heights of 20cm - 45cm. A control reading was taken of a leaf with minimal pre-existing damage to collect data that is used to compare with data from our damaged samples to look for any changes in assimilation trends with and without damage. A leaf lowest to the ground was selected for Ion Chromatography readings because of its proximity to a resting area for our LICOR reading sensor.

Two Mealworms which were prepared for one week without food to promote herbivories damage to the leaves. Leaves were subjected to mealworm herbivores for a time period between 15 and 20 minutes in which they did not consume any of the sample leaves. During the time the leaves were subjected to herbivore stress, further research into mealworms was conducted in which we found that mealworms do not consume leaves, and instead consume a variety of other stock suck as carrots, wheat, oats, etc. Herbivore damage tests were concluded without success and the second method of using a standard 1-hole punch was used to artificially simulate herbivore stress on our plant samples.

A 1-hole punch with a diameter 6±0.5 mm was used to wound the leaf of a sample plant in order to gather data on leaf assimilation rates after damage from herbivores. A located of soft leaf material was removed from the leaf using the hole punch approximately 2/5 of the way from the stem to the tip of the leaf and 3/8 the distance from the center of the leaf to the outer edge. Major leaf veins were avoided to mimic damage found on other leaves of mostly soft tissue areas without heavy vein structure. The leaf was given one minute to adjust to the damage and allow the plant to exhibit any symptoms of trauma or shock which could be detected using LICOR data.

Ion Chromatography readings were then taken from the section of leaf sample damaged by removal of a 6mm leaf section by method of one-hole punch. The LICOR device was programmed to account for the missing area of leaf. Our original leaf sample was damaged and accidentally severed from the plant after artificial damaged was induced by one-hole punch method. The weight of our LICOR device broke the leaf from the stem of the plant. Our group selected a leaf similar in size, ground height, lack of damage and plant size to carry out damage tests using the hole punch method to compare to our control data.

LICOR programming and readings were taken by instructor and overseer Ann Murkowski. Data from the LICOR 6800 was uploaded to Canvas for further analysis by the scientists. Group collaboration was carried out using Google Docs and Drive services which allowed the LICOR group to share and analyses the data while working on the Ion Chromatography Research.

Ion Chromatography was used to test plant samples which we have for now identified as a dogwood plant.

**Results**

**Assimilation**

LICOR Ion Chromatography data shows two different trends in assimilation between our Control and Punch Experiments. Control data shows a highly variable range of assimilation rates over the light intensities which our LICOR device submitted our sample to. Our punch data show a trendline with a constant negative slope of assimilation rate per increase in light intensity, lower overall efficiency and a much lower range of variance from the trend line of assimilation values for the domain of light intensities in which the plant was subjected to.

Our control readings show the ability for our sample plant to produce a local maximum assimilation rate of **.2 (µmol m⁻² s⁻¹)** , when exposed to a **200 (µmol m⁻² s⁻¹)** light intensity. The data recorded from the LICOR device shows an immediate loss in the plant’s ability utilize light in the process of assimilation through photosynthesis. Time of leaf puncture was at x = -60(s), the time our readings were started was at x = 0(s), Our test was concluded at x = 1500(s).

The equation of the line for our Ion Chromatography readings for Assimilation rates vs Light Intensity on our control sample was **f(x) = (-3.98 e-5)(x) +( 0.106)**, our r2 value was = **0.071.**

The equation of the line for our Ion Chromatography readings for assimilation rates vs light intensity on our punch sample was **f(x) = (-5.38 e-5)(x)+(0.0775)**, our r2 value was = **0.807**

Our data shows that the ability to photosensitize in our sample leaf was non-existent immediately after hole punch damage has occurred. To further back our analysis of post damage data, readings could be taken of an area of the damaged leaf without the missing diameter. This would allow us to determine whether or not a missing circular diameter within our reading head contributed to our null assimilation rate readings.

While our data from the damaged leaf shows a lack of an ability to photosynthesize, our control data shows a rich variance in assimilation rates along the intensities of light in which our sample was submitted to. When data output from the LICOR 6800 device was used to create a graph of our control sample, it showed a maximum efficiency within specific light intensity ranges. This data suggests that plant assimilation can be artificially tuned via exposing a plant species to a specific intensity of light.

**Discussion**

Our control data shows that our plant samples show trends in efficiency within certain ranges of light intensity that would allow scientists to maximize the efficiency of plant assimilation in artificial conditions. Our Ion Chromatography data contained maximum assimilation rates at specific light intensities, that could be charted for different plant species in order to improve selection methods for producing larger volumes of oxygen for artificial environments and terraforming research.

* Plants used to produce oxygen in space flight would produce higher volumes of O2 under specific intensities of light which could be determined for specific plant species via Ion Chromatography
* If light intensity of specific areas of a planet are known, specific plants could be looked at for their efficiency in producing oxygen under those specific conditions. This data is valuable for future terraforming projects.

Our data shows that immediately after being damaged by the 1-hole punch method of removing a diameter of area from a plant leaf, the test leaf loses all ability to use any intensity of light to efficiently assimilate through photosynthesis. As we see many cases in nature where damaged leaves are still part of the plant structure long after being damaged, we are faced with the question of whether or not plants are able to recover the ability to use damaged leaves to assimilate through photosynthesis. Further readings of the damaged leaf should be taken to determine if the leaf has regained the ability to assimilate.

If readings of the same damaged leaf are positive for efficient assimilation data, we could then analyses data related to long term changes in efficiency of single leaves damaged by physical removal of a known diameter. We could then compare data from single leaves to data collected on average damage of plants in our area to determine at what efficiency these plants are able to photosynthesize in their natural habitat.

* If we find that plants are able to recover the ability to photosynthesize with damaged leaves, further data on could be collected to determine average recovery times in plant leaves by size and other variables.
* New readings of a damaged leaf sample could be taken in decreasing time intervals until a consistent recovery time could be determined.
* Multiple readings of different sized leaves could be taken to find recovery time per gram of plant, which could be used to determine recovery rate per mol of plant substance or per volume.

As we further research into plant recovery, we could attempt to look at how the plant recovery process works.

* Do plants re-route resources around damaged leaf sections?
* Do plants cauterize their wounds and work around damaged tissue?
* Do plants perform compensation for damaged leaf sections to perform at maximum efficiency?
* Can plants learn to compensate for new leaf damage after initial trauma is recovered from?
* What steps are involved in plant recovery?

Also, separate readings should be recorded of a section of the damaged leaf without the hole on it. It would bring confidence to the analysis of the data to know if the recording of data is effected by the hole punch being within the recording area.

**Conclusion**

Initial readings of our control experiment show high efficiency areas in our data that produce higher assimilation rates at specific values of light intensity. In Ion chromatography tests conducted on our 1-hole punch experiments, immediately after a section is removed from a leaf, it loses the ability to efficiently use the light of our LICOR device for photosynthesis. These two data tables show that immediately after damage has been inflicted on our test leaf, it losses the ability to use any intensity of light for photosynthesis. The fact that our leaf showed decreasing assimilation rates with increasing light intensity shows that for photosynthesis the leaf is at this point non-functional.

Data from our control specimen shows that our plant sample reacted to a specific intensity of light to produce high levels of assimilation. Further research in local minimums and maximums of assimilation vs light intensity would allow scientists to produce higher volumes of oxygen in artificial environments through photosynthesis.

Further research needs to be carried out to discover whether plants have the ability to recover from the punch damage and operate with efficient levels of assimilation instead of providing data that shows a linear downward slope of assimilation vs light intensity. Further research would allow scientists to learn more about plant recovery, including recovery time, recovery methods and post recovery efficiency.

Bibliography

Using the LI-6800 Portable Photosynthesis System Instruction Manual. (n.d.). Retrieved November 05, 2017, from https://www.licor.com/documents/6afbbpwybdanht6xrbgwicur4yohpx1n