**Project/Activity Number: S1069**

**Project/Activity Title**: Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources

**Start Date**: 11/01/2021

**End Date**: 9/30/2026

**Date of This Report**: 08/15/2025

**Annual Meeting Date(s)**: June 9-10, 2025

Annual Meeting Location: IN-Person (Brookings, SD) and Online (Zoom)

**Introduction:** This year, the S1069 and NCERA 180 multi-state groups held a joint meeting. Peter Kovacs opened the session, welcoming and thanking all participants for attending. Dr. John Blanton, Associate Dean for Research and Director of SDSU’s Agricultural Experiment Stations, also greeted the attendees and shared a brief overview of the College’s structure and organization. Those attending in person had the opportunity to tour the Raven Precision Ag Center and learn about various precision agriculture projects underway at SDSU on June 09.

**Participants:**

*In-person*

1. Peter Kovacs, South Dakota State University,
2. Kasiviswanathan Muthu Muthukumarappan, South Dakota State University
3. John Fulton, Ohio State University
4. Rob Proulx, North Dakota State University Extension
5. Natasha Rayne, University of Wisconsin
6. Simerjeet Virk, Auburn University
7. Alex Thomasson, Mississippi State University
8. Won Suk Lee, University of Florida
9. Glen Reins, University of Georgia
10. Guillermo Balboa, University of Nebraska, Lincoln
11. Nick Uilk, South Dakota State University
12. Van Kelley, South Dakota State University
13. Dharmendra Saraswat, Purdue University
14. Abhilash Chandel, Virginia Tech University
15. Sunoj Shajahan, University of Illinois, Urbana-Champaign
16. Manoj Karkee, Cornell University
17. Rupak Karn, North Dakota State University, Carrington Research Extension Center

*Online:*

1. Jennifer Lachowiec, Montana State University
2. Amire Verdi, University of California, Riverside
3. Mahendra Bhandari, Texas A&M University
4. Randy Raper, Oklahoma State University

**Summary of the discussions at the meeting on June 10:**

Kasiviswanathan Muthukumarappan (NCERA 180 group’s administrative advisor), provided an administrative update on behalf of both him and Christina Hamilton. He emphasized that multi-state projects are designed to create meaningful impact. A reviewer had suggested a possible merger of the S-1069 and Ag Innovation NC 180 groups; however, the ensuing discussion raised concerns about potential loss of members and a dilution of each group’s research focus. Dr. Muthukumarappan recommended maintaining the groups as separate entities while seeking opportunities for joint meetings and collaborative projects. Dr. Randy Raper (NCERA 180 group’s administrative advisor) reminded S1069 participants about proposal submission requirements and associated deadlines for those planning to resubmit. Dr. John Fulton shared updates from the International Society of Precision Agriculture, noting that the Society has new leadership and a strong financial position. Its mission remains to advance precision agriculture science worldwide. Efforts are underway to integrate conferences (such as ESPA and Latin-American PA) to enhance information sharing, preserve presentations, and unify activities under one organizational umbrella. Additional initiatives include developing corporate membership opportunities and creating a global database of precision agriculture courses. The next International Conference will be held in Porto Alegre, Brazil, from July 13–16, 2026. Dr. David Clay of South Dakota State University is leading an international project to update the Precision Ag Basics textbook for undergraduate students, with revisions to existing chapters and the addition of new content. Each station representative presented their station efforts for bothe NCERA 180 and S1069. Several efforts with a potential multi-state collaboration were identified and discussed.

1. A digital ag survey was conducted across the Midwest states to establish a baseline of what technology farmers are currently using or aware of.
2. Multiple states are working on planter related research to improve seeding quality.
3. States are working the utilization of machine learning and deep learning for crop phenotyping using UAS
4. Machine learning and artificial intelligence (AI) aided weed detection, identification, and targeted spraying research involves many states.

The group also discussed the advantages and disadvantages of holding joint meetings in the future. Due to low participation from S1090 members, it was decided to reconvene online in the coming weeks to further evaluate whether to continue the project and determine if the group wishes to pursue joint meetings moving forward.

**Impact:**

Working collaboratively in both small and large groups, the S-1069 team made notable advancements in several areas: exploring new applications of UAS in breeding, agricultural production, and natural resource management; developing training materials for UAS use; creating platforms for UAS-based data analysis, storage, and sharing; and conducting extension and outreach activities to expand UAS-driven agricultural production. The outcomes outlined below from S-1069 members highlight numerous opportunities for continued collaboration in the future.

**Products:**

**Journal articles, pre-prints published**

1. Killian E.Z., Eberly J.O., & Lachowiec J. (2025) Utilizing QGIS for Open-Source UAS Imagery Plant Classification and Plot Segmentation. The Plant Phenome Journal, 8, e70030. <http://dx.doi.org/10.1002/ppj2.70030>
2. Sahayaraj, Sathish Raymond Emmanuel, Abhilash K. Chandel, Maria Balota, Matthew Chappell, and Venkat Sridhar. "Leveraging stacked generalization for peanut maturity mapping using aerial multispectral imagery and growing degree days." In Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping X, vol. 13475, pp. 202-212. SPIE, 2025.
3. Jjagwe, P., Chandel, A., Balota, M., & Raman, R. (2025, May). Faba bean crop plant identification using aerial multispectral imagery and convolutional neural network-based deep learning models. In Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping X (Vol. 13475, pp. 227-236). SPIE.
4. Chandel, A. K., Khot, L. R., Stöckle, C. O., Kalcsits, L., Mantle, S., Rathnayake, A. P., & Peters, T. R. (2025). Canopy Transpiration Mapping in an Apple Orchard Using High-Resolution Airborne Spectral and Thermal Imagery with Weather Data. AgriEngineering, 7(5), 154.
5. Jjagwe, P., Chandel, A. K., & Langston, D. B. (2024). Impact Assessment of Nematode Infestation on Soybean Crop Production Using Aerial Multispectral Imagery and Machine Learning. Applied Sciences, 14(13), 5482.
6. Raman, R., Neely, H. L., Rajan, N., Bhandari, M., Siegfried, J., Ibrahim, A. M., ... & Hardin, R. H. (2025). UAS‐derived vegetation indices detect wheat leaf rust infection and its influence on grain yield and canopy temperature. *Crop Science*, *65*(3), e70062.
7. Khuimphukhieo, I., Zhao, L., Ghansah, B., Scott, J. L. L., Fernandez-Montero, O., da Silva, J. A., ... & Bhandari, M. (2025). Use of Uncrewed Aerial System (UAS)-Based Crop Features to Perform Growth Analysis of Energy Cane Genotypes. *Plants*, *14*(5), 654.
8. Ghansah, B., Scott, J. L. L., Zhao, L., Starek, M. J., Foster, J., Landivar, J., & Bhandari, M. (2025). Satellite vs uncrewed aircraft systems (UAS): Combining high-resolution SkySat and UAS images for cotton yield estimation. *Computers and Electronics in Agriculture*, *234*, 110280.
9. Pal P., J. Landivar, J. L. Scott, L. Zhao, N. Duffield, K. Nowka, J. Jung, A. Chang, K. Lee, \***M. Bhandari.** 2025. Unmanned Aerial System and Machine Learning Driven Digital-Twin Framework for Cotton Crop Forecasting. *Computer and Electronics in Agriculture, 228, 109589.* <https://doi.org/10.1016/j.compag.2024.109589>
10. Reddy J., Niu H., J. L. Scott, **M. Bhandari**, J. Landivar, C. W. Bednarz, N. Duffield. 2024. Cotton yield prediction via UAV-based cotton bolls image segmentation using YOLO and SAM Models. *Remote Sensing, 16, 4346.* <https://doi.org/10.3390/rs16234346>
11. Khuimphukhieo I., **M. Bhandari**, J. Enciso, J. A. da Silva. 2025. Estimating sugarcane yield and its components using unmanned aerial systems (UAS)- based High throughput phenotyping (HTP). *Computers and Electronics in Agriculture*. <https://doi.org/10.1016/j.compag.2025.110658>
12. Nethala P., D. Um, N. Vemula, O.F. Montero, K. Lee, **M. Bhandari**. 2024. Techniques for Canopy to Organ Level Plant Feature Extraction via Remote and Proximal Sensing: A Survey and Experiments. *Remote Sensing*, *16, 4370.* <https://doi.org/10.3390/rs16234370>
13. Sarupria, M, Vargas, R., Walter, M., Miller, J, & Mondal, P. (2025). Non-linear spectral unmixing for monitoring rapidly salinizing coastal landscapes. Remote Sensing of the Environment. 319. e114642.
14. Miller, J & Adkins, J. (2024). Vegetation indexes to detect plant density and nitrogen rate effects on maize yield. ESS Open archvie. Pre-print.
15. Miller, J.O., Shober, A.L., Taraila, J. (2024). Assessing relationships of cover crop biomass and nitrogen content to multispectral imagery. Agronomy Journal. 116(3).
16. Soto, M., Poncet, A.M., Roma-Burgos, N., France, O.W., Velasquez, J.C., Ashworth, A.J., Brye, K.R. & Koparan, C., (2025). Hyperspectral indicators and characterization of glyphosate-induced stress in common lambsquarters (Chenopodium album L.). Smart Agricultural Technology, 11, p.100890.
17. Betitame, K., Igathinathane, C., Howatt, K., Mettler, J., Koparan, C., & Sun, X. (2025). A practical guide to UAV-based weed identification in soybean: Comparing RGB and multispectral sensor performance. Journal of Agriculture and Food Research, 20, 101784.
18. Tagoe, A., Silva, A., Koparan, C.\*, Poncet, A., Wang, D., Johnson, D., & Worthington, M. (2024). Blackberry Growth Monitoring and Feature Quantification with Unmanned Aerial Vehicle (UAV) Remote Sensing. AgriEngineering, 6(4), 4549-4569.
19. G C, S., Koparan, C., Upadhyay, A., Ahmed, M.J., Zhang, Y., Howatt, K., Sun, X. (2024). A Novel Automated Cloud-Based Image Datasets for High Throughput Phenotyping in Weed Classification. Data in Breif, DIB-D-24-00702R3.
20. Upadhyay, A., G C, S., Zhang, Y., Koparan, C., & Sun, X. (2024). Development and evaluation of a machine vision and deep learning-based smart sprayer system for site-specific weed management in row crops: An edge computing approach. Journal of Agriculture and Food Research, 18, 101331. doi:https://doi.org/10.1016/j.jafr.2024.101331
21. Akwah, H., Johnson, D. M., Wardlow, G., Koparan, C., & Poncet, A. (2024). Inservice needs of selected Arkansas agriculture teachers related to precision agriculture. Advancements in Agricultural Development, 5(4), 28-41. doi:10.37433/aad.v5i4.509
22. Upadhyay, A., Zhang, Y., Koparan, C., Rai, N., Howatt, K., Bajwa, S., & Sun, X. (2024). Advances in ground robotic technologies for site-specific weed management in precision agriculture: A review. Computers and Electronics in Agriculture, 225, 109363. doi:https://doi.org/10.1016/j.compag.2024.109363
23. Betitame, K., Koparan, C., Zhang, Y., Howatt, K., Ostlie, M., Bajwa, S. G., & Sun, X. (2024). Evaluation of Dicamba Drift Injury and Yield Loss on Soybean Using Small Unmanned Aircraft Systems (sUAS) and Multispectral Imaging Technologies. Journal of Natural Resources and Agricultural Ecosystems, 2(2), 63-76. doi:https://doi.org/10.13031/jnrae.1568
24. Fernandez-Figueroa, E., S.R. Rogers, D. Neupane. (2025). Drones and deep learning for detecting fish carcasses during fish kills. Drones, 9, 482. <https://doi.org/10.3390/drones9070482>.
25. Bagherian, K, E. Fernandez-Figueroa, S.R. Rogers, A.E. Wilson, Y. Bao. (2024). Predicting chlorophyll-a concentration and harmful algal blooms in Lake Okeechobee using time-series MODIS satellite imagery and long short-term memory. Journal of the ASABE (American Society of Agricultural and Biological Engineers), 67(5): 1191-1202, <https://doi.org/10.13031/ja.15995>.
26. Fernandez-Figueroa, E., S. Mapes, S.R. Rogers. (2024). “Fish kill lessons and data needs: a spatiotemporal analysis of citizen fish kill reports in Southwest coastal Florida”. Marine Ecology Progress Series, 742:21-33 <https://doi.org/10.3354/meps14627>
27. Ermatinger, L. S., Powell, S. L., Peterson, R. K. D., & Weaver, D. K. (2025). Mapping Wheat Stem Sawfly (Cephus cinctus Norton) Infestations in Spring and Winter Wheat Fields via Multiway Modelling of Multitemporal Sentinel 2 Images. Remote Sensing, 17(11), 1950. <https://doi.org/10.3390/rs17111950>
28. Shrestha, O., A. Khan, J.A. Torrion, W.A. Sigler, K. McVay, S.L. Powell, Stoy, P. (2025). Actual crop coefficients for cereal crops in Montana USA from eddy covariance observations. Agricultural Water Management 316 109561
29. Ermatinger, L. S., Powell, S. L., Peterson, R. K. D., & Weaver, D. K. (2024). Multitemporal Hyperspectral Characterization of Wheat Infested by Wheat Stem Sawfly, Cephus cinctus Norton. Remote Sensing, 16(18), 3505. <https://doi.org/10.3390/rs16183505>
30. Adak, Alper, Aaron J. DeSalvio, Mustafa A. Arik, and Seth C. Murray\*. 2024. Field-based high-throughput phenotyping enhances phenomic and genomic predictions for grain yield and plant height across years in maize. G3: Genes, Genomes, Genetics 4: jkae092. <https://doi.org/10.1093/g3journal/jkae092>
31. Washburn\*, Jacob D., Alper Adak, Aaron J. DeSalvio, Mustafa Arik, and Seth C. Murray. 2024. High temporal resolution unoccupied aerial systems phenotyping provides unique information between flight dates. The Plant Phenome Journal, 7(1), e20113. <https://doi.org/10.1002/ppj2.20113>
32. DeSalvio, Aaron J., Alper Adak, Mustafa A. Arik, Nicholas R. Shepard, Serina M. DeSalvio, Seth C. Murray\*, Oriana García-Ramos, Himabindhu Badavath, and David M. Stelly. 2024. Temporal Image Sandwiches Enable Link between Functional Data Analysis and Deep Learning for Single-Plant Cotton Senescence. in silico Plants 6: diae019, <https://doi.org/10.1093/insilicoplants/diae019>
33. Seth C. Murray\*. 2024. Unlocking alleles from exotic wheat. Nature Plants 10 (9), 1280-1281. <https://doi.org/10.1038/s41477-024-01764-2>
34. Chatterjee, Sumantra, Seth C. Murray\*, Felipe Mattias, and Noah Fahlgren. 2025. FIELDimagePy: A tool to estimate zonal statistics from an image, bounded by one or multiple polygons. Crop Science. 65 (1), e21357 <https://doi.org/10.1002/csc2.21357>
35. Seth C. Murray\*, Aart Verhoef, Alper Adak, Dipankar Sen, Riva Salzman, Pankaj Jaiswal and Sushma Naithani. 2025. Detecting novel plant pathogen threats to food system security by integrating the Plant Reactome and remote sensing. Current Opinion in Plant Biology. 83, 102684 <https://doi.org/10.1016/j.pbi.2024.102684>
36. Shepard, Nicholas R., Aaron J. DeSalvio, Mustafa Arik, Alper Adak, Seth C. Murray\*, Jose Ignacio Varela, and Natalia de Leon. 2024. Deep Learning-Based High-Throughput Phenotyping Of Maize (Zea mays L.) Tasseling From UAS Imagery Across Environments. The Plant Phenome Journal 8 (1), e70021 <https://doi.org/10.1002/ppj2.70021>
37. Adak, Alper, Aaron J. DeSalvio, and Seth C. Murray\*. 2025. A computational framework for modeling and predicting maize senescence: integrating UAV phenotyping, logistic growth, and genomics. Computers and Electronics in Agriculture 237, 110471. <https://doi.org/10.1016/j.compag.2025.110471>
38. Ozair, Fatma, Alper Adak, Seth C. Murray\*, Ryan T. Alpers, Alejandro C. Aviles, Dayane C. Lima, Jode Edwards, David Ertl, Michael A Gore, Candice N Hirsch, Joseph E Knoll, James C Schnable, Maninder P Singh, Erin E Sparks, Addie Thompson, Teclemariam Weldekidan, Wenwei Xu. 2025. Phenotypic plasticity in maize grain yield: Genetic and environmental insights of response to environmental gradients. The Plant Genome 18 (3), e70078. <https://doi.org/10.1002/tpg2.70078>
39. Ojeda-Rivera, Jonathan Odilón, Allison C. Barnes, Elizabeth A. Ainsworth, Ruthie Angelovici, Bruno Basso, Lara J. Brindisi, Matthew D. Brooks Wolfgang Busch, Gretta L Buttelmann, Michael J Castellano, Junping Chen, Denise E Costich, Natalia de Leon, Bryan D Emmett, David Ertl, Sarah L Fitzsimmons, Sherry A Flint-Garcia, Michael A Gore, Kaiyu Guan, Charles O Hale, Sam Herr, Candice N Hirsch, David H Holding, James B Holland, Sheng-Kai Hsu, Jian Hua, Matthew B Hufford, Shawn M Kaeppler, Emma N Leary, Zong-Yan Liu, Anthony A Mahama, Tyler J McCubbin, Carlos D Messina, Todd P Michael, Sara J Miller, Seth C Murray, Sakiko Okumoto, Elad Oren, Alexa N Park, Miguel A Piñeros, Nicholas Ace Pugh, Victor Raboy, Rubén Rellán-Álvarez, M Cinta Romay, Travis Rooney, Rebecca L Roston, Ruairidh JH Sawers, James C Schnable, Aimee J Schulz, M Paul Scott, Nathan M Springer, Jacob D Washburn, Michelle A Zambrano, Jingjing Zhai, Jitao Zou, and Edward S Buckler\*. 2025. Designing a nitrogen-efficient cold-tolerant maize for modern agricultural systems. The Plant Cell 37 (7), koaf139. https://doi.org/10.1093/plcell/koaf139

**Extension Publications**

1. Aljawasim, B., Richardson, P., Samtani, J., & Chandel, A. (2025). Researchers see promise in multi-spectral imaging for latent detection of anthracnose disease on strawberry crop. Virginia Strawberry Association News
2. Chandel, A.K., Jjagwe, P., Langston, D., 2024. Drone imaging to evaluate impact of Nematodes on Soybean Yield. Virginia Cooperative Extension. <https://www.pubs.ext.vt.edu/BSE/bse-362/bse-362.html>
3. Miller, J. O. 2025. Mapping with drones: Optimal times for Delaware. University of Delaware Extension. Factsheet.
4. Miller, J.O. 2025. Types of drones for field crop production. University of Delaware Extension. Factsheet.
5. Lamichhane, S., Tarpley, L., Munkaila, M. 2024. Off-grid heating setup to capture crop responses to high night temperatures. Texas Rice Special Section – Highlighting Research in 2024 (eds. L. T. Wilson and B. Morace). Texas A&M Research & Extension Center at Beaumont, Beaumont, Texas. P. 21-22.

**Scientific Presentations given**

1. Lachowiec, J. Early detection of herbicide resistant wild oat. North American Plant Phenotyping Conference. Virtual. February 25-27, 2025.
2. Kantar M, Glancy T., Killian E, Lachowiec J, Ewing P. A New R-Package to Quantify the Home-Field Advantage of Modern Plant Breeding. CANVAS meeting of the Tri-Societies ASA-CSSA-SSSA. San Antonio Texas. Nov. 10-13, 2024.
3. Tate, C. B., Frame, W. H., Chandel, A., Eick, M. J., Guo, F., Shortridge, J., & Stewart, R. (2024, November). Nitrogen Prediction Algorithm for Cotton Grown in the Upper Southeast Coastal Plain. In ASA, CSSA, SSSA International Annual Meeting. ASA-CSSA-SSSA.
4. Raymond, S., Chandel, A.K., Balota, M., 2025. Precision Peanut Maturity Mapping for Virginia-Type Cultivars using Aerial Spectral Imagery, Weather Data and Advanced Machine Learning. American Peanut Research and Education Society Meeting, July 15-17, 2025, Richmond, VA. (oral presentation).
5. Jjagwe, P., Chandel, A.K., Balota, M., Raman, R., 2025. Towards weed identification and management in Faba bean crop using aerial multispectral imagery and convolutional neural network-based computer vision models. Defense + Commercial Sensing exhibition, April 13-17, 2025, Orlando, FL. (oral presentation).
6. Raymond, S., Chandel, A.K., Balota, M., Chappell, M., Shridhar, V., 2025. Leveraging Stacked Generalization for Peanut Maturity Mapping Using Aerial Multispectral Imagery and Growing Degree Days. Defense + Commercial Sensing exhibition, April 13-17, 2025, Orlando, FL. (oral presentation).
7. Jjagwe, P., Chandel, A.K., Balota, M., Raman, R., 2025. Faba bean crop plant identification using aerial multispectral imagery and convolutional neural network-based computer vision models. AI in Agriculture and Natural Resources Conference, March 31- April 2, 2025, Starkville, MS. (oral presentation).
8. Raymond, S., Chandel, A.K., Balota, M., 2025. Advancing Non-Invasive Peanut Maturity Prediction using Aerial Multispectral Imagery and Weather data with stacked ensemble Multi-View Learning. AI in Agriculture and Natural Resources Conference, March 31- April 2, 2025, Starkville, MS. (oral presentation).
9. Emmanuel, S.R., Jjagwe, P., Balota, M., Chappell, M., Chandel, A.K., 2024. Non-invasive peanut maturity mapping using aerial spectral imaging and artificial intelligence techniques. 2024 American Peanut Research and Education Society Meeting, July 8-11, 2024, Oklahoma City, OK. (poster presentation).
10. Vennam, R.R., Chandel, A.K., Balota, M., Beard, K., Haak, D., 2024. Exploring the Feasibility of High Throughput Phenotyping Technology to Enhance Peanut Physiological Resilience for Heat and Drought Tolerance. 2024 American Peanut Research and Education Society Meeting, July 8-11, 2024, Oklahoma City, OK. (poster presentation).
11. Vennam, R.R., Chandel, A.K., Beard, K., Balota, M., 2024. Leveraging UAV Remote Sensing to Enhance Phenotyping of Peanut Physiology for Heat and Drought Tolerance. 24th Annual GIS and Remote Sensing Research Symposium, April 5, 2024. Blacksburg, VA. (poster presentation).
12. Jjagwe, P., Chandel, A.K., Langston, D., 2024. Quantifying Impact of Nematodes on Soybean Production using Aerial Multispectral Imagery and Machine Learning. 24th Annual GIS and Remote Sensing Research Symposium, April 5, 2024. Blacksburg, VA. (poster presentation).
13. Emmanuel, S.R., Chandel, A.K., Langston, D., 2024. Corn grain yield mapping using aerial-spectral imagery and machine learning techniques. 24th Annual GIS and Remote Sensing Research Symposium, April 5, 2024. Blacksburg, VA. (poster presentation).
14. Miller, J. (2025). Drone Mapping and Sensor Based Nitrogen Management on Delmarva. Delaware Ag Week Precision Agriculture Meeting. January 16, 2025
15. Fruge, A.; Johnson, D.; Mcwhirt, A.; Koparan, C.\* (2025). UAV Remote Sensing for Western Mayhaw Flower Intensity Assessment. Poster presented at American Society of Horticultural Science (ASHS) Conference, New Orleans, LA. <https://ashs2025.sched.com/speaker/austin.fruge>
16. Tagoe, A., Bist, R. B., Koparan, C.\*, Johnson, D., Wang, D., Worthington, M., & Poncet, A. (2025). Preliminary Analysis of Computer Vision for Blackberry Flower Quantification. Oral presentaion at American Society of Horticultural Science (ASHS) Conference, New Orleans, LA. <https://ashs2025.sched.com/speaker/atagoe>
17. Tagoe, A., Bist, R. B., Koparan, C.\*, Johnson, D., Wang, D., Worthington, M., & Poncet, A. (2025). Preliminary Analysis of Computer Vision for Blackberry Flower Quantification. Paper presented at the 2025 ASABE Annual International Meeting, St. Joseph, MI. <https://elibrary.asabe.org/abstract.asp?aid=55560&t=5>
18. Azmir, M. N., Tagoe, A., Koparan, C.\*, Burgos, N. R., Davis, J., Runkle, B., & Wang, D. (2025). Automated Weed Pressure Measurement System Evaluation for Unmanned Aerial Vehicles. Paper presented at the 2025 ASABE Annual International Meeting, St. Joseph, MI. <https://elibrary.asabe.org/abstract.asp?aid=55502&t=5>
19. Tagoe, A., Bist, R. B., Koparan, C.\*, Johnson, D., Wang, D., Worthington, M., & Poncet, A. (2025). Preliminary Analysis of Computer Vision for Blackberry Flower Quantification. Poster presented at S1090 Multistate Meeting - AI in Agroecosystems: Big Data and Smart Technology-Driven Sustainable Production. AI in Agriculture and Natural Resources Conference, Starkville, MI.
20. Azmir, M. N., Tagoe, A., Koparan, C.\*, Burgos, N. R., Davis, J., Runkle, B., & Wang, D. (2025). Automated Weed Pressure Measurement System Evaluation for Unmanned Aerial Vehicles. Poster presented at S1090 Multistate Meeting - AI in Agroecosystems: Big Data and Smart Technology-Driven Sustainable Production. AI in Agriculture and Natural Resources Conference, Starkville, MI.
21. Tagoe, A, Koparan, C.\*, Poncet, A., Wang, D., Johnson, D., Worthington, M. (2024). Vegetation Coverage Specific Flower Density Estimation in Blackberry Using Unmanned Aerial Vehicle (UAV) Remote Sensing. ISPC Conference Proceeding, 11348.
22. Tagoe, A, Koparan, C.\*, Poncet, A., Wang, D., Johnson, D., Worthington, M. (2024). Vegetation Coverage Specific Flower Density Estimation in Blackberry Using Unmanned Aerial Vehicle (UAV) Remote Sensing. Poster presentation at S1069 Multistate Meeting. Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources. Montana State University, Boseman, MT.
23. Koparan, C. (2024). UAV-Assisted Real Time Mapping of Crop Phenotype Research Updates. Oral presentation at S1069 Multistate Meeting. Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources. Montana State University, Boseman, MT.
24. Wilson, A.E., E.G. Fernandez-Figueroa, S.R. Rogers. “Using unoccupied aerial system to monitor cyanobacterial across seasons.” Society of Environmental Toxicology and Chemistry North America 45th Annual Meeting. Ft. Worth, Texas. Oct 2024.
25. Wilson, A.E., E.G. Fernandez-Figueroa, S.R. Rogers. “Using unoccupied aerial system to monitor cyanobacterial across seasons.” North American Lake Management Society. South Lake Tahoe, Nevada. Nov 2024.
26. Ghansah B., I. Khuimphukhieo, J. Landivar, **M. Bhandari**, M. Starek, J. Da Silva, H. Li. High Throughput Phenotyping of the Energy Cane Crop Using UAS Lidar. 2024 IEEEGARSS, July 2024, Athens, Greece (*abstract accepted for presentation*).
27. Wilson, E.G. Fernandez-Figueroa, S.R. Rogers. “Using unoccupied aerial system to monitor cyanobacterial across seasons.” Aquaculture 2025, New Orleans, LA.
28. Lamichhane, S., Munkaila, M., Tarpley, L. 2024. Developing Field-Based Heating Setup for Study of Rice Response to High Night Temperature. ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. November 10-13, 2024. Paper 159220.
29. Murray, S.C.\* 2024. Capturing Nature AND Nurture with Temporal Field Phenomics to Breed Better Crops. Syngenta Global Breeders. 7/09/2024.
30. Murray, S.C.\* 2024. Capturing Nature AND Nurture with Temporal Field Phenomics to Breed Better Crops. AgBioData Webinar. 8/07/2024.
31. Murray, S.C.\* 2024. Capturing Nature AND Nurture with Temporal Field Phenomics to Breed Better Crops. Genomics for Climate Change Research Center – “From Gene to Trait 2024 – Special Edition Microbiome and Phenotyping” Campinas, Brazil 11/07/2024
32. Landivar-Scott, J. L., Salazar, C., Pal, P., Tiwari, A., Bhandari, M., Landivar, J. A. Management System for Characterizing Crop Performance Using UAV Data. Beltwide Cotton Conferences, January 2025, New Orleans, LA (oral).
33. Tiwari A., J. Landivar Scott, L. Zhao, B. Ghansah, O. Fernandez, J. Landivar, M. Bhandari. UAV and Satellite Data Fusion for Cotton Biomass Estimation, 2024 ASA, CSSA, SSSA International Annual Meeting, November 2024, San Antonio, TX (Oral).

**Dataset/software published**

1. multiPLOT QGIS semi-manual plot detection, <https://github.com/erikthekillian/multiPLOT>
2. A greenhouse-based automatic data acquisition system generated a dataset: <https://data.mendeley.com/datasets/hs7d7kpd3z/3>
3. Chatterjee, Sumantra, Seth C. Murray\*, Felipe Mattias, and Noah Fahlgren. 2025. FIELDimagePy: A tool to estimate zonal statistics from an image, bounded by one or multiple polygons. Crop Science. 65 (1), e21357 https://doi.org/10.1002/csc2.21357

**Patents**

1. Murray, Seth C., A. D. A. K. Alper, and Aaron James DeSalvio. "Systems and methods for detecting and predicting phenotypic measurements and phenotypes." U.S. Patent Application 18/921,809, filed April 24, 2025.
2. Murray, Seth C., A. D. A. K. Alper, Steven Anderson, Aaron DeSalvio, Holly Lane, and Shakirah Nakasagga. "Systems and methods for discovery and predicting phenotypes." U.S. Patent Application 18/921,951, filed April 24, 2025.

**Outreach events**

1. Chandel, A.K. Drone applications in strawberry production. Mid-Atlantic strawberry field day. February 26, 2024. Chesapeake, VA. (Contact time: ~1 h, Attendees: ~60).
2. Chandel, A.K., Raymond, S. Drones and AI for peanut maturity mapping, Virginia peanut grower annual meeting, Franklin, VA. Feb 22, 2024. (Contact time: 10 min. Attendees: ~150).
3. Chandel, A.K. Raymond, S, Jjagwe, P. Technologies for peanut production management Peanut variety and quality evaluation field day. September 11, 2024. Williamston, NC. (Contact time: ~30 min, Attendees: ~50).
4. Chandel, A.K. Raymond, SG, Jjagwe, PG. Precision Agriculture Technologies to support peanut production. Cotton and Peanut field day. August 18, 2024. Tidewater AREC, Suffolk, VA. (Contact time: ~30 min, Attendees: ~60).
5. Chandel, A.K. Raymond, S.G, Jjagwe, PG. Precision Agriculture Technologies to support efficient crop production in VA. Virginia Ag Expo. August 1, 2024, Champlain, VA. (Contact time: ~30 min, Attendees: ~30).
6. Chandel, A.K. Precision Agriculture Technologies to support efficient crop production in VA. The Berry field day. June 4, 2024. Hampton Roads AREC, Virginia Beach, VA. (Contact time: ~30 min, Attendees: ~40).
7. Koparan, C. Alsea Summer School, Drone workshop. University of Arkansas, Fayetteville Arkansas, June 17, 2025.

**Number of students supported/trained: 45**