AG2PI COCONUT GRANT - PROJECT FINAL REPORT

PROJECT NAME	**Facilitating community unoccupied aerial systems (UAS, drone) knowledge, communication, and data processing**

PROJECT PRINCIPAL INVESTIGATOR	TODAY'S DATE	PROJECT START DATE	DATE OF COMPLETION
Seth C. Murray (PI), sethmurray@tamu.edu	4/25/2024	March 2023	Febuarary 2024
TEAM MEMBERS (co-PI, co-I, personnel)		COLLABORATORS	
Mahendra Bhandar (Co-PI), **Jose L. Landivar Scott** (Senior Research Associate) **Anna Porter** (Project Coordinator), **Mustafa Arik** (Research Assistant), **Aaron DeSalvio** (Graduate Student), **Alper Adak** (Postdoc)		*(S1069)* **Maria Balota**, Virginia Tech; *(S1069)* **Lav R. Khot**, Washington State; *(S1069 & SPIE)* **J. Alex Thomasson**, Mississippi State; *(G2F)* **Edgar Spalding**, U.Wisconsin Madison; *(G2F)* **David Ertl**, Iowa Corn; *(G2F)* **Jose Ignacio Varela**, U.Wisconsin Madison; *(G2F)* **Natalia DeLeon**, U.Wisconsin Madison; *(G2F)* **Addie Thompson**, Michigan State University; *(G2F)* **Jacob Washburn**, USDA-ARS; *(G2F, Plant Phenome Journal)* **Michael Gore**, Cornell; *(G2F and HIPS)* **James Schnable**, U. Nebraska-Lincoln; *(HIPS)* **Yeyin Shi**, U. Nebraska-Lincoln; *(HIPS)* **Yufeng Ge**, U. Nebraska-Lincoln; *(PhenomeForce and FIELDimageR)* **Filipe Matias,** Syngenta; *(D2P, ODD-PIG)* **David LeBauer**, U. Arizona; *(software)* **Jinha Jung**, Purdue; *(software)* **Kelly Robbins**, Cornell; *(cattle)* **Joshua Jackson**, University of Kentucky; *(Small grains)* **Margaret Krause**, Utah State U.; *(Vegetables)* **Carlos Avila,** Texas A&M AgriLife; *(NAPPN)* **Sierra Young**, Utah State University; *(Peanuts)* **John Cason**, Texas A&M AgriLife;	

NOTE: A shortened version of this report will be made available on the AG2PI website after any sensitive items have been removed. You will have final approval of the website version.

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.

(HINT: You can expand sections as necessary by pulling down on the square in the lower right corner of each box)

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

This project demonstrated that there are many ongoing, yet separate, activities ongoing to use unoccupied aerial systems (UAS, UAVs, drones) in agricultural genome to phenome research, with additional researchers wanting to leverage these tools, but that interactions and communication across research silos is needed. Furthermore, dedicated project personell are critical to both facilitate communication and process the data into consistant usable products. The major successes of this project were in hosting activities (webinars, a website, presentations, a meeting and a conference) to enable sharing of research knowledge as well as in processing UAS data sets that have been collected into products that others can use. In addition to other activities, 10 early career researchers were supported to attend the S-1069 UAS multi-state UAS meeting, a website was developed (https://cropphenotypinghub.org), and a national Artificial Intellegence in Agriculture conference was organized. In total there were nearly 1000 participant interactions resulting from this project. The maize genomes to fields (G2F) UAS dataset processed here comprised 18 diverse environments over 660 hybrids with 420 flights and 10.6TB of information. Additionally, this project supported the processing of RGB and Multi-Spectral UAS data obtained from 15 wheat breeding programs (10 times during the growing season) in 2023 under the WheatCAP project. The maize and wheat are now largest unified processed UAS data sets globally to our knowledge. These data sets are being used for substantial knowledge generation on genotype (G), environment (E), and GxE interations through plant growth across the U.S. and will serve as a reference for development of artificial intellegence tools. The major accomplishment has been demonstrating that there is a large community of researchers interested in UAS phenotyping and to provide them tools, data and services to help enhance the understanding of biology across agricultural crops. UAS hold substantial promise for connecting genotype to phenotype and in understanding GxE interactions beyond genomics, but support of communication and data processing are needed.

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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 prodcuts 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**
Poster on project activities and outcomes	Seth C Murray, Mahendra Bhandari, Jose L. Landivar Scott, Mustafa Arik, Aaron James DeSalvio, Alper Adak. 2023. Facilitating community unoccupied aerial systems (UAS, drone) knowledge, communication, and data processing across agriculture. National Association of Plant Breeders annual meeting. 7/16-20/2023 Greenville, S.C.	Approximately 300 attendees to meeting
Poster on project activities and outcomes	Anna Porter, Seth C Murray, Mahendra Bhandari, Jose L. Landivar Scott, Mustafa Arik, Aaron James DeSalvio, Alper Adak. 2024. "Facilitating community unoccupied aerial systems (UAS, drone) knowledge, communication, and data processing across agriculture". North American Plant Phenotyping Network annual meeting. 2/13-15/2024 Purdue University.	Approximately 300 attendees to meeting
Presentation on project activities and outcomes	Seth C Murray, Mahendra Bhandari, Jose L. Landivar Scott. 2024. "Facilitating community unoccupied aerial systems (UAS, drone) knowledge, communication, and data processing across agriculture". AG2PI Field Day #29 - UAS Community & Plant Stress Ontologies - AG2PI "Coconut" Grant Outcomes. 2/21/2024 https://www.youtube.com/watch?v=O-Ns8gPqFnk	42 online attendees
Presentation and demonstration of project activities (planned)	1. Oral presentation: UAV-based High-Throughput Phenotyping: From Sensors to Data Driven Decision Support. 2. Demonstration of the web-based UAS data processing and management along with the website developed from this project. Mahendra Bhandari, Jose Landivar, Seth Murray, Lei Zhao, Juan Landivar, Mahmoud Eldefray PhenoHarmonics Workshop, 27-30 May, 2024 in Montpellier, France	79 participants confirmed so far
Website	Online portal for learning, sharing, and exploring Unmanned Aircraft System (UAS) in agriculture. https://cropphenotypinghub.org	Website is publicly available.
Wheat data set	15 environments across the U.S., each location collected data 10-12 times during the season using RGB and multi-spectral sensors (5.4 TB of data). Canopy cover, canopy height, excess green index, Normalized Difference Vegetation Index (NDVI), and Normalized Difference	Processed data was sent to respective breeding programs as well as deposited to T3 database

	RedEdge Index (NDRE) were extracted and made available for further analysis and use	
Webinar discussion	"UAV/UAS/Drone restrictions for agricultural research and how organizations are dealing with them." 1/8/2024. Zoom. https://www.youtube.com/watch?v=AABalsvds80	86 online participants and 90 views since availability on YouTube
Maize G2F UAS data set	In total, 18 environments across the U.S. on 660 hybrids temporal UAS datasets containing 420 flights were processed into 10.6TB of orthomosaics, tabular height and vegetation indicies for unifed analysis of G, E, and GxE of numerous traits.	Processed data was returned to 10 research programs, we are continuing to investigate how to make this available long term, and working on multiple publications from this work.
Conference	The 3rd National Artificial Intellegence in Agriculture conference held in College Station Texas, April 15-17, 2024 was planned by the Project Coordinator, who was partially supported by AG2PI. Many presentations focused on UAS tools, workshops and discussions were held. All presentations were recorded and are being made available on YouTube. https://na.eventscloud.com/website/63088/	270 in person attendees, 60 online attendees. Already 80 views on some presentations.

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.

The primary audience was and continues to be other scientists interested in using unoccupied aerial systems (UAS, UAV, drones) for their agricultural and phenotyping research, some already currently using these tools. This includes students, professional staff, faculty, government and industry, all whom have participated. These products have been distributed through poster presentations, webinars, websites, meetings and data sets. Two scientific meetings that provided training opportunities were supported by this project, 1) the 2023 S-1069 multi-state UAS project meeting, which directly funded 10 early career attendees; 2) The 3rd National AI in Agriculture Conference which hosted a number of workshops for 330 attendees.

CHALLENGES

Changes to team

Have there been any changes to the original team membership (including collaborators) from who was included in the proposal? Please review your proposal then provide an explanation if changes were made.

The PIs remained the same on this project and most of the collaborators were engaged in some or all of our activities.

Other changes

Were there changes to your project, not including changes to team membership? This may include expansion or reduction in scope. If changes occurred, did these have a significant impact on expenditures? Please explain.

Hiring a Project Coordinator took longer than expected and was more expensive than we budgeted. This delay reduced the number of outreach webinar activities we had planned on, however we plan to continue these activities moving forward. We also directed the Project Coordinator's time to help support coordinating the Artificial Intellegence in Agriculture meeting, which hosted approximately 270 in person and 60 online participants to engage in research sharing, networking and community building. As most of the 101 presentations given in the AI in Ag conference include UAS data, this was perfectly aligned with this AG2PI coconut project. We are currently seeking long-term repositories to host the 10TB of data. No significant impacts to expenditures occurred.

Challenges

Have you experienced any challenges or delays? Please provide the actions you took to resolve them, if possible.

The largest challenge was due to the one year funding cycle as explained regarding personel in the previous question. We modified our outreach activities accordingly to leverage additional opportunities presented (AI in Ag conference). Two year funding cycle would be more effective.

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 plan to continue this work, however financial resources are limited to doing so at the same capacity. We plan to write grant proposals (primarily USDA) to support further outreach to the community on UAS tools, that would continue to process maize G2F data and make it publicly available, do similar activities in the wheat community and continue facilitating communication in this area.