2024 NCERA-101 Station Report – University of Wyoming Plant Growth & Phenotyping Facility (PGPF)

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1. **New Facilities & Equipment** The plant phenotyping project, oQulus, has been finalized with an expected day of deployment in June 2025. oQulus will equip the facility of a camera platform on a movable gantry system allowing users to record images monitoring plant photosynthetic efficiency, plant morphology and plant response to environmental variation. The project is led by PhotosynQ Inc., company involved in providing phenotyping systems for both private corporations and research institutes. The system will provide monitoring of multiple plants, growing in individual pots or flats, using a multimodal imaging platform on a XYZ robotic gantry. The base sensor platform will comprise: 1) a PAM fluorescence imaging system for tracking photosynthetic performance, 2) a high resolution RGB camera for visualizing plant color, morphology, and size, 3) a 3D imaging system for tracking height, growth, and architecture and 4) a thermal camera 5) any accessory lighting required for each imaging method. The system will provide an integrated suite of software tools as requested for controlling the gantry, collecting data, processing image data, and analysis. With the collaboration of the Wyoming Data Hub and the University of Wyoming School of Computing, researchers on and off campus will be able to utilize the collected datasets for their research projects.

2. **Unique Plant Responses Results:**

2A. Two peppers (Capsicuum annum) varieties, *ACE (F1)* and *Cornito Giallo*, showed different response in their photosynthetic efficiency when assessed as a means of photosystem II energy partitioning. Although the two varieties did not show significance different in the quantum yield or operating efficiency of photosystem II (φPSII), significant variation in the quantum yield of regulated and unregulated heat dissipation, (φNPQ) and (φNO) was reported when exposing the two varieties to different light spectra (agumented RED, augmented WHITE, augmented BLUE) with respect to a FULL SPECTRUM. These results suggest that the lighting spectra could be better optimized for production in controlled environment by focusing on the study of energy partitioning at photosystem II level

2B. Potted lettuce grown in peat-based media (peat-perlite mixture – BM6; peat-bark mixture (BM7)) exhibited higher productivity than those in calcined clay substrate (Turface MVP). Productivity was estimated via growth measurements such as the number of leaves longer than 10 cm, total leaf area, and

leaf fresh and dry weight, collected at 25, 39, and 60 days after sowing (DAS). Vegetative growth in all lettuce and soilless growth substrates decline after 60 DAS. These results are relevant for space crop management techniques and sustainable fresh vegetable production needed for long-term space exploration missions

2C. Transgenic plants of pine tree genes showed same phenotype of their autologous gene in *Arabidopsis,* demonstrating functional conservation of these genes. Pine tree genome was not assembled well until recently and long-living tree genome might contain information for their long lifespan

2D. A computer vision pipeline was developed to enhance the significance of leaf-level thermal images across 27 distinct cotton genotypes cultivated at the PGPF under progressive drought conditions. The approach involved employing a customized software pipeline to process raw thermal images, generating leaf masks, and extracting a range of statistically relevant thermal. These features were then utilized to develop machine learning algorithms capable of assessing leaf hydration status and distinguishing between well-watered (WW) and dry-down (DD) conditions. Two different classifiers were trained to predict the plant treatment-random forest and multilayer perceptron neural networks-finding 75% and 78% accuracy in the treatment prediction, respectively.

3. **Accomplishments:**
    - The PGPF has been the center of operations for the first interdisciplinary class in Controlled Environment Agriculture (CEA) – AGRI 4990 – at University of Wyoming. The Facility Director, Dr. Guadagno, has coordinated the class while the Facility Manager, Mike Baldwin, led the laboratorial activities with CEA system. Faculties from 10 different departments were involved in the 8 weeks class where 10 students had the opportunity to listen the latest advancement in CEA from external business representatives and spend two weeks internship at Plenty Unlimited, Inc. in Laramie. The class will be implemented in the current REU site for CEA in 2025 awarded to the school and future offer in the CEA curriculum
    - The PGPF has been developing a Virtual Reality Program in collaboration with CD&M (TX) and the 3DHub at University of Wyoming. The program will enhance plant science related classes across the state with access for all students to the Facility and VR activities
    - The PGFP infrastructures have supported the submission of more than 10 extramural collaborative proposals in 2024; for now, four of these proposals, totaling over $4M, have been awarded to University of Wyoming personnel. Funded research will be facilitated by PGPF operations over the next coming years
    - Collaborative Research: Tribal community resilience under climate change: Harnessing controlled environment agriculture to secure sustainability and economic growth - this 4-year grant will support extensive phenotyping cross-state collaborative work with New Mexico and South Dakota (Guadagno)
    - Empowering early stress detection with AI: A global plant phenotyping initiative (Guadagno)
    - A two-day workshop in high-throughput phenotyping was hosted at the Facility in May 2024, care of Dr. Guadagno. The workshop, sponsored by PhotosynQ. Inc. and the Wyoming Innovation program hosted 39 participants who utilized the facility for hands-on activities in the greenhouse bays

- The PGPF has been developing an MOU with University of Wyoming General Counsel aimed to build a network of private and public entities, from community colleges to private industries, collaborating in shaping new educational interdisciplinary opportunities for youth in controlled environment agriculture
- Dr. Guadagno has been added as State representative to the HATCH Project No. and Title: NC1212: Exploring the Plant Phenome in Controlled and Field Environments in representation of the PGPF

4. **Impact Statement**

The vision of the PGPF is to build bridges between academia and businesses in CEA towards a skilled workforce development and economic resilience for the state and the region. In 2024, the PGPF has proven itself at the forefront of sustainable innovation and education. This state-of-the-art facility provides a dynamic, interdisciplinary hub where students, educators, and researchers collaboratively study plants while fostering early exposure to technology and community awareness for controlled environment agriculture.

Published Written Works

Renó, V., Cardellicchio, A., Romanjenko, B.C. and Guadagno, C.R., 2024. AI-assisted image analysis and physiological validation for progressive drought detection in a diverse panel of Gossypium hirsutum L. Frontiers in Plant Science, 14, p.1305292. https://doi.org/10.3389/fpls.2023.1305292

Jang, MJ., Cho, H.J., Park, YS. et al. Haplotype-resolved genome assembly and resequencing analysis provide insights into genome evolution and allelic imbalance in Pinus densiflora. Nat Genet 56, 2551–2561 (2024). https://doi.org/10.1038/s41588-024-01944-y