

AG2PI SEED GRANT - PROJECT FINAL REPORT

PROJECT NAME	Using unmanned aerial vehicles to detect nitrogen stress in alfalfa (<i>Medicago sativa</i> L.)
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PROJECT PRINCIPAL INVESTIGATOR	TODAY'S DATE	PROJECT START DATE	DATE OF COMPLETION
Anju Biswas and Esteban Rios	07/31/2023	06/01/2022	5/31/2023
TEAM MEMBERS (co-PI, co-I, personnel)	COLLABORATORS		
Dr. Aditya Singh	Ayush Sharma		

ACCOMPLISHMENTS

Please provide a short summary of the conclusions (both successes and failures) made from your project. Include a description of how this project will provide benefits to the agricultural genome to phenome community and, possibly, to a broader audience. You should include both qualitative and quantitative details, as necessary, to support your conclusions. Include a short accomplishment statement in non-technical language and do not include names.

This is not a technical report. Please keep to no more than 6-8 sentences (e.g., 1-2 sentences per point, above).

Our project focused on studying whether nitrogen fertilization can reduce the decline in yield and persistence in alfalfa in Florida, especially during summer slump.

We measured dry matter yield, stand persistence, and N content in 144 half-sib families and 5 commercial checks, grown in two environments represented by: i) no nitrogen application, and ii) 40 lbs N / acre after each harvest event. We collected data in June, August and October 2022. Samples were dried and ground, and we used a NIRS Foss 2500F to scan the samples, and measured N content using wet chemistry in 20% of the samples.

We developed a pipeline to acquire and process hyperspectral imagery for nitrogen stress detection and dry matter yield. The pipeline was presented in May 2023 during a workshop organized by AG2PI, where we shared our image processing pipeline, which is now publicly available. This pipeline can be beneficial for researchers interested in using hyperspectral sensors in their studies. Furthermore, our research article will demonstrate the advantages of combining genomics and phenomics for broader applications in the field.

We genotyped our population using Breeding Insight's marker array. Genomic prediction models for dry matter yield resulted in predictive ability ranging between 0.2 and 0.35 across harvests. We also fitted phenomic prediction models using the NIRS spectra and predictive abilities for dry matter yield ranged between 0.4 and 0.6 across harvests. The combination of genomic + phenomic prediction models resulted in greater predictive ability (average of 0.55). These results showed the power of combining genomics and phenomics in the prediction of complex traits. The use of phenomic and genomic selection can result in greater genetic gain for complex traits.

Future work: fit phenomic-based prediction models using the hyperspectral data collected with drones, and compare these models with genomic prediction (marker based), and phenomic prediction using NIRS. Besides, we will expand our models to predict N content and stand persistence.

Products

Please list any products from this project. This may include (but not limited to) publication, concept/white paper, workshop, conference presentation, website, publicly available data or pipelines, etc. Reminder: you are required to make your products available to the broader stakeholder community using standard USDA practices, open source, FAIR, or other models. Metrics may include number of participants or times accessed, etc. Include links to recordings, DOI, etc. when possible. For presentations and posters, provide authors, date, location and presentation title.

ACTIVITY / PRODUCT	DESCRIPTION (include URL, if applicable)	OUTCOME / METRICS
Interview	Dr. Anju Biswas was interviewed by my Field Max, geneticist of USDA and shared her knowledge about highthroughput phenotyping	Max is using that survey for his publication
Workshop	AG2PI arranged a workshop where Dr. Esteban Rios and Dr. Anju Biswas presented updates on the project. Dr. Rios presented about the whole project summary, while Dr. Biswas presented the hyperspectral imagery processing pipeline. She shared the pipeline with the AG2PI community. Dr. Aditya Singh, Ayush Sharma, Anju Biswas worked on that pipeline and Dr. Esteban Rios reviewed the pipeline before final presentation	The recorded video and pdf format pipeline are available. 111 participants and 101 people accessed the youtube video since May 23, 2023.
Conference	Dr. Anju Biswas presented a poster at the AG2PI Conference, 2023 in Kansas City.	She disseminated the research findings to various audiences and gained insights from the research of others. A diverse array of universities contributed to the presentation of nearly thirty-five posters. Students, postdoctoral researchers, professors, and USDA NIFA representatives actively participated, fostering an environment of increased interactivity.
Publications	We are working on the first publication that will focus on: 1- Pipeline for imagery and data processing from drone. 2- Ground-based results to show the lack of improvement in yield and N stress during the summer slump by applying N to alfalfa in Florida. 3- Dry matter yield, plant population, and N stress detection using hyperspectral imagery. Dr. Biswas, Dr. Singh, and Dr. Rios will lead the writing for the first manuscript. A second manuscript will focus on developing phenomic and genomic prediction models for yield, persistence, and N content in alfalfa. Pablo Sipowicz is a PhD candidate in Dr. Rios' lab and he will lead the second manuscript	This publication will help audience to know how remote sensing and phenomics can be implemented in plant breeding decision making. It will also contribute to understanding the summer slump in alfalfa, while using remote sensing to estimate yield, persistence, and N content in alfalfa.

Audience

With whom has this work been targeted to and shared? Please describe how this project and its products have been disseminated to a community of interest. Include any outreach activity or information sharing as well as training or professional development opportunities provided in this project.

Plant scientists and plant breeders who are interested in utilizing remote sensing and genomic prediction in their research/breeding programs.

Dr. Rios presented results from this project in various venues:

- a. Plant breeding courses at UF (undergrad and graduate students).
- b. Field days (county agents and producers)
- c. Summer short-course at UF for 90 participants from 11 countries: Multi-Omic Integration for AI Genomic Prediction Breeding Short Course (<https://conference.ifas.ufl.edu/moai/index.php>).

CONTINUATION OF WORK

Next steps

How do you/your team plan to continue moving this project forward? Include how AG2PI can assist in your forward momentum.

We envision to develop a manuscript to show the following outcomes from this project: 1- Pipeline for imagery and data processing from drone. 2- Ground-based results to show the lack of improvement in yield and N stress during the summer slump by applying N to alfalfa in Florida. 3- Dry matter yield, plant population, and N stress detection using hyperspectral imagery. Dr. Biswas, Dr. Singh, and Dr. Rios will lead the writing for the first manuscript. A second manuscript will focus on developing phenomic and genomic prediction models for yield, persistence, and N content in alfalfa. Pablo Sipowicz is a PhD candidate in Dr. Rios' lab and he will lead the second manuscript.