Plant Growth and Food Security in a Changing Atmosphere

Andrew Walter-McNeill, 2019

Through the wonderous chemistry of photosynthesis, plants manufacture all of the sugar they need to survive. After a sugar molecule is produced, it must be transported to a part of the plant where it can be metabolized. If a plant is struggling to get enough water, it might invest this sugar into more root hairs to scout for novel water sources. If it suddenly cannot get enough sunlight (perhaps due to a neighbor's recent growth spurt), it might use its sugar to grow taller, or produce wider leaves.

Since plants do not have brains, they do not consciously "decide" how to use their sugar, but they do employ complex hormonal signaling systems that allow their different structures to communicate, enabling them to be efficient with their sugar use. This process is known as resource allocation. In a competitive environment with limited resources, investing in the wrong structures can prove costly, so modern plants have evolved to be masters of resource allocation. However, the recent and rapid increase in atmospheric carbon dioxide has dramatically altered the ratio of resources available to plants (less water and nitrogen available per unit of CO2). Due to our limited understanding of the mechanisms behind resource allocation, it is unclear how this atmospheric change might affect plant growth in the coming decades. Given that plants are at the bottom of every food chain on earth (including our own), this uncertainty is concerning. My research this summer aimed to lower this uncertainty.

Collaborating with Dr. Barry Logan of Bowdoin College, Dr. David des Marais of MIT, and my Bowdoin peer Anna Blaustein at Harvard University's Arnold Arboretum, I explored the effects of atmospheric CO2 concentration on resource allocation in grasses in the genus *Brachypodium*. *Brachypodium* has recently been established as a good model system for cereal grains, like rice, wheat, and corn, which account for the majority of the calories humans consume around the globe. Though it is closely related to wheat, *Brachypodium* is unlike most cereal grains because it has a short generation time, and a small, already sequenced genome, qualities that make it very easy to work with.

We reared 960 *Brachypodium* individuals to maturity in low (180 ppm), medium (400 ppm), and high (1500 ppm) CO2 concentrations. 36 plants were harvested each week after germination, creating a representation of growth and resource allocation over time with ample replication. For each harvest, plants were separated into their different structures (roots, stems, leaves, flowers, and seeds) which were then weighed and scanned (scans were later used to calculate area). Other data on metabolites, photosynthetic rate, and pigment content were also collected.

Complete results are still being finalized as of this writing, but preliminary analyses have yielded one intriguing finding. Overall biomass was clearly compromised throughout the experiment in the low CO2 chamber, as expected. However, *Brachypodium* growth appeared to suffer slightly in the high CO2 chamber, compared to the medium—an unexpected result. The medium CO2 concentration is quite close to current conditions, and while it is unlikely the atmosphere will ever contain 1500 ppm of CO2, the slight downward trend in biomass observed in the high chamber does not bode well for future plant growth.

Especially because this finding is inconsistent with existing literature, more data need to be collected, and more robust analysis conducted before this result can be reported with confidence. However, it demonstrates the clear need for further research on the relationship between plant growth, resource allocation, and our changing atmosphere.

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