Investigating the Differences in the Elemental Composition of Pollen from Common Houseplants Under Different Growing Conditions Using Laser Induced Breakdown Spectroscopy

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Overview

The effects of location, and fertilizer on plant matter was analyzed with laser induced breakdown spectroscopy over 8 weeks on 3 different types of plants. Elements were observed to change by fertilizers while locations did not show much of a difference. All plants with fertilizer added showed a change in levels of K and N. Pollen can be individualized under specific circumstances. There is not enough research to confirm if plant species have unique elemental profiles.

Introduction

Laser induced breakdown spectroscopy (LIBS) is an instrument that sends laser pulses into the sample, creating a plasma that results in a vaporization of small amounts of the target material. The light released from the plasma excites electrons into higher energy levels, and as the plasma cools, the movement of electrons moving to ground state emits wavelengths of light, corresponding to a particular element. Previous experiments showed that LIBS was capable of determining the elemental composition of plant leaves to identify spectroscopic markers (Kunz, 2017) , as well as studying levels of metal concentrations in tree stumps (Martin, 2007) . Pollen is significant in forensic science because it is a commonly found type of trace evidence used to link specific objects and locations. If LIBS is able to express that pollen does have an individualistic elemental profile, there is a higher possibility that the pollen sample can be connected back to a particular plant. This can be a significant aspect used in forensics, to identify the origins of plant matter found at a crime scene.

The *goals* of this research to determine if:

- different plant species have different elemental profiles
- the location of the plants played a change on their elemental composition
- pollen can be individualized by their elemental composition

Materials and Methods

Plants (3):Orchids, anthuriums, and peace lilies.

Locations (3): DODDS room 408, DODDS room 304, House in Middletown, CT

Fertilizers (2): Jack's 20-20-20 fertilizer, Jack's 10-30-40 fertilizer

- 6 plants of each variety were placed in room 408, and 3 plants of each variety were placed in room 304 and the location in Middletown, CT.
- After locations were determined, the plants were placed alongside the window sill, or farther from the window according to their light requirements.
- Each week, the plants were routinely watered, hole punched (3/4 inch hole punch), and pollen was collected from blooms. For the desired weeks testing fertilizer, the plants were watered weekly with its corresponding fertilizer at ¼ tsp in 1 gallon of water (3785 mL).
- To prepare the leaf samples for analysis, they were placed on a labeled glass slide with double sided tape and placed into the loading dock. Depending on the sample, there were corresponding methods to how the sample is shot in LIBS (the model J200 from Applied Spectra) and parameters to get the optimal spectra reading.
- All spot size of the laser were set to 40 micrometers for all samples

Results

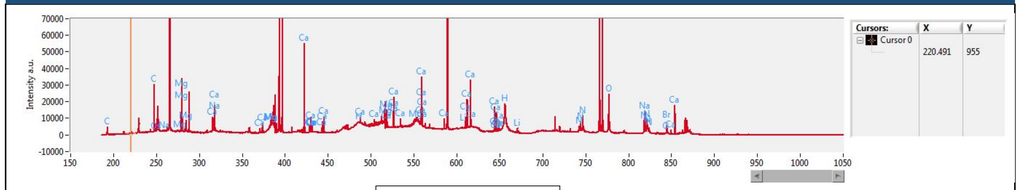


Figure 1: LIBS spectra example

Figure 1 is an example spectra from a sample of anthurium leaf. From the spectra you can see the abundance of Ca peaks, and a clear view of the oxygen peak at the 777 wavelength.

Fig. 3 Average Intensity of K in Orchid Pollen

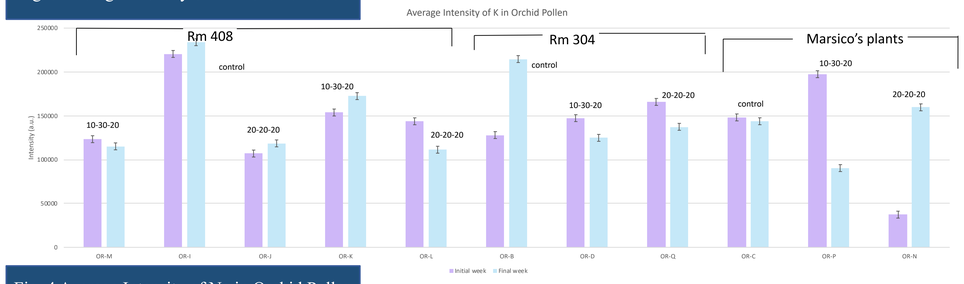


Fig. 4 Average Intensity of Na in Orchid Pollen

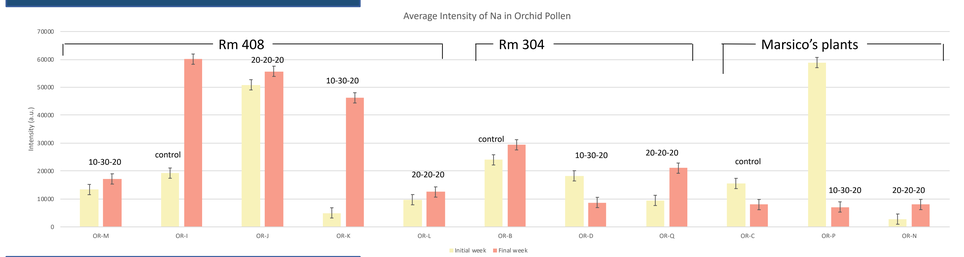
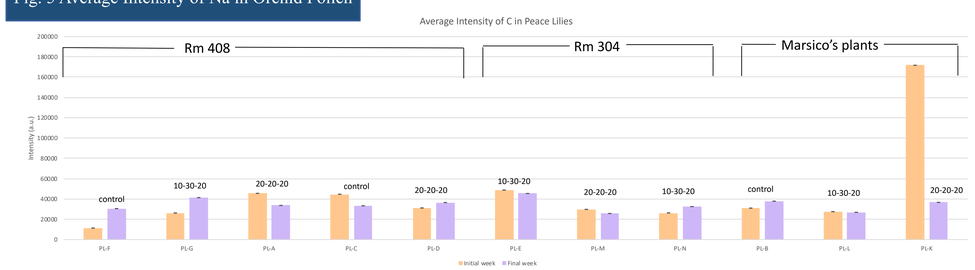


Fig. 5 Average Intensity of Na in Orchid Pollen



Discussion

- Figures 3 to 5 show the initial and final week for each plant in the levels of average intensity of K in Fig. 3, the average intensity of Na in Fig. 4 for orchid pollen. Lastly the average intensity of Na in orchid pollen for Fig. 5. The graphs are also labeled with location and the various fertilizers added throughout the project
- From observing the graphs, differences can be seen, but it is difficult to establish any concrete trend lines
- All the graphs for the elements studied (Barium, carbon, potassium, calcium, oxygen, hydrogen, magnesium, nitrogen) in the leaf and pollen samples followed no discernable trends (similar to the above graphs)
  - Most shots of the sample did show an increase in elements of nitrogen and potassium. Certain samples from other plants showed rather the opposite occurring, making it harder to interpret if a fertilizer was added at all or if location made a difference.

Conclusion

- We were able to investigate that there were visible differences in the elemental composition of plant matter from common houseplants under different growing conditions using laser induced breakdown spectroscopy
- Unless the location of the plants had a drastic difference in environment, it is difficult to decipher if there is a geological difference between each plant
  - The plants placed in DODDS had no real observable change because the environments were too similar and no stress was generated (similar light patterns, same water source). Because Dr. Marsico's house was more of a bigger change it's plausible the increase in sodium detected in her plants are attributed to the increase in stress levels
- There is also the potential issue of misidentifying peaks in the spectra as well.
  - Some elements seen in the spectra were excluded from the analysis due to lack of relevance
- We were successfully able to see the growing conditions of some of the plants reflected back in the elemental composition of the plant matter
  - The increase in C could be consistent with the increase in decaying matter from the plants, as some were sunburnt and dropped their leaves
  - The change in Na could indicate the stress level in plants
  - Change in N, and K could be attributed to the respective fertilizers
- Homogeneity is also an inevitable issue that could explain the lack of a observable trends observed in the graphs.
  - It is near impossible to have a even consistency of each element throughout the whole sample.
- We were able to detect subtle differences in the elemental composition from the different growing factors, but there is not enough research done to concretely say that we can individualize each plant. In terms of forensics, the research isn't enough to connect back to a specific plant at a specific location due to issues in homogeneity and the lack of research.

Future Direction

- The environment factors in this experiment weren't drastic enough to see a clear change in the elements composition spectra, so making these more drastic could result in discernable changes
- Homogeneity of each sample was a major factor that impacted the results, possibly better sample prep, such as grounding and making the samples in pellets, would be more efficient
- More research on finding accurate parameters could yield better results with more significant elements found using LIBS (could not find phosphorus at all)
- Conducting this experiment with possibly ICCD instead of EC to compare our results are due to sensitivity of the instrument itself
- Conducting this experiment but with flower petals to investigate if we can observe an elemental differences from different growing conditions

References

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