Project Notes:

Project Title: Utilizing sucrose to upregulate nitrate assimilation and protein production in plants under elevated CO_2 conditions

Name: Golji, Mohammad

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times, so set aside enough time in your schedule.

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
What soil additive or stimuli to use/ develop	I can use cytokinin and sucrose as primary additives to enhance NR performance and protein production. Preliminary tests using attapulgite to increase SWR may be conducted beforehand (from conversations with Dr.C) Light can be incorporated as another stimuli- has a large impact on NR regulation.	From both Transcription factors involved in controlling the expression of nitrate reductase genes in higher plants and The interaction between elevated carbon dioxide and nitrogen nutrition. Conversations with Dr.C about potential project ideas and developments.	9/28/2025
How to measure nitrite and nitrate	Griess reaction with nitrite. Conversion (through non-organic ion or enzyme) of nitrate to nitrite to use Griess to measure nitrate.	Conversations with Dr. C. Information regarding test specifically located with High Throughput Griess Assay of Nitrite and Nitrate in Plasma and Red Blood Cells for Human Physiology Studies under Extreme Conditions Brizzolari, A., Dei Cas, M., Cialoni, D., Marroni, A., Morano, C., Samaja,	10/2/2025

		M., Paroni, R., & Rubino, F. M. (2021). High-Throughput Griess Assay of Nitrite and Nitrate in Plasma and Red Blood Cells for Human Physiology Studies under Extreme Conditions. *Molecules*, *26*(15), 4569. https://doi.org/10.3390/molecules26154569	

Literature Search Parameters:

These searches were performed between (8/21/2025) and XX/XX/2025.
List of keywords and databases used during this project.

Database/search engine	**Keywords**	**Summary of search**
Gordon Library: Agriculture	Soil Additive, Soil	Articles on environmentally friendly soil additives use of manufacturing additives in agriculture
Gordon Library: General	Micrograms AND protocol	Wide variety of specific measurement protocols for topics outside my research (ex. Proteins). Since I want to be measuring sucrose out in micrometers, I will add that to the subsequent search. I also learned Mm referred to micro moles not micrometers, that will adjust as well.
Gordon Library: General	Micromoles AND protocol AND Sucrose	This had little relevant results, most being specific studies on crops. Little involved a protocol.

Google Scholar	Elevated CO2 affecting Nitrate Reductase	Many articles on mostly organism-specific studies comparing a change in CO2 levels to some form of nitrate assimilation. More information about nitrate reductase was needed from here
Google Scholar	Nitrate Reductase	More articles involving nitrate reductase. A lack of search parameters led to many different articles with little use.
Science Direct	Nitrate Reductase	Definition was provided based on different sources. This allowed me to analyze Transcription factors involved in controlling the expression of nitrate reductase genes in higher plants (Yanagisawa 2014) which provided a lot of needed information on Nitrate Reductase as well as Glutamine Synthetase (similarly involved in nitrate assimilation).
Google Scholar	sucrose foliar application	Little relevant foliar applications. Failed to access a patent
Google Scholar	sucrose AND measurement AND plant	Variety of articles discussing sucrose measurements in plants across a variety of contexts.
Google Scholar	plant samples AND liquid nitrogen	Manya articles detailing DNA extraction. Few articles involving nutrient measurements
Google Patents	Nitrate Reductase	Patents regarding

		compounds and procedures for cellular enzymatic reactions.

Tags:

Tag Name	

Article #1 Notes: Title

Article notes should be on separate sheets

Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: "Individual Versus Combined Effects of Warming, Elevated CO2 and Drought on Grassland Water Uptake and Fine Root Traits"

Article notes should be on separate sheets

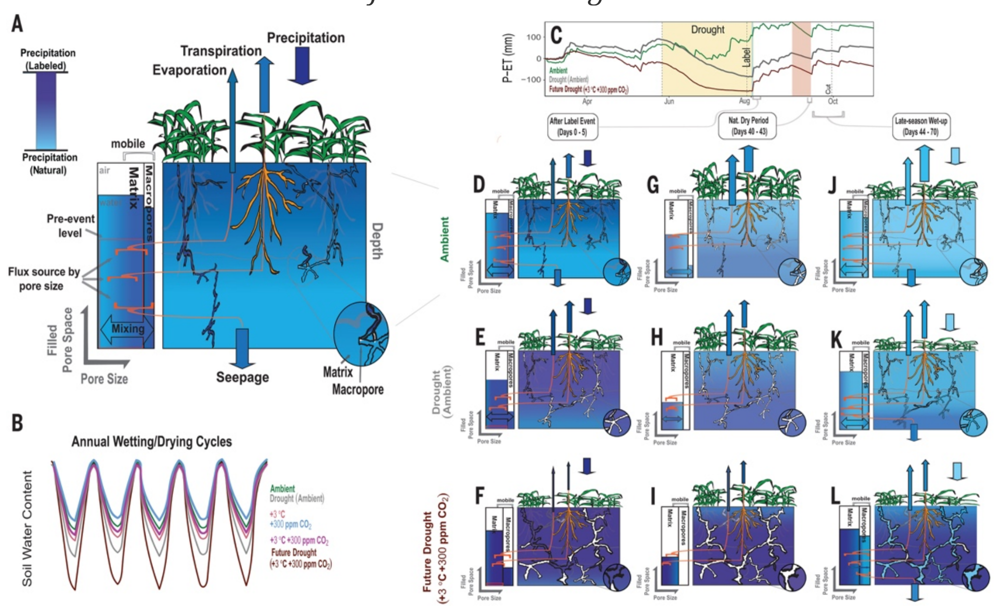
Source Title	Individual Versus Combined Effects of Warming, Elevated CO2 and Drought on Grassland Water Uptake and Fine Root Traits
Source citation (APA Format)	Tissink, M., Radolinski, J., Reinthaler, D., Venier, S., Pötsch, E.M., Schaumberger, A. & Bahn, M. (2025). Individual versus combined effects of warming, elevated CO2 and drought on grassland water uptake and fine root traits. *Plant, Cell & Environment, 48*: 2083-2098. https://doi.org/10.1111/pce.15274
Original URL	https://onlinelibrary.wiley.com/doi/10.1111/pce.15274
Source type	Journal
Keywords	Drought. Root Water Uptake (RWU). C3 Grasslands. Climate Change.
#Tags	
Summary of key points + notes (include methodology)	Using n=25 different plots, the team assigned multiple treatments of +eCO2, +T(C°), and increased drought, and their combinations across plots to find the connections between these environmental traits and its effects such as root water uptake and fine root growth. The team found that high temperatures under drought would further exacerbate the reductions in root water uptake (RWU), whereas increases in CO2 would decrease those effects; ultimately reinforcing the findings discussed in the article "Drought in a warmer, CO2-rich climate restricts grassland water use and soil water mixing" which was also developed by the same researcher, Jesse Radolinski.
Research Question/Problem/ Need	The study tackles the question of how future warming conditions, elevated CO2, and increasing drought levels will impact a variety of

	grassland traits through both individual and combined effects.
Important Figures	- Warming increased the ration of fine root production to shoot production by **48%**, while also decreasing SRL by **20%** - Droughts increased plant water intake from the deepest soil levels from a variable range of **20-50%**
VOCAB: (w/definition)	- C3 grassland: Grasses growing in cooler conditions under either wet or dry environments - Stomatal: referring to the stomata of a plant - Phenological: referring to/ of the study of seasonal natural and cyclic phenomenon - Linear Mixed Effects Models: an extension of simple linear models that include both fixed and random effects
Cited references to follow up on	- The Austrian Academy of Sciences (ÖAW) ESS-project "ClimGrassHydro"
Follow up Questions	To further the research and my own understanding, I would ask: • How could the size of each plot (4m by 4m) influence the results through a lack of biodiversity? • When increases in CO_2 reduce the plants' intake needs allowing them to survive on little water, how does the plants' long-term growth get impacted and what does that look like for our future grasslands? • Were there, or would there be, any day-to- day effects on RWU for any spikes in the set conditions, such as a high outlier temperature?

Article #2 Notes: Article #2 "Drought in a warmer, CO2-rich climate restricts grassland water use and soil water mixing"

Article notes should be on separate sheets

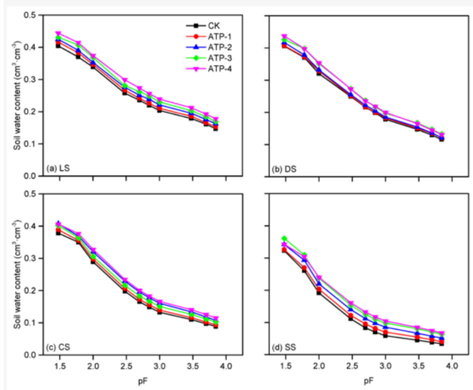
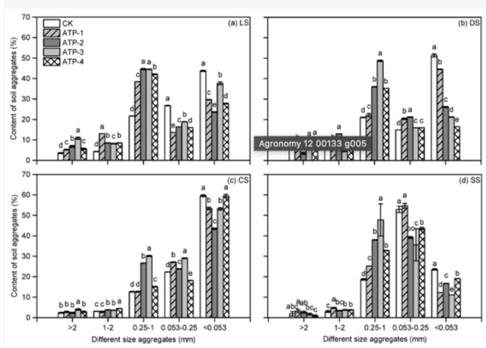
Source Title	Drought in a warmer, CO2-rich climate restricts grassland water use and soil water mixing
Source citation (APA Format)	Radolinski, J., Matevz Vremec, Wachter, H., Birk, S., Brüggemann, N., Herndl, M., Ansgar Kahmen, Nelson, D. B., Kübert, A., Schaumberger, A., Stumpp, C., Tissink, M., Werner, C., & Bahn, M. (2025). Drought in a warmer, CO 2 -rich climate restricts grassland water use and soil water mixing. Science*, 387(6731), 290–296. https://doi.org/10.1126/science.ado0734 *after cross checking with multiple sources the only confirmed journal it was published in was Science vol 387
Original URL	https://www.science.org/doi/10.1126/science.ado0734
Source type	Journal
Keywords	Drought, Climate change, CO2, Grasslands
#Tags	
Summary of key points + notes (include methodology)	The article "Drought in a warmer, CO2-rich climate restricts grassland water use and soil water mixing" explores the impacts of heightened temperature, CO2, and future drought conditions on soil-water transport and evapotranspiration in select grasslands. The study was composed of 3-6 replicated experiments per treatment in a large Austrian grassland. Treatments included individual and combined effects of heightened CO2, increased temperature, and recurring drought using a deuterium labeling system (h2) to track precipitation and soil-water movement throughout the process. Not only does the study relate how an increase in CO2 levels will conserve the use of water in plants under drought conditions and an increase in warming will increase the need of water for the same plants, but under future drought conditions the mixing between old and new precipitation in the rootzone will greatly depreciate and plants will

<table>
<tr><td></td><td>more commonly rely on newer precipitation. Highlighting the strange effects of a future global climate, this study points towards a shifting relationship within rootzone soil between precipitation events and water usage, indicating a new understanding of rootzone soil water and significant repercussions for the availability and flow of surface water in the near future.</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>How does global warming and climate change affect soil-water movement in grassland.</td></tr>
<tr><td>Important Figures</td><td>- Grasslands cover 30 to 40% of Earth’s terrestrial surface
Below are a combination of graphical representations of subterranean water flow across drought levels


</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>- Abiotic factors: non-biological environmental factors
- Ecohydrological: adjective describing processes, systems, or factors related to ecohydrology
- Ecohydrology: scientific field that studies the interactions between water and ecology</td></tr>
<tr><td>Cited references to follow up on</td><td>- A. M. Ukkola, I. C. Prentice, T. F. Keenan, A. I. J. M. van Dijk, N. R. Viney, R. B. Myneni, J. Bi. (2016). Reduced streamflow in water-stressed climates consistent with CO2 effects on vegetation. Nat. Clim. Chang. 6(), 75–78.</td></tr>
<tr><td>Follow up Questions</td><td>- Having considered developing a heat-expanding supplement to break up dry soil during the drought, I now question how a segregated soil-water setting will be affected by physical mixture and expansion, and how that will then affect the ecohydrological climate of modern agriculture.</td></tr>
</table>

Article #3 Notes: An Environmentally Friendly Soil Amendment for Enhancing Soil Water Availability in Drought-Prone Soils

Source Title	An Environmentally Friendly Soil Amendment for Enhancing Soil Water Availability in Drought-Prone Soils
Source citation (APA Format)	Yang, T., Xing, X., Gao, Y., & Ma, X. (2022). An Environmentally Friendly Soil Amendment for Enhancing Soil Water Availability in Drought-Prone Soils. *Agronomy*, *12*(1), 133. https://doi.org/10.3390/agronomy12010133
Original URL	https://www.mdpi.com/2073-4395/12/1/133
Source type	Journal Paper
Keywords	Attapulgite, Soil Additive, Soil, Drought.
#Tags	
Summary of key points + notes (include methodology)	- "Applied ATP (attapulgite) can enhance soil water retention and soil stability, which may improve limited water use efficiency and relieve soil desiccation in arid and semiarid areas or similar hydrogeological areas" - Clay mineral attapulgite is used to moderate the balance between soil and water in an environment - ATP was tested on a variety of different soils to judge its water retention - These soils included (1) lou soil (LS), (2) dark loessial soil (DS), (3) cultivated loess soil (CS), (4) sandy soil (SS) - 20 treatments were prepared with replication of 3, netting 60 - Soil mixtures were dried, then tested for water retention through a variety of factors -
Research Question/Problem/ Need	- Plants in certain climates are harmed by their own water needs and high growth rates in inadequate, unbalanced soil with limited clay content - Their hypotheses: (1) applied ATP improves the water holding capacity significantly, (2) the soil structure will be improved within a specific range of addition by adding ATP, and (3) ATP

	has a more beneficial effect on sandy soil than other soils.
Important Figures	- The clay content of LS, DS, CS, and SS with ATP-3 treatments were increased by 11.2%, 6.5%, 25.4%, and 53.7%, respectively - Statistical analysis revealed that ATP has no significant effect on the CP (capillary porosity, import component of water retention in pores), but has significant effects on other physical parameters. **Figure 2.** Soil water retention curve (SWRC) for lou soil (LS), dark loessial soil (DS), cultivated loess soil (CS), and sandy soil (SS). pF = log10|h|, where h is the pressure head (cm).  - **Figure 5.** Composition of soil water-stable aggregates with lou soil (LS), dark loessial soil (DS), cultivated loess soil (CS), and sandy soil (SS). Different letters within a size fraction indicate significant differences between the four treatments ($p < 0.05$). Error bars refer to the standard deviation.  -
VOCAB: (w/definition)	- Porosity: quality of being porous (full of small holes). Ratio of pore volume to total volume - Aggregate: whole composed of small pieces, loosely compacted mass - Supernatant: (denoting the) liquid lying above a solid residue after a process such as crystallization or centrifugation
Cited references to follow up on	- Ding, D.; Zhao, Y.; Feng, H.; Peng, X.; Si, B. (2016). Using the double-exponential water retention equation to determine how soil pore-size distribution is linked to soil texture. *Soil Tillage Res*, *156*, 119–130. [Google Scholar] [CrossRef]

	- Chen, Y., Wang, K., Lin, Y., Shi, W., Song, Y., & He, X. (2015). Balancing green and grain trade. *Nature Geoscience*, *8*(10), 739-741.
	  ○ *this was mentioned in the text, important to read*
	- Laird, D. A., Fleming, P., Davis, D. D., Horton, R., Wang, B., & Karlen, D. L. (2010). Impact of biochar amendments on the quality of a typical Midwestern agricultural soil. *Geoderma*, *158*(3-4), 443-449.
	  ○ *Could be relevant*
	- Zhang, C., Zeng, G., Huang, D., Lai, C., Chen, M., Cheng, M., ... & Wang, R. (2019). Biochar for environmental management: Mitigating greenhouse gas emissions, contaminant treatment, and potential negative impacts. *Chemical Engineering Journal*, *373*, 902-922.
	- Sheffield, J., & Wood, E. F. (2008). Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. *Climate dynamics*, *31*(1), 79-105.]

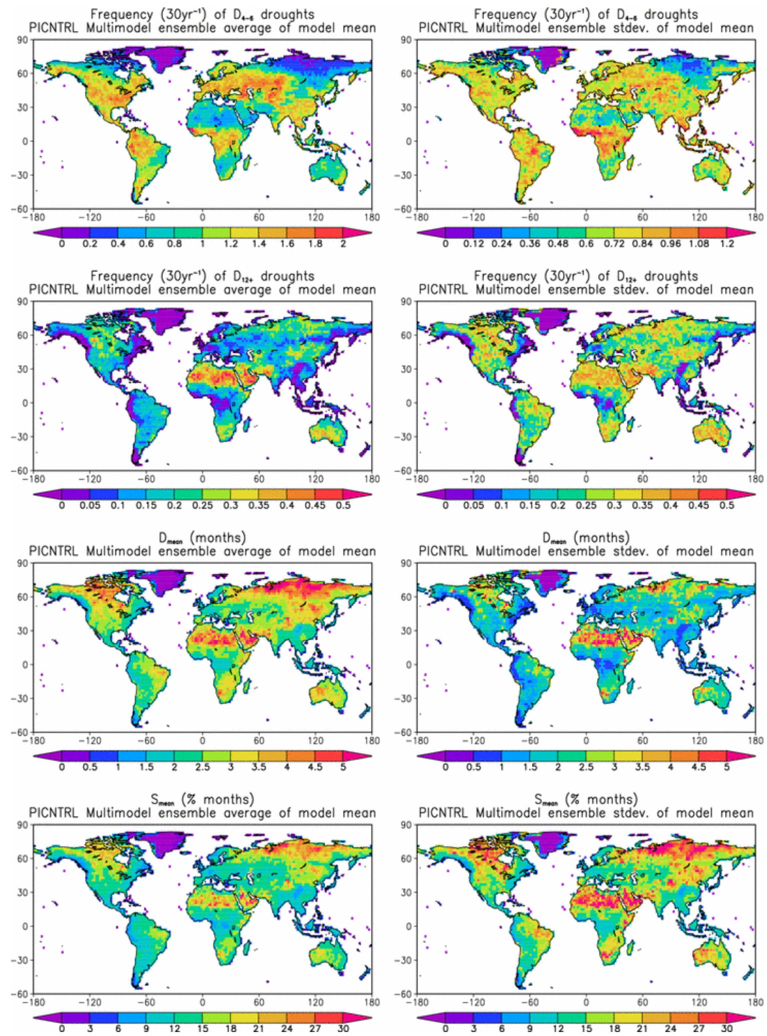
Follow up Questions	- How can ATP's composition be optimized for this use - Will more aggregate soils have a stronger soil-water system under future drought - if plants were tested as a next step in this soil development, how would their growth and life directly face an impact?

Article #4 Notes: Projected changes in droughts occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations

Article notes should be on separate sheets

Source Title	Projected changes in droughts occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations
Source citation (APA Format)	Sheffield, J., Wood, E.F. (2008). Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. *Clim Dyn 31*, 79–105. https://doi.org/10.1007/s00382-007-0340-z
Original URL	https://link.springer.com/article/10.1007/s00382-007-0340-z#citeas
Source type	Journal- Complete Paper on *Nature*
Keywords	Soil Moisture, Future Climate Scenario, drought
#Tags	
Summary of key points + notes (include methodology)	- global warming is correlated to drought change - The study thought to use a variety of virtual models to predict drought conditions and frequency to a strong level of confidence - Drought variables included long term frequency and longevity versus short term, soil moisture during and without drought, geographic specific climates - Drought increases were driven mainly from lack of rain and increased evaporation, and in some regions even precipitation increases were still offset by evaporation - Before this study, the IPCC had already predicted a “likely” increase in droughts in certain regions - Data was used from the IPCC AR4 General Circulation Model (GCM) simulations. As the range of future climates predicted with GCMs was large and regionally dependent, data was taken from multiple GCMs and three scenarios: A2, A1B, and B1 - Each scenario’s fixed variables included changes in population, economy, land use, energy use, and maximum CO2 concentration - Drought prevalence was defined as a long period of low soil moisture

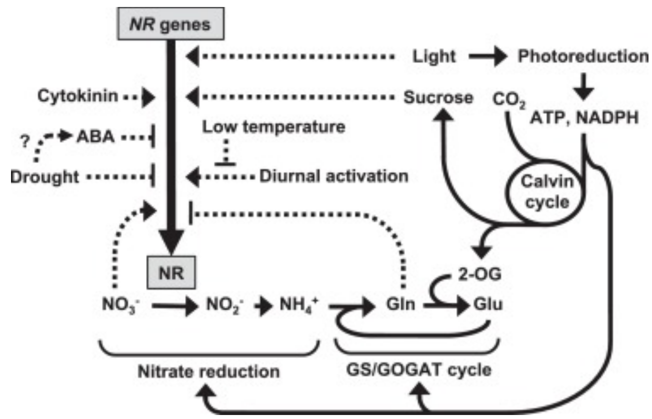
	- Changes in drought are tested with alpha (significance level) of 0.05% - The simulations suggested that the frequencies of shorter droughts would be found in more tropical areas, while longer droughts would be more frequent in North America, Mid-Asia, and Eastern South America - Frequency and condition were highly variable across different regions - Larger areas were predicted to have a greater frequency of shorter droughts, whereas longer droughts were globally scattered - Prolonged droughts (12+ months) were projected to increase in frequency alongside high CO2 emission scenarios - Predicted changes in regional drought were skewed towards the warmer season - Precipitation and evaporation are expected to be the main determinates of drought. Precipitation increases soil moisture, but heightened temperatures cause increased evaporation which take it away - As their alpha is 0.05, the study recognizes an increased risk in a type-1 error
Research Question/Problem/ Need	How does global warming and established climate factors contribute to the frequencies and conditions of droughts over the next century.
Important Figures	- over the next years long term droughts are estimated to become 3x more common - Larger land areas were expected to experience over 5 droughts across a 30-year period

	 -
VOCAB: (w/definition)	- IPCC: intergovernmental panel on climate change - Aerosol(s): microscopic solid particles or liquid droplets suspended in the air
Cited references to follow up on	Ciais, P., Reichstein, M., Viovy, N. *et al.* (2005). Europe-wide reduction in primary productivity caused by the heat and drought in 2003. *Nature* ,*437*, 529–533. https://doi.org/10.1038/nature03972
Follow up Questions	- Why was a t-test used for changes in drought as opposed to a Chi-Square test when comparing multiple models? - They predicted the conditions of small and long droughts, but not medium length. Why?

Article #5 Notes: Transcription factors involved in controlling the expression of nitrate reductase genes in higher plants

Article notes should be on separate sheets.

Source Title	Transcription Factors Involved In Controlling The Expression Of Nitrate Reductase Genes In Higher Plants
Source citation (APA Format)	Yanagisawa, S. (2014). Transcription factors involved in controlling the expression of nitrate reductase genes in higher plants. *Plant Science*, *229*, 167–171. https://doi.org/10.1016/j.plantsci.2014.09.006
Original URL	https://www.sciencedirect.com/science/article/pii/S0168945214002234?via%3Dihub
Source type	Journal- Plant Science
Keywords	Enzymes, Nitrate Reductase, Plants
#Tags	
Summary of key points + notes (include methodology)	- Nitrate Reductase is influenced by a wide variety of envoromental factors. - NR can be upregulated in plants by sucrose, light, cytokinin, but de-regulated by Glutamine, low temperature, and drought - Nitrate assimilation is highly energy dependent, and is strongly affected by light sources -Glutamine synthetase functions similarly - Sucrose can enhance nitrate assimilation through a variety of factors, even inducing nitrate assimilation in low-energy environments - NLP genes have been found to have a very nuanced impact on NR - This study reviewed and summarized the current understanding of NLP on NR and nitrate assimilation - They discussed how NLP can regulate NR alongside environmental factors, and how specific genes will also modulate other pathways of the plants - By identifying all transcription factors involved in NR, the paper hypothesized that a greater understanding will be reached

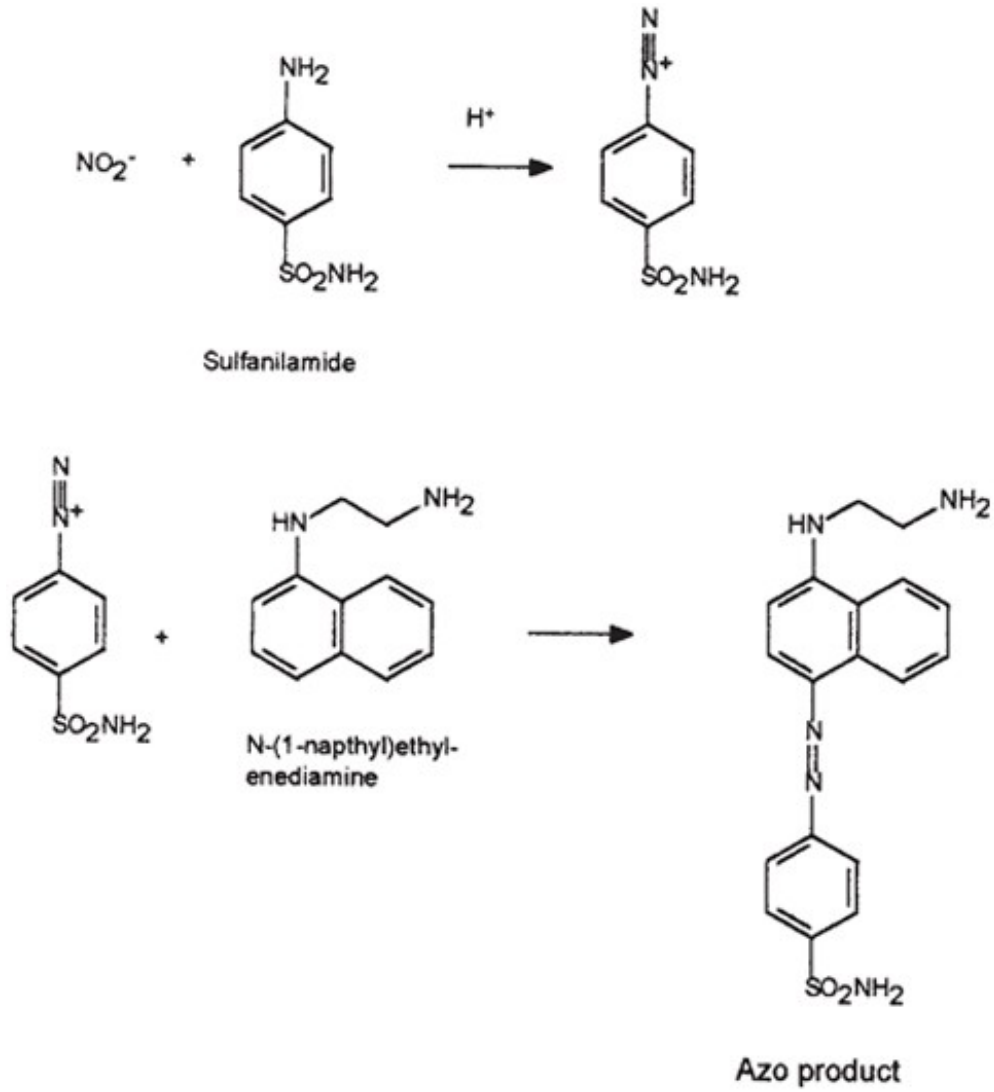
<table>
<tr><td></td><td>regarding the complete mechanics of Nitrate assimilation, which is very important for agriculture</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>How do NLPs impact and regulate NR expression according to current research?</td></tr>
<tr><td>Important Figures</td><td>


This figure relates the up and down-regulators of NR through NR genes and photosynthesis</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>Biosynthesis: important biological function in which enzymes are used to produce complex compounds, usually using energy derived from ATP or the sun</td></tr>
<tr><td>Cited references to follow up on</td><td>Hoff, T., Truong, H.-N., & Caboche, M. (1994). The use of mutants and transgenic plants to study nitrate assimilation. Plant, Cell and Environment, 17(5), 489–506. https://doi.org/10.1111/j.1365-3040.1994.tb00145.x</td></tr>
<tr><td>Follow up Questions</td><td>
- Under very high CO2 conditions, how does a plants energy needs increase to support nitrate assimilation?
- What environmental stimuli have the greatest effect on NR gene
- Are the effects of sucrose on NR greater when taken from photosynthesis or through an artificial insertion</td></tr>
</table>

Article #6 Notes: The Enzymatic Measurement of Nitrate Nitrite

Article notes should be on separate sheets

Source Title	The Enzymatic Measurement of Nitrate and Nitrite
Source citation (APA Format)	Titheradge, M.A. (1998). The Enzymatic Measurement of Nitrate and Nitrite. *Methods in Molecular Biology*, *100*. https://doi.org/10.1385/1-59259-749-1:83
Original URL	https://link.springer.com/protocol/10.1385/1-59259-749-1:83#citeas
Source type	Journal- Protocol
Keywords	Nitrate, Enzymes, Griess, Protocol
#Tags	#how-to #measurements
Summary of key points + notes (include methodology)	- Nitrate and Nitrite are primary measurements of nitrate assimilation and reaction in an organism, where nitrite is the product which is then synthesized in the biological system further - These two are usually measured in a two-step procedure using the Griess Reaction: - Nitrite is measures, then the nitrate is converted to nitrite (through enzymes or certain nonorganic reactants like metallic Cadmium) to be measured - The difference in the two nitrite measurements yields the nitrate measurement - The Griess reaction is first prepared with the combination of (1-naphthyl)ethylenediamine hydrochloride and sulfanilamide - Enzymes (or nonorganic) are applied to nitrate to convert to nitrite (specifically enzyme Formate Nitrate Reductase—most common) - Nitrite/Nitrate standards are incubating with Griess solution or 15 minutes to develop color - Colorimeter is used to measure nitrite content - Subsequently a standard curve is developed to relate nitrate to nitrite - This curve can be used to study nitrate assimilation and NO activity in the organism
Research Question/Problem/	Accurate measurements of Nitric Oxides are required for the

Need	measurement of many biological factors across a variety of settings.
Important Figures	 Scheme 1. The Griess reaction. *The Griess Reaction*
VOCAB: (w/definition)	- Effector: biological entity that carries out a response to some stimuli - Pathological: involved or caused by a physical/mental disease/disorder - Chemiluminescence: the emission of light produced form a chemical reaction
Cited references to follow up on	Gross, S. S. and Wolin, M. S. (1995) Nitric oxide: Pathophysiological mechanisms. *Ann. Rev. Physiol.* **57**, 737–769.

	Davison, W. and Woof, C. (1978) Comparison of different forms of cadmium as reducing agents for the batch determination of nitrate. *Analyst* **103**, 403–406. Green, L. C., Wagner, D. A., Glogowski, J., Skipper, P. L., Wishnock, J. S., and Tannenbaum, S. R. (1982). Analysis of nitrate, nitrite and nitrate in biological fluids. *Anal. Biochem,* 126, 131–138. https://doi.org/10.1016/0003-2697(82)90118-x
Follow up Questions	- What are the cheapest modes of NO measurement - How do reactant' needs change form situation to situation - How much inaccuracy needs to be accounted for when subtracting the two nitrite measurements to yield a nitrate measurement - Can I do this at the MAMS lab

Article #7 Sucrose-feeding leads to increased rates of nitrate assimilation, increased rates of alpha-oxoglutarate synthesis, and increased synthesis of a wide spectrum of amino acids in tobacco leaves:

Article notes should be on separate sheets

Source Title	Sucrose-feeding leads to increased rates of nitrate assmilation, inceased rates of alpha-oxoglutarate synthesis, and increased synthesis of a wide spectrum of amino acids in tobacco leaves
Source citation (APA Format)	Morcuende, R., Krapp, A., Hurry, V., Stitt, M., & Weber, H. (1998). Sucrose-feeding leads to increased rates of nitrate assimilation, increased rates of α-oxoglutarate synthesis, and increased synthesis of a wide spectrum of amino acids in tobacco leaves. *Planta*, *206*(3), 394–409. https://doi.org/10.1007/s004250050415
Original URL	https://link-springer-com.ezpv7-web-p-u01.wpi.edu/article/10.1007/s004250050415#citeas
Source type	Journal
Keywords	NR, Sucrose, Nitrogen Assimilation, Plant Nutrition
#Tags	

Summary of key points + notes (include methodology)	- Carbon and Nitrogen nutrition are strongly correlated
	- While certain effects of increased carbohydrates have been measured, there is a lack of clarity in the field
	- The team used detached tobacco leaves to monitor the changes in nitrate assimilation and amino acid distributions
	- The leaves choses were picked form tobacco plants grown in a greenhouse with 50% rh, supplementary light, and consistent temperatures
	- After being cut, leaves were placed in water for a 30-minute incubation period (using either sucrose or glucose additive), then applied into liquid nitrogen to be ground into a powder
	- Qualities were assessed as follows:
	  ○ Metabolite Analysis:
	    ▪ Carbohydrates were extracted from the samples with 80% ethanol

        - Sucrose, Glucose, and Fructose were measured in the extract
        - Amino Acids were measured using HPLC
        - Remaining matter was measured for NR using NR assay
    - Chlorophyll fluorescence:
        - Samples were put in the dark for 30-40 minutes before being applied with a water treatment
        - Fluorometer was subsequently used to measure fluorescence
- Results:
    - The control group exhibited an increase in starch, which slightly increased in the sugar fed groups alongside a great increase in soluble sugars
    - As glucose and sucrose levels increased in the treatment, do did nitrate assimilation ad activation and amino acid count
    - ATP slightly increased with treatment
    - Most amino acids increased the greatest with the 25 mM sucrose treatment compared to 50 mM of glucose
    - A subsequent experiment revealed that nitrate as its own additive only slightly increased nitrate assimilation
    - Nitrate feeding did however reduce starch content

Research Question/Problem/ Need

How do sugar additives modulate nitrogen nutrition in tobacco leaves?

Important Figures

Parameter	25 mM Glucose	50 mM Glucose	25 mM Sucrose	50 mM Sucrose	Water
Glucose[a]	14.21 ± 1.79	25.61 ± 1.02	23.86 ± 1.64	50.57 ± 3.32	1.90 ± 0.40
Fructose[a]	10.68 ± 1.43	16.85 ± 1.91	21.73 ± 1.26	46.16 ± 2.59	1.64 ± 0.28
Sucrose[a]	5.09 ± 0.91	7.64 ± 0.67	7.67 ± 1.26	14.73 ± 2.05	6.15 ± 0.89
Starch[a]	85.83 ± 11.13	90.68 ± 4.09	84.19 ± 7.89	79.31 ± 11.35	60.31 ± 7.47
NR activity[b]	9.31 ± 0.90	14.88 ± 1.57	10.70 ± 1.15	12.03 ± 0.65	7.17 ± 0.52
NR activation	72.53 ± 7.20	76.90 ± 5.82	67.02 ± 6.37	82.35 ± 1.95	54.14 ± 3.76
Hexose-P[c]	180.58 ± 6.75	236.03 ± 17.64	204.41 ± 15.17	212.16 ± 6.99	207.85 ± 21.29
3PGA[c]	123.50 ± 13.27	121.52 ± 8.87	66.65 ± 9.01	69.95 ± 17.15	140.13 ± 14.04
2PGA[c]	5.85 ± 0.84	5.77 ± 1.44	5.39 ± 0.60	5.06 ± 0.75	7.02 ± 0.99
PEP[c]	14.92 ± 3.14	13.96 ± 1.28	6.69 ± 1.80	11.55 ± 2.79	14.94 ± 0.86
Pyruvate[c]	29.18 ± 1.83	24.97 ± 4.41	15.45 ± 1.41	24.60 ± 1.34	19.54 ± 2.45
Malate[a]	18.35 ± 0.60	16.88 ± 1.07	19.59 ± 0.48	19.05 ± 0.38	18.41 ± 1.16
Citrate[a]	0.75 ± 0.10	0.71 ± 0.08	1.39 ± 0.31	1.07 ± 0.10	1.76 ± 0.43
α-Oxoglutarate[c]	59.82 ± 7.76	84.99 ± 12.35	125.91 ± 33.56	163.55 ± 43.89	48.87 ± 4.59
ATP[c]	74.73 ± 4.35	74.17 ± 4.92	71.83 ± 16.77	86.38 ± 11.37	62.98 ± 4.70
Amino acids[a]	20.62 ± 1.36	22.84 ± 2.35	21.84 ± 0.62	25.60 ± 1.44	17.16 ± 0.78

[a]Results in micromoles per gram fresh weight of tissue
[b]Results in micromoles per hour per gram fresh weight of tissue
[c]Results in nanomoles per gram fresh weight of tissue

Table 4. Changes in individual amino acids after supplying leaves with sucrose, nitrate or glutamine. The measurements were carried out on the same material as used for Table 3. The results are the mean ± SE from four individual leaves. Results in micromoles per gram fresh weight of tissue

Amino acids	Initial value	Water	Sucrose	Nitrate	Nitrate and sucrose	Glutamine	Glutamine and sucrose
Glutamate	2.18 ± 0.01	2.15 ± 0.25	1.74 ± 0.24	3.15 ± 0.07	2.06 ± 0.33	4.03 ± 0.43	2.40 ± 0.28
Aspartate	1.38 ± 0.07	1.47 ± 0.08	0.89 ± 0.11	2.99 ± 0.17	1.74 ± 0.19	1.45 ± 0.06	1.15 ± 0.14
Asparagine	0.13 ± 0.01	0.22 ± 0.05	0.17 ± 0.02	0.31 ± 0.02	0.38 ± 0.01	0.37 ± 0.02	0.46 ± 0.02
Alanine	0.19 ± 0.02	0.32 ± 0.02	0.51 ± 0.10	0.70 ± 0.06	1.36 ± 0.11	0.74 ± 0.06	1.41 ± 0.08
Glycine	0.19 ± 0.03	0.40 ± 0.05	1.33 ± 0.71	1.04 ± 0.21	2.33 ± 0.65	2.79 ± 0.54	2.15 ± 0.33
Serine	0.55 ± 0.05	0.44 ± 0.05	0.80 ± 0.15	1.41 ± 0.14	1.28 ± 0.15	1.32 ± 0.19	1.83 ± 0.35
Phenylalanine	0.10 ± 0.01	0.37 ± 0.05	0.56 ± 0.16	0.89 ± 0.19	1.12 ± 0.19	1.13 ± 0.14	0.97 ± 0.12
Trptophan	0.01 ± 0.00	0.07 ± 0.01	0.12 ± 0.01	0.09 ± 0.01	0.15 ± 0.01	0.11 ± 0.01	0.16 ± 0.01
Tyrosine	0.02 ± 0.00	0.09 ± 0.01	0.21 ± 0.02	0.13 ± 0.02	0.27 ± 0.02	0.18 ± 0.02	0.33 ± 0.04
Leucine	0.04 ± 0.00	0.19 ± 0.02	0.34 ± 0.03	0.17 ± 0.04	0.31 ± 0.02	0.20 ± 0.01	0.37 ± 0.03
Isoleucine	0.02 ± 0.00	0.15 ± 0.02	0.26 ± 0.01	0.13 ± 0.03	0.28 ± 0.04	0.16 ± 0.02	0.29 ± 0.03
Valine	0.05 ± 0.00	0.17 ± 0.00	0.27 ± 0.02	0.18 ± 0.02	0.28 ± 0.02	0.16 ± 0.01	0.30 ± 0.04
Threonine	0.18 ± 0.00	0.37 ± 0.02	0.43 ± 0.02	0.48 ± 0.03	0.61 ± 0.03	0.37 ± 0.02	0.59 ± 0.06
Methionine	0.01 ± 0.00	0.02 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	0.07 ± 0.01	0.03 ± 0.00	0.06 ± 0.01
Histidine	0.01 ± 0.00	0.02 ± 0.00	0.05 ± 0.01	0.07 ± 0.02	0.10 ± 0.01	0.04 ± 0.01	0.14 ± 0.04
Lysine	0.04 ± 0.00	0.11 ± 0.02	0.15 ± 0.02	0.09 ± 0.02	0.12 ± 0.01	0.09 ± 0.01	0.17 ± 0.03
Arginine	0.02 ± 0.00	0.10 ± 0.03	0.07 ± 0.00	0.11 ± 0.01	0.22 ± 0.02	0.14 ± 0.02	0.19 ± 0.02

Table 2. Changes in amino acids after supplying sucrose or glucose to detached tobacco leaves. The measurements were carried out in samples from the experiment shown in Table 1, and are given as the mean ± SE ($n = 4$)

Amino acid μmol $(g\ FW)^{-1}$	50 mM Glucose	25 mM Sucrose	Water
Glutamine (Gln)	6.31 ± 0.30	8.25 ± 0.23	1.16 ± 0.02
Glutamate (Glu)	1.62 ± 0.05	0.77 ± 0.01	1.72 ± 0.16
Aspartat (Asp)	1.26 ± 0.06	0.67 ± 0.00	1.16 ± 0.07
Asparagine (Asn)	0.29 ± 0.01	0.31 ± 0.02	0.21 ± 0.02
Alanine (Ala)	0.61 ± 0.03	0.85 ± 0.04	0.23 ± 0.01
Glycine (Gly)	2.66 ± 0.07	2.63 ± 0.10	0.31 ± 0.00
Serine (Ser)	0.92 ± 0.00	1.12 ± 0.01	0.48 ± 0.03
Phenylalanine (Phe)	0.84 ± 0.04	0.73 ± 0.01	0.42 ± 0.00
Tryptophan (Trp)	0.12 ± 0.00	0.12 ± 0.00	0.00 ± 0.00
Tyrosine (Tyr)	0.17 ± 0.01	0.23 ± 0.01	0.05 ± 0.00
Leucine (Leu)	0.18 ± 0.01	0.25 ± 0.00	0.08 ± 0.00
Isoleucine (Ile)	0.15 ± 0.00	0.19 ± 0.00	0.09 ± 0.00
Valine (Val)	0.17 ± 0.01	0.21 ± 0.00	0.09 ± 0.00
Threonine (Thr)	0.35 ± 0.01	0.38 ± 0.00	0.20 ± 0.00
Methionine (Met)	0.38 ± 0.02	0.34 ± 0.01	0.30 ± 0.01
Histidine (His)	0.06 ± 0.00	0.05 ± 0.00	0.02 ± 0.00
Lysine (Lys)	0.06 ± 0.00	0.07 ± 0.00	0.05 ± 0.00
Arginine (Arg)	0.10 ± 0.00	0.10 ± 0.00	0.05 ± 0.00

VOCAB: (w/definition)

- Incubate/Incubation:
  - Keeping a biological entity under growing conditions (such as heat) to allow development (like a bird laying on eggs so they grow)
- In-vivo
  - A process taking place in an organism
-

Cited references to follow up on

Möllering, H. (1984). Citrate. In H. U. Bergmeyer (Ed.), *Methods of enzymatic analysis 3* (7), 2-12. [10.1016/S0031-3025(16)36756-3](10.1016/S0031-3025(16)36756-3),

Huber, S. C., & Huber, J. L. (1996). Role and regulation of sucrose-phosphate synthase in higher plants. *Annual Review of Plant Physiology and Plant Molecular Biology, 47*, 431–444. https://doi.org/10.1146/annurev.arplant.47.1.431

Follow up Questions

- How would these results change under different levels of CO2 and across different species?
- How can sucrose be added to live plants as an agricultural additive?

	- If Nitrate increased natural sugars in the plant, would that have subsequently led to an increase in Nitrate Assimilation as noted? o Expanding on this, why is environmentally added sucrose more potent than natural productions, in its effects on Nitrate Assimilation

Article #8 Notes: Rising Carbon Dioxide and Global Nutrition: Evidence and Action Needed

Article notes should be on separate sheets

Source Title	Rising Carbon Dioxide and Global Nutrition: Evidence and Action Needed
Source citation (APA Format)	Ziska L. H. (2022). Rising Carbon Dioxide and Global Nutrition: Evidence and Action Needed. *Plants (Basel, Switzerland)*, *11*(7), 1000. https://doi.org/10.3390/plants1107100
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC9003137/
Source type	Journal
Keywords	Climate, CO2, Agriculture
#Tags	

Summary of key points + notes (include methodology)	- Over the next years Carbon Dioxide is expected to greatly elevate
	- Theory suggests that this will lead to an increase in plant mass, but a decrease in nutritional value, specifically key vitamins and proteins
	- To prove these multiple possible explanations must be explored for the witnessed decrease in nutritional value
	    o One possible reason is the effects of warming. However, this does not have nearly the quantitative effect seen
	    o Another is how CO2 alters stomatal operature, which has both positive and negative outcomes
	    o It is even possible that under elevated CO2 there is less nutrition demand, decreasing nutrition production
	- Existing data was used to prove how warming only partly diminished the negative effects of CO2 in regard to plant protein levels
	- Backing their previous statements, the team cited a meta-analysis describing how many corps experienced a 8% decrease in mineral content
	- This is significant because, as cited in the study, if CO2 trends follow as predicted an estimated 175 and 122 million more people will become zinc and protein deficient, respectively
	- These effects are strongly skewed towards poorer region of the world

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- Thus the study summarized that as atmospheric CO2 levels increase, the world will begin to face an elevated food crisis
- This was not an experiment, nor a study, but an analysis and conclusion of existing works to defend and disprove a variety of hypothesis

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<tr><td>Research Question/Problem/ Need</td><td>Exploring the impacts of a shifting climate on the global food web</td></tr>
<tr><td>Important Figures</td><td>

Table 1.

Changes in essential amino acid composition (mg g^{-1}) in rice grown at ambient (a) and elevated CO_2 and temperature (e), aCaT, ambient check; aCeT, elevated temperature (+1.5 °C), eCaT (+200 ppm CO_2) and eCeT. Letters indicate significant differences. Data are from [24].

Amino Acid	aCaT	aCeT	eCaT	eCeT	CO_2	Temp.
Histidine	1.62 a	1.61 a	1.47 ab	1.44 b	0.012	n.s
Isoleucine	2.39 a	2.38 a	2.14 a	2.14 a	n.s	n.s
Leucine	5.44 a	5.38 a	4.91 ab	4.81 b	0.018	n.s.
Lysine	2.45 a	2.49 a	2.27 bc	2.22 c	0.013	n.s.
Methionine	1.39 a	1.21 b	1.20 b	1.12 c	0.001	0.002
Phenylalanine	3.61 a	3.59 a	3.28 a	3.22 a	n.s.	n.s.
Threonine	2.66 a	2.67 a	2.46 ab	2.42 b	0.014	n.s.
Valine	3.99 a	3.97 a	3.60 a	3.59 a	n.s.	n.s.
TOTAL	23.55 a	23.31 a	21.34 ab	20.89 b	0.013	n.s.

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<tr><td>VOCAB: (w/definition)</td><td>

- Ubiquitous: present and found (nearly) everywhere
- Foliar: relating to/of leaves—hence foliar spray for potential sucrose additive

</td></tr>
<tr><td>Cited references to follow up on</td><td>Ziska L.H., Blumenthal D.M., Franks S.J. (2019) Understanding the nexus of rising CO2, climate change, and evolution in weed biology. Invasive Plant Sci. Manag. 12, 79–88. doi: 10.1017/inp.2019.12. [DOI]
Sionit N. (1983) Response of Soybean to Two Levels of Mineral Nutrition in CO2-Enriched Atmosphere. Crop Sci. 25, 329–333. doi: 10.2135/cropsci1983.0011183X002300020035x. [DOI]</td></tr>
<tr><td>Follow up Questions</td><td>

- What are existing viable methods to counter it?
- How do best-case scenario CO2 levels in 50 years change the outlook of this situation?
- How can agriculturalists counter these problems in their crops?

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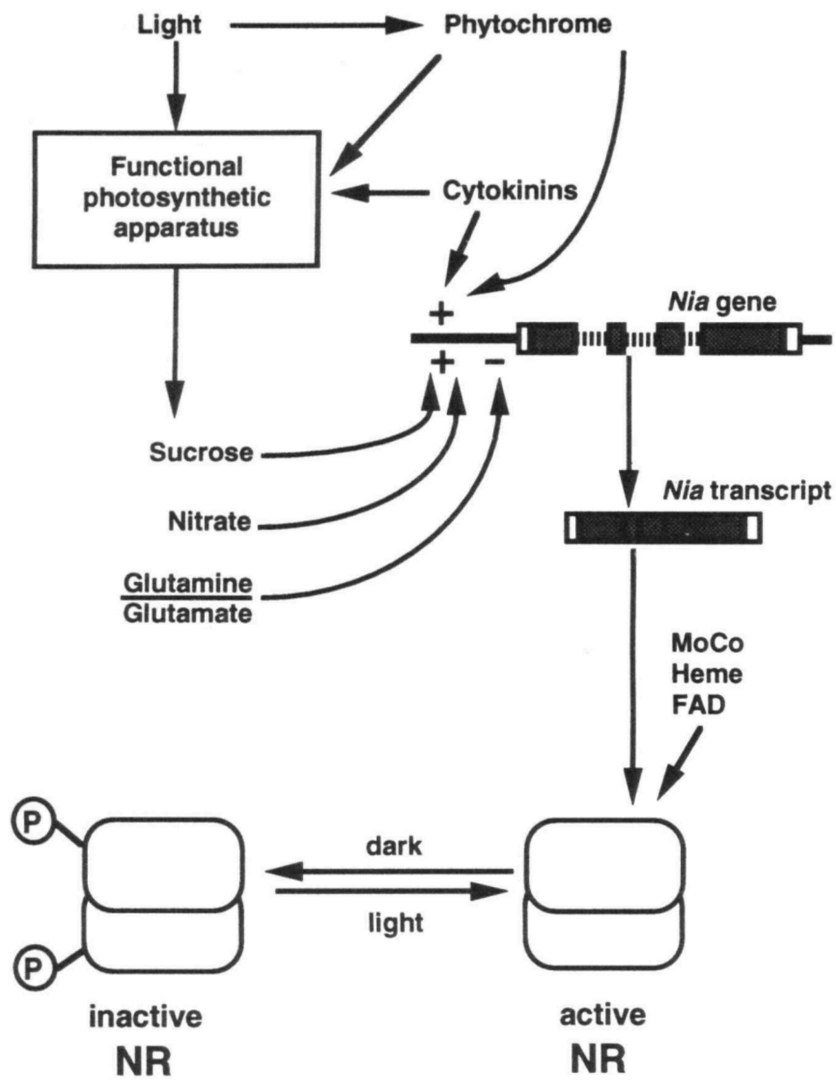
Article #9 Notes: The Use of Mutants and Transgenic Plants to study nitrate assimilation

Article notes should be on separate sheets

Source Title	The Use of Mutants and Transgenic Plants to study nitrate assimilation
Source citation (APA Format)	Hoff, T., Truong, H.-N., & Caboche, M. (1994). The use of mutants and transgenic plants to study nitrate assimilation. *Plant, Cell and Environment, 17*(5), 489–506. https://doi.org/10.1111/j.1365-3040.1994.tb00145.x
Original URL	https://www.researchgate.net/profile/Tine-Hoff/publication/230034199_The_use_of_mutants_and_transgenic_plants_to_study_nitrate_assimilation/links/645a562e2edb8e5f094adabd/The-use-of-mutants-and-transgenic-plants-to-study-nitrate-assimilation.pdf
Source type	Journal-Meta Analysis
Keywords	Nitrate Assimilation, Measurement
#Tags	

Summary of key points + notes (include methodology)	- Nitrate is reduced to ammonium in two key steps: through nitrate reductase (converts nitrate to nitrite) and glutamine synthetase
	- Mutations in the NiR protein can cause a plant to have a disrupted nitrate assimilation
	- These mutations have differed across many different species
	- Due to a biological resistance to chlorate as related to a decrease in NR, in the past chlorate resistance has been used to isolate mutated plant samples
	    ○ An Assay exists for this purpose as well
	- There are two main categories of mutants with different effects:
	    ○ Nitrate transport mutant: Mutants occurring in the transportation of nitric oxides
	    ○ Nitrite reductase mutant: Mutants occurring with the transport and behavior or nitrite—this is a difficult mutant to deal with due to shifting nitrite being potentially fatal to plant cells
	- Through earlier stated methods and modern technologies, new mutants and their information can be located

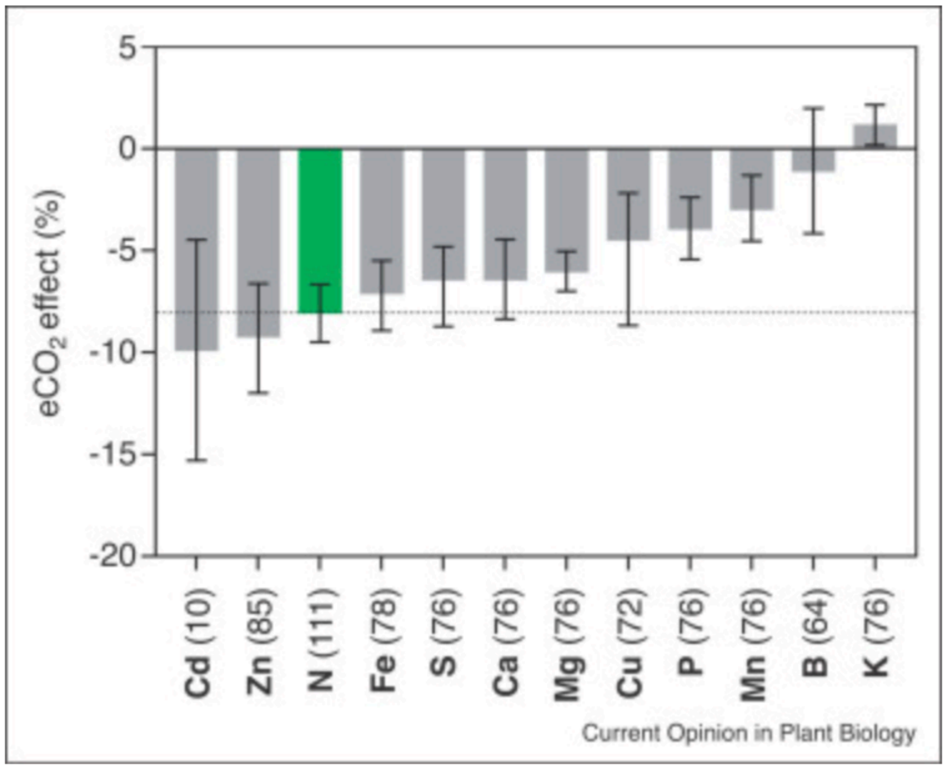
	- This as well as cited data comparing certain factors (such as metabolites) with NR activity allow the team to suggest that in most plants, genetic mutation play a significant role in the development and activity of nitrate assimilation
Research Question/Problem/ Need	Overview on existing understanding of the relation between certain plant mutations and nitrate assimilation
Important Figures	 **Figure 2.** A schematic view of the factors regulating *Nia* gene transcription, translation and NR enzyme activity.
VOCAB: (w/definition)	- Transgenic: o Referring to an organism with artificially inserted

	DNA or DNA belonging to another organism/species - Circadian Rhythm: o Internal biological 'clock' that mediates energy levels and biological conditions, adjusting over a period of time
Cited references to follow up on	Doddema H., Hofstra J.J. & Feenstra W.J. (1978). Uptake of nitrate by mutants of Arabidopsis thaliana, disturbed in uptake or reduction of nitrate. I. Effect of nitrogen source during growth on uptake of nitrate and chlorate. *Physiologia Plantarum 43*, 343-350. Doddema H. & Telkamp G.P. (1979). Uptake of nitrate by mutants of Arabidopsis thaliana, disturbed in uptake or reduction of nitrate. II. Kinetics. *Physiologia Plantarum 45*, 332-338.
Follow up Questions	- On a quantitative scale, how impactful are mutations compared to environmental factors on nitrate assimilation and enzymatic activity - Can technologies such as CRISPR be used to further study or expand on these mutations? - Where can these mutations in the proteins play a positive role in plant life?

Article #10 Notes: Crop quality under rising atmospheric CO2

Article notes should be on separate sheets

Source Title	Crop quality under rising atmospheric CO2
Source citation (APA Format)	Uddling, J., Broberg, M. C., Feng, Z., & Pleijel, H. (2018). Crop quality under rising atmospheric CO_2. *Current Opinion in Plant Biology, 45*, 262–267. https://doi.org/10.1016/j.pbi.2018.06.001
Original URL	https://www.sciencedirect.com/science/article/pii/S1369526617302406?via%3Dihub
Source type	Journal
Keywords	CO2, Enviromental Factors, Nutrition, Agriculture
#Tags	
Summary of key points + notes (include methodology)	- Crops grown under elevated CO2 have been traditionally found to have greater yield but less nutritional content - Already, 1-2 billion people are already iron or zinc deficient, which could increase as mineral levels decrease in plants under CO2 - Existing possible reasons include a increased need in nutrition being established by elevated plant matter, possibly a reduction in Rubisco demand, and that the availability of nitrate diminishes under CO2 heavy environments, but these lack quality and quantity of evidence - Evidence does suggest a change in N and protein across any environmental factor- making them directly correlated, even indicating causation - While N and protein differences can be attributed to changes in enzymatic activity, current research and theory suggests that the diminishment of minerals such as iron and zinc is instead due to changes in a variety of plant metabolic processes - One study incorporated into the meta-analysis described how in wheat, gluten content and amino acid composition was changed during elevated CO2 conditions as well indicating a need of further research across plant variables - Ultimately, the meta-analysis summarized that decreases in N and protein is a direct response to elevated CO2, and is

<table>
<tr><td></td><td>attributable more to direct changes in the biological systems than in environmental factors
◦ This increases the need to find a solution for decreases in plant nutritional value, as environmental conditions such as dirt-depth or nitrate availability are much easier to solve than, say, regulation of enzymatic activity.</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>What factors can possibly explain the changes in a plants nutritional value under elevated CO2 levels</td></tr>
<tr><td>Important Figures</td><td>
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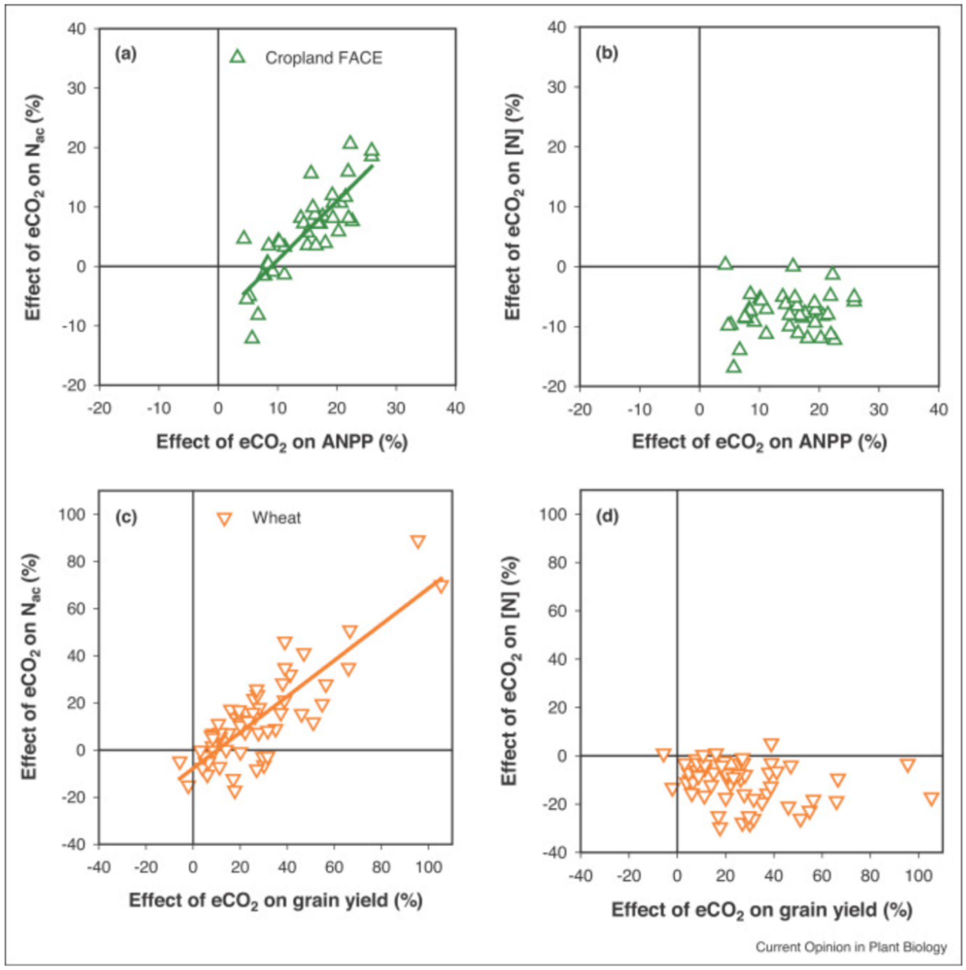
<td>Effects on minerals corresponding to change in CO2


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<td>VOCAB: (w/definition)</td>
<td>- FACE experiments
○ Free-Air CO2 Enrichment Experiments—type of experiment examining the impact of atmospheric CO2 level on an variable
- Exudate
○ Substance secreted from an insect or plant</td>
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<tr>
<td>Cited references to follow up on</td>
<td>Jablonski, L. M., Wang, X., & Curtis, P. S. (2002). Plant reproduction under elevated CO2 conditions: A meta-analysis of reports on 79 crop and wild species. New Phytologist, 156(1), 9–26. https://doi.org/10.1046/j.1469-8137.2002.00494.x</td>
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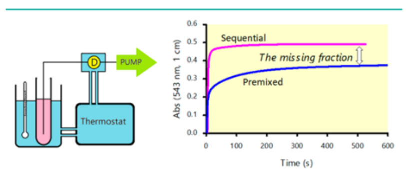
Follow up Questions	- This meta-analysis was made 7 years ago in 2018. How can current data and knowledge validate what was explained here? - To what extent are other environmental factors ruled out in regard to causation of decrease in plant nutritional value?

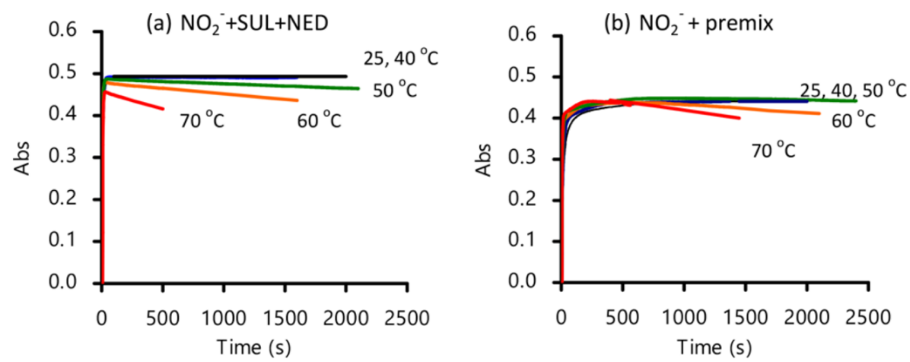
Article #11 Notes: Determination of Nitrate in Natural Waters by Vanadium Reduction and the Griess Assay: Reassessment and Optimization

Article notes should be on separate sheets

Source Title	Determination of Nitrate in Natural Waters by Vanadium Reduction and the Griess Assay: Reassessment and Optimization
Source citation (APA Format)	Pai, S.-C., Su, Y.-T., Lu, M.-C., Chou, Y., & Ho, T.-Y. (2021). Determination of nitrate in natural waters by vanadium reduction and the Griess assay: Reassessment and optimization. *ACS ES&T Water*, *1*(7), 1524–1532. https://doi.org/10.1021/acsestwater.1c00065
Original URL	https://labs.rcec.sinica.edu.tw/mbl/tyho/source/publications/SCPai_2021_ACSESWater.pdf
Source type	Journal-article
Keywords	Griess, Vanadium Reduction, Assay, Nitrate, Nitrite, Water
#Tags	
Summary of key points + notes (include methodology)	- Vanadium Reduction is already an established method to reduce nitrate to nitrite in biological samples - This process is needed because nitric oxides are best measured through the Griess Assay, which requires a nitrate form. - this method can be optimized for efficiency by controlling several factors—that was what was done in this study - Apart from vanadium, Cadmium processing is more commonly used to reduce nitrate, but is very slow and toxic - Certain inconsistencies in the VIII reduction method alter results (which are measured through the prevalence of pink azo dye through spectrometry) - The study began by measuring the temperature as it correlated with PAD formation - Beakers were connected to mainstream the reactions, which were read with both thermometers and spectrometry at the end of the system - Absorbance during this method was measured using cuvette holders

	- Chemicals used throughout the process included the Griess reagents (sulfanamide and N-1-naphthylethylenediamine), Vanadium III, HCL, and distilled water - The study determined that acidity is a very important factor when performing the vanadium reduction - They observed the premixed Griess reagents also led to slower PAD formation, sometimes around 20 minutes, compared to separate chemicals being subsequentially added - Five different SUL concentrations between 0.43 and 17.2 mM and 8 different concentrations of NED between 0.009 and 0.86 were tested for their effects on PAD formation - As NED concentrations decreased the absorbances lowered and the time of reaction increased to above 15 minutes. As NED increased the times were much shorter, with less impact on absorbance. However, at a certain point the effects led to a lower final absorbance and slower reaction rates - In premixed reagents, higher SUL than NED concentrations were favorable for PAD formation - Adding SUL first results in a longer PAD formation but a more accurate measurement - Even despite the indicated slower reaction times with proper sequential addition, temperature plays a big impact. While certain effects are stimulated with higher temperatures, room temperature was found best having more readable and accurate results - For premixed reagents, observations indicated that temperatures should be kept under 60 degrees Celsius rather than just room temperature - They ultimately found for these tests that the optimal conditions for nitrate reduction includes a heating temperature of less than 50 degrees Celsius and a V(III) concentration between 7.62 to 10.17mM - The study subsequently carried out tests to optimize conditions to reduce PAD fading at the higher temperatures (fading of PAD) before reading leads to inaccurate results - These tests include three steps: heating samples gradually up to 50° C in a water bath; then keeping these samples at that temperature for another 10 minutes for maximum nitrate reduction and an insignificant loss of PAD formation; finally

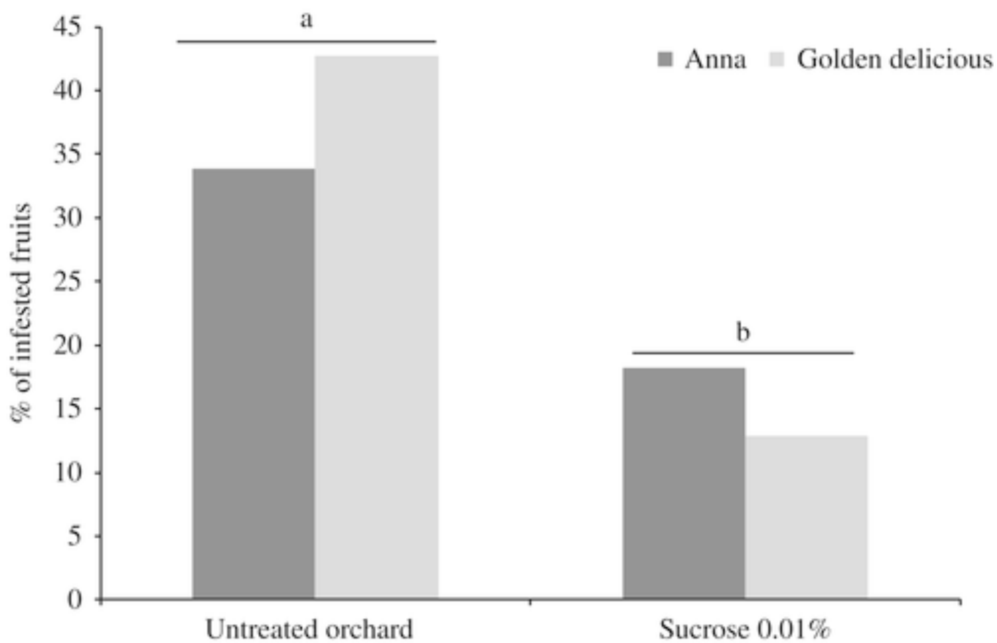
	removing samples form water bath and cooling them in a cold-water bath - They found that the one-minute cooling after heating effectively stopped the color fading - Final conclusions indicated that the added acidity for the VIII reaction should be greater than 100 mM, the heating temp for nitrate reduction should be no greater than 50°C and that high reagent strengths should be used for better measurements
Research Question/Problem/ Need	Environmental and agricultural scientists need fast, efficient, and accurate measurements of nitrate content in biological samples.
Important Figures	 **Figure 2.** Device for monitoring PAD formation at the designated temperature (left). The sample vessel is placed in a thermostat bath, and after reagents are added, the liquid is taken up by a peristaltic pump. The liquid flow may be stopped or continue to flow through a 1 cm flow cuvette with a 71 μL capacity, which is also connected to a thermostat jacket in a spectrophotometer (D). Typical PAD formation curves (right) for a 10 μM nitrite sample at room temperature using sequential reagent addition and premixed reagent addition. The gap between the two curves is the missing fraction. The final concentrations of SUL, NED, and H^+ are 4.3, 0.43, and 67 mM, respectively. The reactions of nitrous acid with SUL and NED can be described with formation constants K_A and K_B: $HNO_2 + SUL \rightarrow DAZ \quad K_A = [DAZ]/([HNO_2][SUL])$ (1) $DAZ + NED \rightarrow PAD \quad K_B = [PAD]/([DAZ][NED])$ (2)

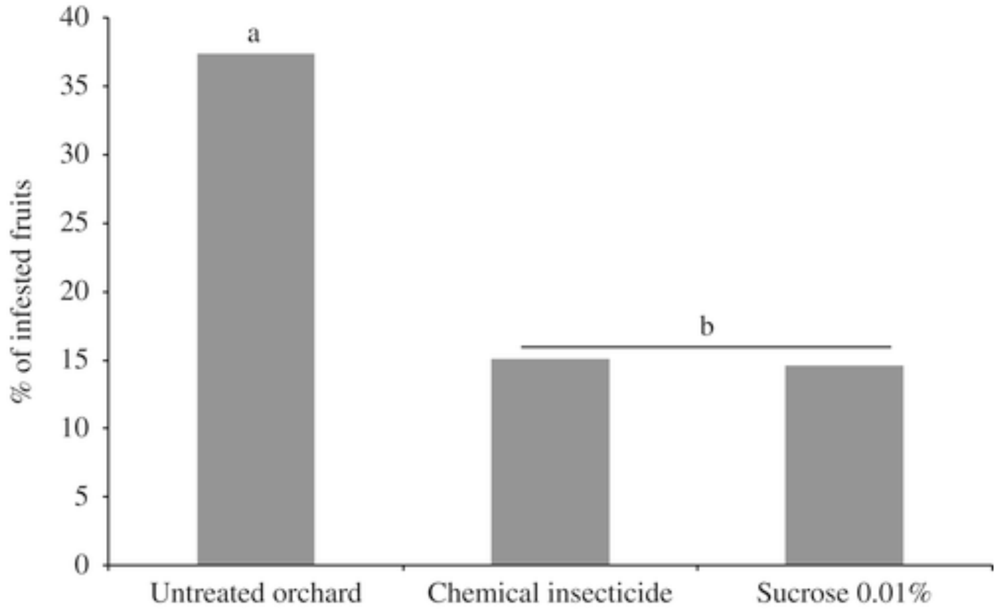
	 **Figure 5.** Comparison of PAD formation and stability of an initial 10 μM nitrite sample by (a) sequential and (b) premixed reagent additions at various constant temperatures. The sample and cuvette holder were both preheated to the designated temperature of the water bath.
VOCAB: (w/definition)	- Cuvette ○ A small, straight-sided tube used to hold liquid samples for measurement in optical analysis
Cited references to follow up on	Schnetger, B., & Lehners, C. (2014). Determination of nitrate plus nitrite in silicate-rich marine water with a then-called vanadium(III)chloride method. *Marine Chemistry*, *160*, 91–98. https://doi.org/10.1016/j.marchem.2014.01.010
Follow up Questions	- How can these optimizations be implicated in labs with limited equipment like at MAMS? - To what extent/when does PAD fading become statistically significant for plant nitrite and nitrate measurements?

Article #12 Notes: Foliar application of microdoses of sucrose to reduce codling moth *Cydia pomonella* L. (Lepidoptera:Torticridae) damage to apple trees

Article notes should be on separate sheets

Source Title	Foliar application of microdoses of sucrose to reduce codling moth *Cydia pomonella* L. (Lepidoptera: Torticidae) damage to apple trees
Source citation (APA Format)	Arnault, I., Lombarkia, N., Joy-Ondet, S., Romet, L., Brahim, I., Meradi, R., Nasri, A., Auger, J., & Derridj, S. (2016). Foliar application of microdoses of sucrose to reduce codling moth *Cydia pomonella* L. (Lepidoptera: Tortricidae) damage to apple trees. *Pest Management Science*, *72*(10), 1901–1909. https://doi.org/10.1002/ps.4228
Original URL	https://doi.org/10.1002/ps.4228
Source type	Journal paper
Keywords	Sucrose additive, trees, sucrose, foliar
#Tags	
Summary of key points + notes (include methodology)	- Codling flies are one of the most damaging pests to crops, and have adapted to resist many insecticides - To reduce the reliance of pesticide use, new biocontrol strategies must be used - Altered levels of plant sugars adjust pest egg laying preferences, biasing them away from sucrose heavy plants - The study indented to apply sucrose in microdoses to discourage pest infestations - Nine experiments were conducted in Algeria and France, where multiple treatments controls of the moths were applied to the trees - Field damage was measured using Abbotts formula which compares the percentage of damage of treated fruits versus untreated controls - Sucrose was applied at 0.01% the first day before maximum egg laying period, and renewed every 20 days

	- Statistical testing, majority ANOVA, proved that the sucrose treatment significantly reduced the percentage of infested fruits across two varieties: Anna and Golden delicious - Similar impacts on infestation was observed between both pesticides and the sucrose method, implying great potential with this application
Research Question/Problem/ Need	Commercial (apple) farms face high risk of crop damage from codling moth infestations
Important Figures	



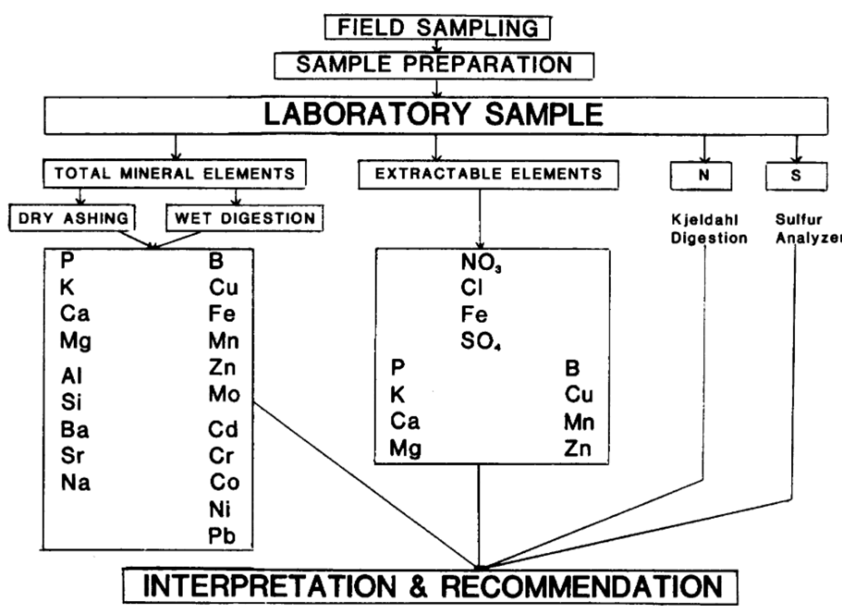
VOCAB: (w/definition)	Phytosanitary - Referring to the health of plants
Cited references to follow up on	Derridj, S., Arnault, I., Guez, H., & Auger, J. (2012). Sugars: New methods in crop protection. *Proceeding of the 10th International Conference on Plant Diseases*, 369–378.
Follow up Questions	- My main purpose in reading this paper was to become familiar with the process of foliar additives. In this agricultural application, sucrose was applied as a 0.01% microdose every 20 days, is this a standard method for foliar treat meant?

Article #13 Notes: Sampling, Handling, and Analyzing Plant Tissue Samples

Article notes should be on separate sheets

Source Title	Sampling, handling, and analyzing plant tissue samples
Source citation (APA Format)	Jones, J. B., Jr., & Case, V. W. (1990). Sampling, handling, and analyzing plant tissue samples. In R. L. Westerman (Ed.), *Soil testing and plant analysis* (3rd ed., pp. 389–427). Soil Science Society of America. https://doi.org/10.2136/sssabookser3.3ed.c15
Original URL	https://acsess.onlinelibrary.wiley.com/doi/epdf/10.2136/sssabookser3.3ed.c15?saml_referrer
Source type	Book chapter
Keywords	Methodology, Liquid Nitrogen, Samples, Data Collection
#Tags	

Summary of key points + notes (include methodology)	- Plant analysis is commonly referred to as the total elemental measurement of a plants part
	- These quantities can be compared to a sufficiency range to determine the plants relative health
	- These methods have applications for both soil and plant processing and analysis
	- All samples must be taken in respect to their populations, where bias must be avoided to prevent misinterpretation of data and or a hypothesis testing error
	  o Statistical Analysis!
	- Many different tissue sampling techniques can be used to measure different variables. These include:
	  o Taking entire leaf's
	  o Taking whole plants
	  o Picking from seedling vs mid-season
	- After collection, samples must be cleaned, dried to stop enzymatic reaction, reduces to homogenate, and dried to constant weight
	- Certain components of this can be adjusted for different situations. For example, when measuring an enzymatic reaction

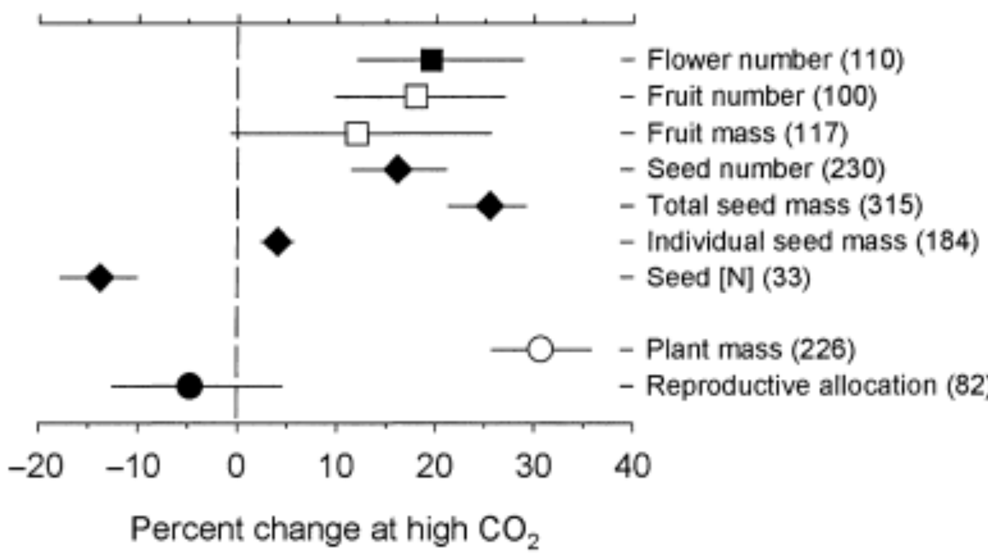
	most of these steps are done rapidly to prepare a sample for the assay's required - For large projects, mills can be used to process large amounts of samples without a fine laboratory setting - Most proper storage includes a medium temperature and minimum moisture to avoid the spread and growth of contaminants - Destroying organic matter is typically either done using acidic digestion or oxidation. In the case of my projects Arabidopsis, liquid nitrogen coupled with reagents transform the entire sample into a homogenous mixture - Each element has different methods of determination, These can typically include the use of reagents to create a spectrometric reading, such as the Griess assay in regard to nitric oxides (a compound, not a strict element) - The chapter summarizes that all of these steps require great care, and assaying a plant tissue is always a great diagnostic tool for a variety of plant experiments.
Research Question/Problem/ Need	Plant tissue samples need to be accurately processed without waste or change in data
Important Figures	 Fig. 15-1. Sequence of procedures for conducting a plant analysis.

VOCAB: (w/definition)	- Homogenate ○ A suspension of cell fragments and cell components obtained when tissue is homogenized
Cited references to follow up on	Grant, C. L., & MacLaughlin, D. J., Jr. (1968). Preparation of biological samples and standards for spectrochemical analysis. *Applied Spectroscopy*, *22*(4), 365.
Follow up Questions	- How are all of these tenants adjusted to the acute environment of a Griess measurement? Can ground tissues be stored in my case as well?

Article #14 Notes: Plant reproduction under elevated CO2 conditions: a meta-analysis of reports on 79 crop and wild species

Article notes should be on separate sheets

Source Title	Plant reproduction under elevated CO2 conditions: a meta-analysis of reports on 79 crop and wild species
Source citation (APA Format)	Jablonski, L. M., Wang, X., & Curtis, P. S. (2002). Plant reproduction under elevated CO2 conditions: A meta-analysis of reports on 79 crop and wild species. *New Phytologist*, *156*(1), 9–26. https://doi.org/10.1046/j.1469-8137.2002.00494.x
Original URL	https://nph.onlinelibrary.wiley.com/doi/10.1046/j.1469-8137.2002.00494.x
Source type	Paper—meta analysis
Keywords	CO2, plant reproduction, meta analysis
#Tags	
Summary of key points + notes (include methodology)	- Plant reproductive traits are key predictors in future ecological system - In agriculture, these effects extend to biomass distributions and crop quality - The meta-analysis uses data from 78 reports of plant behavior under elevated CO2 to predict the changes in plant reproduction under future climate conditions - While crops can be bred to take advantage of rising CO2, wild varieties grow to adapt to many different environments resulting in a lesser allocation to reproductive structures - Biomass had been traditionally found to increase under elevated CO2 - In wild species, reproductive masses have been seen to increase as well, depending on the climate classification

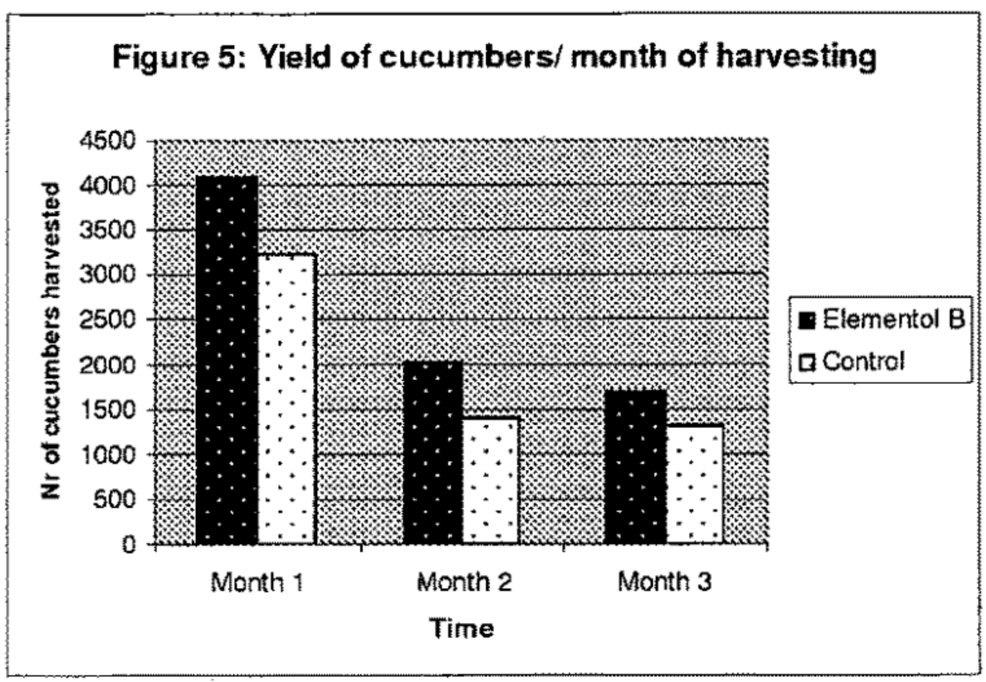
	- The results of all papers indicated that across all species, CO2 enrichment resulted in more flowers, fruits, seeds, and greater total seed mass. - Nitrogen concentration was found to decrease as well - Wild species were found to benefit less than from the crops - Certain crops were found more responsive than others, prompting broad implications for the function of future ecosystems
Research Question/Problem/ Need	How does atmospheric CO2 enrichment affect wild species and crop reproductive patterns
Important Figures	
VOCAB: (w/definition)	Senescence: the biological process of aging and the gradual deterioration of functional characteristics in living organisms Allometry: the study of the relationship between an organisms size and the size of its various parts
Cited references to follow up on	Conroy, J. P., & Hocking, P. (1993). Nitrogen nutrition of C_3 plants at elevated atmospheric CO2 concentrations. *Physiologia Plantarum*, *89*(3), 570–576. https://doi.org/10.1111/j.1399-3054.1993.tb05215.x
Follow up Questions	What are the implications of loosened nitrogen concentration? Did the seeds behave differently than normal seeds?

Article #15 Notes: Plant Support Formulation, Vehicle for the Delivery and Translocation of Phytologically Beneficial Substances and Composition Containing Same

Article notes should be on separate sheets

Source Title	PLANT SUPPORT FORMULATION , VEHICLE FOR THE DELIVERY AND TRANSLOCATION OF PHYTOLOGICALLY BENEFICIAL SUBSTANCES AND COMPOSITIONS CONTAINING SAME
Source citation (APA Format)	Grobler, A. F. (2019). *Plant support formulation, vehicle for the delivery and translocation of phytologically beneficial substances and compositions containing same* (U.S. Patent No. 10,321,681). U.S. Patent and Trademark Office. https://patentimages.storage.googleapis.com/90/a3/fa/1954c2aafe5e5d/US10321681.pdf
Original URL	https://patentimages.storage.googleapis.com/90/a3/fa/1954c2aafe5e5d/US10321681.pdf
Source type	Patent
Keywords	Patent, Foliar Spray, Fatty Acids, Phytological
#Tags	
Summary of key points + notes (include methodology)	- This patent sought to create a component or whole delivery device to transmit beneficial molecules, compounds, and chemicals into plants to upregulate phytological behavior - Fertilizers and the like have already been used to increase select plant nutrients and behavior - Most of these nutrients are not absorbed well after application; this area needs improvement - The team decided to use a formulation comprising of microemulsion with the dispersing of a fatty acid-based component in an aqueous carrier; which may carry the nutrients - The fatty acid component may include natural oils to aid its structure - The vehicle will incorporate a gas such as nitric oxide or CO2 to impart the best parameters on each vesicle (enables high-amount high-precision)

	- Multiple options of nutrient dispersal are possible including a plant pesticide composition and herbicidal composition
	- It can be prepared as follows:
	  o A volume of water is saturated with the chosen gas
	  o The fatty acid base is built up, including large content of Vitamin F Ethyl Ester CLR 110 000
	  o Then antioxidant is added to heated fatty acid content
	  o Water is heated, mixed with fatty acid base
	  o Final solution is diluted for administration the plants
	- This solution can be applied primarily as a foliar spray or drip irrigation, and is easily modified to suit individual plant needs
	- The invention was tested with many species, notably cucumbers. Cucumbers plants (n=720) were germinated and applied the solution though a drip irrigation system multiple times a day. Average growth was measured compared to a control group, yielding a long-term increase in plant length.

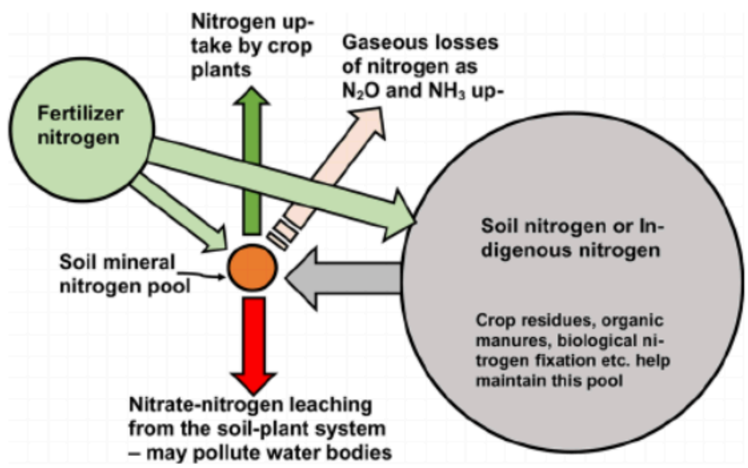
Research Question/Problem/ Need	This patent sought to create a component or whole delivery device to transmit beneficial molecules, compounds, and chemicals into plants to upregulate essential behaviors for agricultural and lab-based uses.
Important Figures	 FIG . 5 is a graph showing the total numbers of cucumbers The invention also provides for a method of supporting harvested at different times

	from plants treated with a plant the local defense and acquired resistance of plants according support formulation acc
VOCAB: (w/definition)	Cationic: having a positive electric charge Chelators: molecules that bind to metal ions to form stable ring like structures called chelates
Cited references to follow up on	Marschner, H. (1995). Functions of mineral nutrients: Micronutrients. In *Mineral nutrition of higher plants* (2nd ed., pp. 313–404). Academic Press. https://doi.org/10.1007/978-3-662-04064-5_9
Follow up Questions	How does this delivery system change with different levels and intensities of treatment and number of subjects?

Article #16 Notes: Fertilizers and nitrate pollution of surface and ground water: an increasingly pervasive global problem

Article notes should be on separate sheets

Source Title	Fertilizers and nitrate pollution of surface and ground water: an increasingly pervasive global problem
Source citation (APA Format)	Khan, M. S., & Aziz, T. (2021). Fertilizers and nitrate pollution of surface and ground water: An increasingly pervasive global problem. *ACS ES&T Water*, *1*(4), 716–717. https://doi.org/10.1021/acsestwater.1c00065
Original URL	https://www.researchgate.net/publication/350524887_Fertilizers_and_nitrate_pollution_of_surface_and_ground_water_an_increasingly_pervasive_global_problem
Source type	Journal article
Keywords	Nitrogen, Fertilizer, Water
#Tags	
Summary of key points + notes (include methodology)	- Nitrogen (spec. nitrate) is used globally for crop fertilization - This is leading to a pervasive pollution into the freshwater system - Moreover, plants are not fully utilizing the fertilizer being provided - Because a large proportion of nitrates end up in the soil pool across decades, the study found they can track these residues to measure the use of past fertilizers - The study aims to use this information to develop a model correlating nitrate accumulation in soil with accumulation in freshwater - They developed a model which simulated nitrate levels across ecosystems and freshwaters with the stable isotopes of nitrogen and oxygen - This model included many area, which were: Mississipi (USA) Amazon (Brazil) Nile (Egypt)

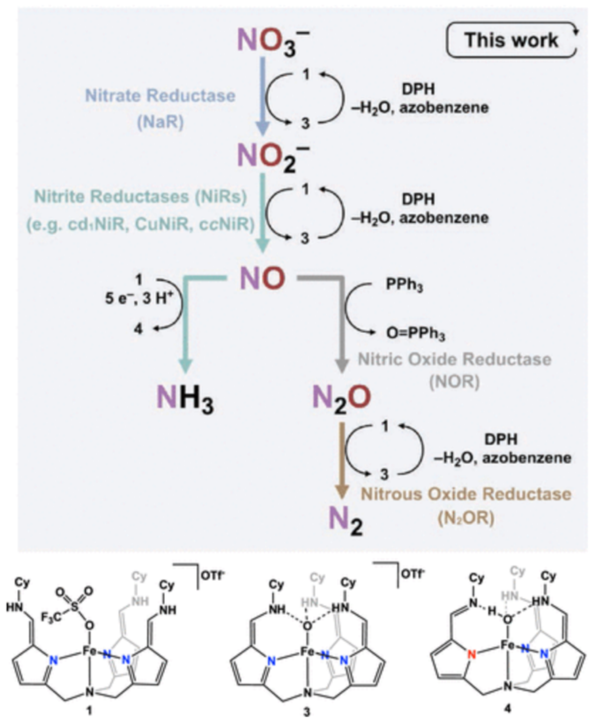
	Zaire (Zaire) Zambezi (Zambia, Zimbabwe, Mozambique) Rhine (Germany) Po (Italy) Ganges (India) Changjiang (China) Huanghe (China) - They concluded that improved water and fertilizer management in larger systems is needed to reduce the pollution of nitrate in water, but many other factors determine this magnitude - Specifically, different existing ecosystems help manage how excess nitrate is treated -
Research Question/Problem/ Need	How does fertilizer use directly correlate to pollutions in freshwater systems
Important Figures	 **Fig. 2** Schematic diagram of the fate of fertilizer N applied to agri-cultural soils
VOCAB: (w/definition)	- Thermostatic: anything that maintains a consistent temperature - Kinetics: scientific study of the rate of change
Cited references to follow up on	Refsgaard, J. C., Thorsen, M., Jensen, J. B., Kleeschulte, S., & Hansen, S. (1999). Large scale modeling of groundwater contamination from nitrate leaching. *Journal of Hydrology*, *221*(3-4), 117–140.

	https://doi.org/10.1016/S0022-1694(99)00081-5
Follow up Questions	At what point does oxidation of vanadium solution prevent nitrate reduction? How is this essay done in mass?

Article #17 Notes: Selective Stepwise Reduction of Nitrate and Nitrite to Dinitrogen or Ammonia

Article notes should be on separate sheets

Source Title	Selective Stepwise Reduction of Nitrate and Nitrite to Dinitrogen or Ammonia
Source citation (APA Format)	Dong, X., Gu, Z., & Gao, J. (2025). High-performance organic electrochemical transistors based on a naphthalene diimide-bithiophene copolymer with oligo(ethylene glycol) side chains. *Journal of the American Chemical Society*, *147*(1), 441–451. https://doi.org/10.1021/jacs.4c16585
Original URL	https://pubs.acs.org/doi/10.1021/jacs.4c16585
Source type	Journal Article
Keywords	Nitrate, Nitrite, Water
#Tags	
Summary of key points + notes (include methodology)	- Nitrite and Nitrate are critical components of natural water systems - To reduce levels of these pollutants, plants have evolved to use enzymatic processes which reduce nitrate to either ammonium or dinitrogen, after the reduction of nitrate to nitrite with nitrate reductase - Then, nitrite is reduced to nitric oxide using heme-based nitrite reductase or copper-based nitrite reductase - Di nitrogen bonds are produced at this point - When catalyzed, either ammonium or dinitrogen are produced - Human fertilizers have disrupted this natural nitrogen cycle, leading to contamination of ground and drinking water - A model was developed to examine the complete processes for the stepwise reduction of nitrate/nitrite to ammonium/dinitrogen for a synthetic system - Different compounds were explored for this process, including: PPh3, 1,2-diphenylhydrazine (DPH), sodium naphthylamide, cobaltocene, and different chemical methods

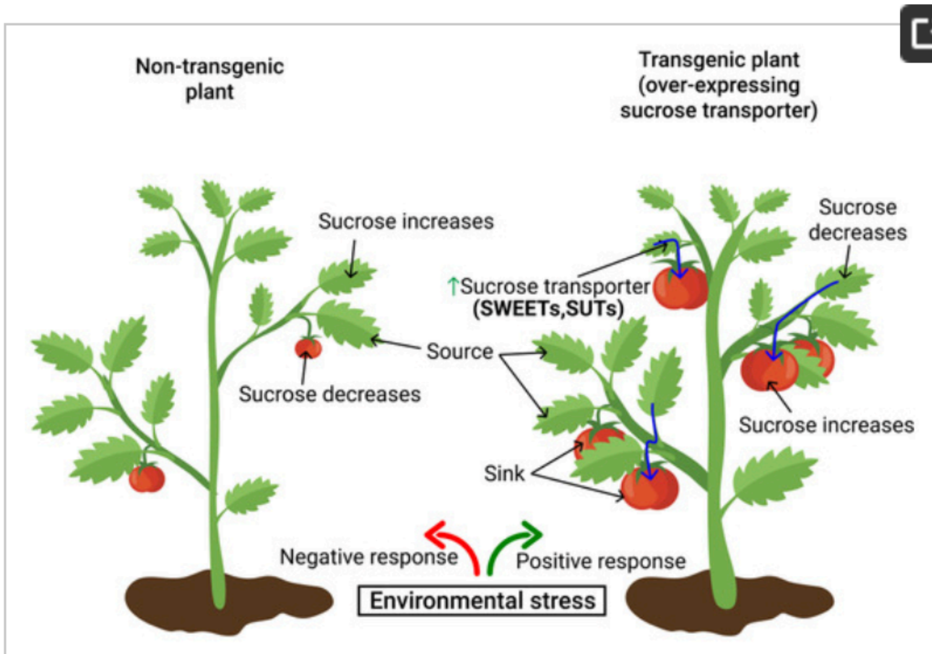
	- For each reduction, a following reduction was executed perfectly. For example, in Nitrate reduction to ammonia, Hydroxylamine was reduced to ammonia - After each reduction was observed and accounted for, they found that when comparand different methods each reduction required individualized methods, and certain products such as an iron-oxo complex produced from the reduction of nitrous oxide to dinitrogen closely matched the biological processes as well
Research Question/Problem/ Need	How can the stepwise reduction of nitrate and nitrite to biological products by analyzed for a synthetic perspective
Important Figures	 Scheme 1. Stepwise Reduction of NO_3^- to NH_3 (Left) or N_2 (Right) by Nature and by our Synthetic Complex $[N(afa^{Cy})_3Fe]OTf_2$ (**1**). The Arrows Representing the Natural Pathways are Color-coded to Correspond to the Appropriate Enzymes: Nitrate Reductase (NaR), Cytochrome *cd₁* Nitrite Reductase (cd_1NiR), Nitric Oxide Reductase (NOR), Nitrous Oxide Reductase (N_2OR), and Cytochrome *c* Ntrite Rductase (ccNiR). The Bottom Panel shows the Structure of Compound **1** Along with the Isolated Reaction Intermediates (**3** and **4**) Formed During the Sepwise Reduction Process.

VOCAB: (w/definition)	- Ligand: a molecule or ion that binds to another larger molecule - Removal of oxygen from a substance
Cited references to follow up on	Bijay-Singh, & Craswell, E. (2021). Fertilizers and nitrate pollution of surface and ground water: An increasingly pervasive global problem. *SN Applied Sciences*, *3*(4), 518. https://doi.org/10.1007/s42452-021-04521-8
Follow up Questions	How can these findings be implemented for the synthetic reduction of nitrogen in the real world?

Article #18 Notes: Sucrose Utilization for improved crop yields: a review article

Article notes should be on separate sheets

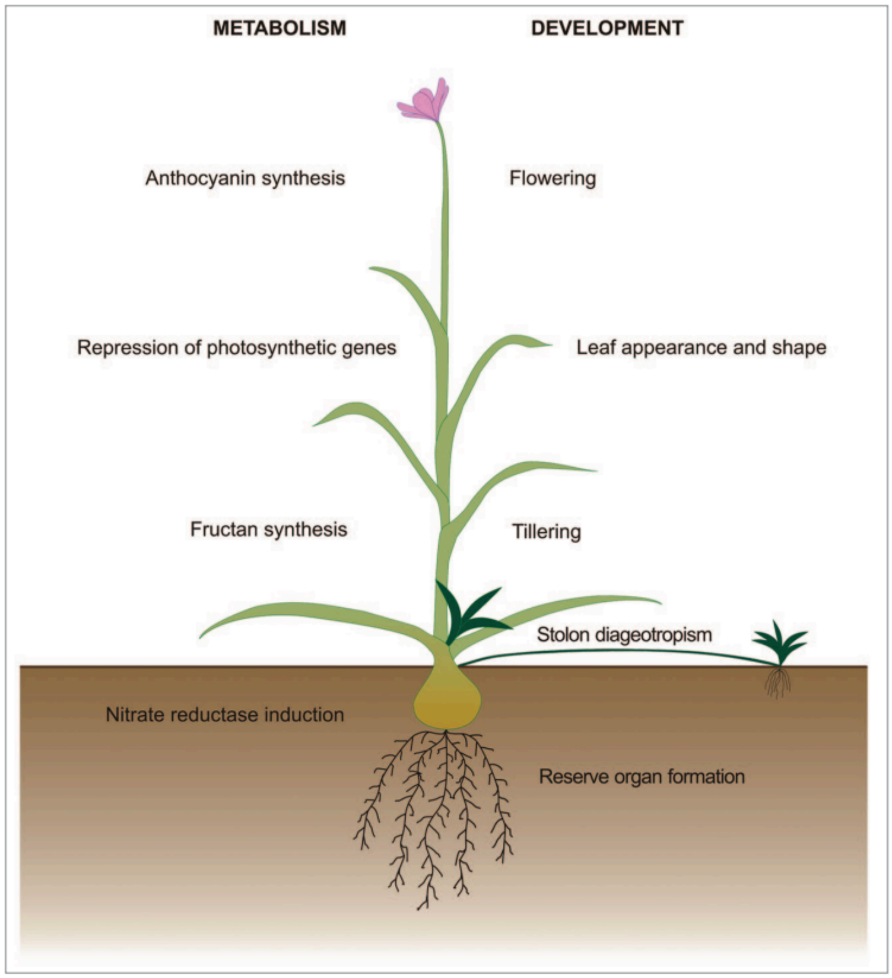
Source Title	Sucrose Utilization For Improved Crop Yields: A Review Article
Source citation (APA Format)	Edel, K. H., & Kudla, J. (2015). Calcium signaling in plants: A world yet to be explored. *Plant Signaling & Behavior*, *8*(3), e23316. https://doi.org/10.4161/psb.23316
Original URL	https://www.mdpi.com/1422-0067/22/9/4704
Source type	Journal Article, Meta Analysis
Keywords	Sucrose, plants, photosynthesis, global warming, CO2
#Tags	
Summary of key points + notes (include methodology)	- Sucrose is a primary energy source that communicates and supports many plant physiological systems - Plant development has been found to be adversely affected when nutrients are not balanced - To meet global food production demand, many crop yields must increase by over 60 percent over the next 30 years - As CO2 levels increase, certain nutrient levels are reduced, callign for the need for an enviromental upregulation of key plant growth and processes - This article summarizes existing information relevant to the use of sucrose to help solve this problem - One major fact is that high metabolism rates are dependent on input and signals from nutrients like sucrose - Sink organs are tissues that store energy through photosynthesis - Sucrose has been found to have a large impact of sink organ abilities - Light has similar positive effects and in fact encourages the production of sucrose - When accounting for a variety of enviromental stress factors (drought, temp extremes, light extremes), it is determined that sucrose presence plays a strong role in plant response - In A. Thaliana, sucrose was observed increasing in root transport

	during enviromental stress as sucrose transporter genes upregulated This has been utilized by overexpressing certain gene transports in crops to increase plant recovery and sucrose levels
Research Question/Problem/ Need	Greater crop demand over next century, need for greater plant growths
Important Figures	
VOCAB: (w/definition)	- Apportioned: to be assigned/allocated - Apoplastic: relating to apoplast, cellular network which forms the pathway for nutrients and signals in plants
Cited references to follow up on	Lemoine, R. (2000). Sucrose transporters in plants: Update on function and structure. *Biochimica et Biophysica Acta (BBA) - Biomembranes, 1465*(1-2), 246–262. https://doi.org/10.1016/S0005-2736(00)00142-5
Follow up Questions	Can sucrose be used as a foliar application to achieve these aims?

Article #19 Notes: Sucrose signaling in plants: a world yet to be explored

Article notes should be on separate sheets

Source Title	Sucrose signaling in plants: a world yet to be explored
Source citation (APA Format)	Edel, K. H., & Kudla, J. (2015). Sucrose signaling in plants: A world yet to be explored. *Plant Signaling & Behavior*, *8*(3), e23316. https://doi.org/10.4161/psb.23316
Original URL	https://www.tandfonline.com/doi/abs/10.4161/psb.23316
Source type	Journal Article, Meta Analysis
Keywords	Sucrose, Signaling, Life Cycle, Plant
#Tags	
Summary of key points + notes (include methodology)	- Sucrose has been proposed as a signaling molecule in plants for several decades - Recently, this role has been completely accepted based on an analysis of genetic and chemical plant components - While the strongest case of sucrose induced signaling has been observed in metabolic processes (relevant to my project), recent data indicates that sucrose signaling impacts a large array of developmental processes along the whole life cycle of the plant - The study observed that sucrose presence in plants is affected by enviromental factors, but interactions with other signaling pathways often skew these effects - After analyzing this data, while sucrose signaling is key in many plant processes, more research is needed to determine an exact quantitative effect and its significance in total plant function. - Many of sucrose's effects were also found to be explained by its response to oxidative damages and its role in carbon and nitrogen metabolism, which dictate plant growth

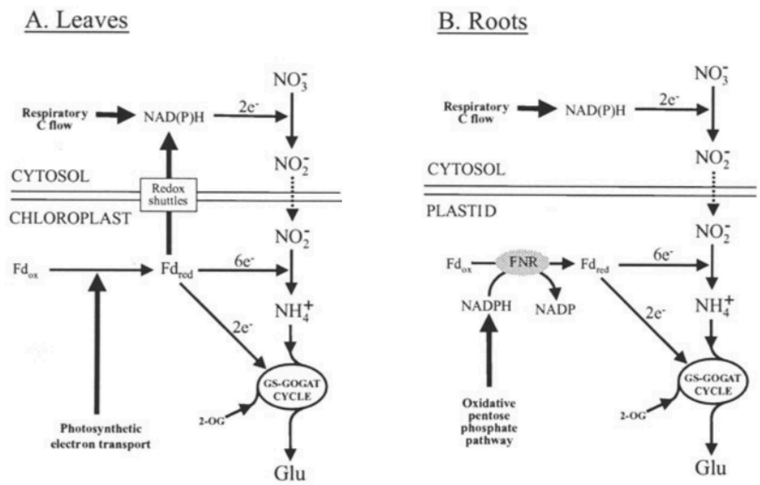
	- Areas in which sucrose had limited impact was root vs. shoot growth, and certain specific root formations such as lateral root formation, of which the development requires more research
Research Question/Problem/ Need	How does sucrose totally impact plant processes beyond metabolisms as a signal?
Important Figures	 **Figure 1.** Examples of processes regulated by the endogenous Suc concentration, as schematized in an hypothetic plant. Metabolic and developmental processes are shown at the left and right of the scheme, respectively. Above is a schematic of many processes encountered in day to day life that involve sucrose signaling
VOCAB: (w/definition)	- Redox: chemical reactions involving the transfer of electrons - Kinase: enzyme that catalyzes the transfer of a phosphate group form ATP to another molecule - Heterotrophic: cannot produce its own food

Cited references to follow up on	Pollock, C., Farrar, J., Tomos, D., Gallagher, J., Lu, C., & Koroleva, O. (2003). Balancing supply and demand: The spatial regulation of carbon metabolism in grass and cereal leaves. *Journal of Experimental Botany*, *54*(382), 489–494. https://doi.org/10.1093/jxb/erg037
Follow up Questions	How do sucrose additives translate as signals into plants through different methods, such as ground versus foliar

Article #20 Notes: Interactions Between Carbon and Nitrogen Metabolism

Article notes should be on separate sheets

Source Title	Interactions Between Carbon and Nitrogen Metabolism
Source citation (APA Format)	Foyer, C. H., Ferrario-Méry, S., & Noctor, G. (2001). Interactions between carbon and nitrogen metabolism. In P. J. Lea & J.-F. Morot-Gaudry (Eds.), *Plant nitrogen* (pp. 237–254). Springer. https://doi.org/10.1007/978-3-662-04064-5_9
Original URL	https://link.springer.com/chapter/10.1007/978-3-662-04064-5_9
Source type	Journal Article
Keywords	Carbon Metabolism, Nitrogen Metabolism
#Tags	#background
Summary of key points + notes (include methodology)	- Plants require metabolic processes to function - These include carbon and nitrogen metabolisms - Carbon metabolism is initialized with photosynthesis and produces sugars and starches, general biomass - Nitrogen metabolism is more discrete and uses energy and nitric oxides in the soil to produce proteins and amino acids - While primary carbon metabolism is dependent on nitrogen assimilation, nitrogen assimilation also requires a continuous supply of energy and carbon skeletons - This balance has been found to call for a partition of photosynthetic products such as sugars, between carbohydrate synthesis and the synthesis of amino acids - This interaction also involves feedback and signaling beyond passive resource sharing
Research Question/Problem/ Need	How are carbon and nitrogen metabolism interconnected?

Important Figures	 **Fig. 1 A, B :** Likely reductant sources for nitrate assimilation in illuminated leaves (**A**) and in roots (**B**). Redox shuttles are included in (**A**) to stress the possible contribution of the chloroplast to cytosolic nitrate reductase activity in the illuminated leaf. Exchange of reducing equivalents between the plastid and cytosol can also occur in roots. *Fd* Ferredoxin; *FNR* Ferredoxin-NADP oxidoreductase; *GS-GOGAT* Glutamine synthetase-glutamate synthase; *2-OG* 2-oxoglutarate
VOCAB: (w/definition)	Anaplerotic: metabolic reactions that replenish intermediates of the citric acid cycle Assimilatory: something related to or causing an assimilation
Cited references to follow up on	Aslam, M., Huffaker, R. C., Rains, D. W., & Rao, K. P. (1979). Influence of light and ambient carbon dioxide concentration on nitrate assimilation by intact barley seedlings. *Plant Physiology, 63*(6), 1206–1209. https://doi.org/10.1104/pp.63.6.1206 P.- Bachmann, M., Huber, J. L., Liao, P.-C., Gage, D. A., & Huber, S. C. (1996). The inhibition of nitrate reductase by phosphorylation and binding of 14-3-3 proteins. *FEBS Letters, 387*(2–3), 127–131. https://doi.org/10.1016/0014-5793(96)00477-8
Follow up Questions	How do enviromental effects impact this partition, and where is the balance shifted to account for different stress factors?

Article #21 Notes: Combining The Effects Of Increased Atmospheric Carbon Dioxide On Protein, Iron, And Zinc Availability And Projected Climate Change On Global Diets: A Modelling Study

Article notes should be on separate sheets

Source Title	Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate change on global diets: a modelling study
Source citation (APA Format)	Beach, R H,. et al. (2019). Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate chang eon global diets: a modelling study. *Lancet Planet Heath,* e307-317. https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(19)30094-4/fulltext
Original URL	https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(19)30094-4/fulltext
Source type	Journal Article
Keywords	CO2, Climate Change, Protein, Minerals, Modelling
#Tags	
Summary of key points + notes (include methodology)	- CO2 levels are expected to reach upwards of 4-600 ppm by 2100 - On the metabolic level, this has known changes in plant protein and mineral production - Under high CO2, plants produce less proteins and minerals - This study used existing data from the Internation Model for Policy Analysis of Agricultural Commodities and Trade to project per capita the availability of three main nutrients: protein, iron, and zinc in 2050 - They then combined two independent sources of existing data which determined the effects of increased atmospheric CO2 on

different key crops, and finalized their model to estimate future nutrient availability

- They observed that while the effects of CO2 fertilization on yield projected to increase the global availability of dietary protein, iron, and zinc, the negative effects of climate change and carbon penalties negated these advantages, resulting in projected decreases of:
  - 4.1-2.9%iron
  - 2.8-3.4%zinc
  - 19.5% protein
- They also observed that countries that have existing nutrient deficiencies would continue to be disproportionally affected

Research Question/Problem/ Need

Estimations are needed to secure closure and information on projected nutrient availabilities based on climate levels.

Important Figures

	2010-climate	2050-climate scenario	2050-nutrient scenarios	
			Loladze (2014)[18]	Myers et al (2014)[19]
Protein availability, g per person per day				
Global	95·09	111·82	107·27 (105·68–108·84)	108·54 (107·56–109·34)
East Asia and Pacific	104·81	134·15	129·23 (127·31–131·15)	130·40 (129·26–131·3)
Europe	127·99	134·83	129·27 (127·68–130·77)	131·32 (130·37–132·16)

This table displays predicted nutrient availabilities based on two datasets: Loladze and Myers et al

VOCAB: (w/definition)

- Disaggregated: something separated into its different parts

Cited references to follow up on

Medek, D. E., Schwartz, J., & Myers, S. S. (2017). Estimated effects of future atmospheric CO_2 concentrations on protein intake and the risk of protein deficiency by country and region. *Environmental Health Perspectives, 125*(8), 087002. https://doi.org/10.1289/EHP1870

Follow up Questions	What are current solutions being developed in this field to combat this issue? How do the effects of CO2 affect plant protein production on the metabolic and assimilatory scale

Article #22 Notes: Foliar fertilizer and method for using the same

Article notes should be on separate sheets

Source Title	Foliar fertilizer and method for using the same
Source citation (APA Format)	Yamashita, T. T. (2000). *U.S. Patent No. 6,165,245*. U.S. Patent and Trademark Office. https://patents.google.com/patent/US6165245A/
Original URL	https://patents.google.com/patent/US6165245A/en
Source type	Patent
Keywords	Foliar additive, fertilizer, patent, protocol, plants, growth, plant growth
#Tags	
Summary of key points + notes (include methodology)	- fertilizers are materials used to supply elements needed for plant nutrition - it can be beneficial to apply these fertilizers directly to the foliage of a plant - a variety of different foliar fertilizer compositions have already been developed - The patent provides methods for different common fertilizations, and how co-enzymes are used alongside aqueous solutions - These co-enzymes primarily include vitamin B compounds - It is better if the foliar solution has a variety of co-enzymes, as well as either/both folic acid and pyridoxine - These foliar applications are applied at rates of 0.25-10 gallons/acre, and consist of water, folic acid, pyridoxine, and a carbohydrate source which must range from 100,000 to 900,000ppm - A complexing agent can be incorporated depending on each setting - If a preservative agent is needed, propionic acid, acetic acid, potassium sorbate, tartaric acid, and malic acid are recommended - All solutions must be aqueous, where the above agents are combined with water. Water may be tap water, but should be treated

	- When applying the solutions, the fertilizer composition should be in contact with at least a portion of the foliage of the plant of which the growth should be enhanced - Amount used (0.25-10 gal/acre) depends on user needs
Research Question/Problem/ Need	Objectified way to use foliar applications of fertilizer in agriculture
Important Figures	No significant figures were provided, although evidence of certain processes and methods can be seen here: Material / Source / Amount/L Folic Acid / Pteroylglutamic Acid / 1 mg Pyridoxine / Pyridoxine Hydrochloride / 1 mg Sucrose / Table Sugar / 7 g Fulvic Acid / 2% Fulvic Acid / 5 ml Citric Acid / Citric Acid Monohydrate / 109 mg
VOCAB: (w/definition)	- Fulvic acid: natural compound found form decomposed matter - Folic acid essential vitamin for making new cells - Disparate: very different, cannot be compared
Cited references to follow up on	Alexander, A. (1986). Optimum timing of foliar nutrient sprays. In A. Alexander (Ed.), *Foliar fertilization: Proceedings of the first international symposium on foliar fertilization, organized by Schering Agrochemical Division, Special Fertilizer Group, Berlin (FRG) March 14–16, 1985* (pp. 44–60). Springer. https://doi.org/10.1007/978-94-009-4386-5_4
Follow up Questions	How are these methods different for non-fertilizer-based additives? What is the chemical significance of a co-enzyme?