# Nicholas Ace Pugh, Ph.D.

Cropping Systems Research La Plant Stress and Germplasm D 3810 4 <sup>th</sup> St. USDA-ARS Lubbock, TX 79415			aboratory evelopment Phone: (405) 246-8355 Email: Nicholas.Pugh@usda.gov LinkedIn: <u>https://www.linkedin.com/in/nicholas-ace-pugh/</u> ResearchGate: <u>https://www.researchgate.net/profile/Nicholas_Pugh3</u>
EMPLC	YME	NT	
2021	-	Present	Postdoctoral Research Geneticist, Crop Systems Research Laboratory, United States Department of Agriculture – Agricultural Research Service, Lubbock, TX
2019	-	2021	Postdoctoral Research Associate, School of Plant Sciences, University of Arizona, Tucson, AZ
EDUCA		l	
2018		Ph.D.	Texas A&M University, College Station, TX. Plant Breeding.
			Advisor – William L. Rooney, Regents Professor
			Dissertation Title: "Evaluation and Implementation of Proximal and Remote Sensing Techniques in a Sorghum Breeding Program"
2015		M.S.	Texas A&M University, College Station, TX. Plant Breeding.
			Advisor – William L. Rooney, Regents Professor
			Thesis Title: "Heritability and Quantitative Trait Loci for Popping Quality Characteristics in Sorghum Grain"
2012		B.S.	University of Central Oklahoma, Edmond, OK. Biology.

# SKILLS AND EXPERIENCE

- Knowledge of the use of RGB, multispectral, and thermographic imagery as applied to crop breeding and genetics
- Understanding of machine learning (ML) and deep learning methodologies, particularly for prediction of key traits in cotton and other crops
- Proficient in the use of genetic resources such as genetic markers, genomic analysis, etc. as applied to research in cotton, sorghum, and other crop species
- Understanding of breeding and crop improvement methodologies including measuring abiotic/biotic stress tolerance and improving agronomically important traits like yield, cotton fiber quality, etc.
- Knowledge of the use of state-of-the-art technologies, including thermal sensors, unoccupied aircraft systems (UAS), and satellite data
- Determining the genetic mechanisms of key traits in cotton and other important crop species, particularly for improvement in dryland conditions
- In-depth knowledge of sorghum breeding and genetics, particularly the use of mutation breeding to discover novel traits for introgression into elite sorghum genotypes

## CURRENT PROJECTS

- Investigating the use of machine learning models, such as random forest and eXtreme gradient boosting (XGBoost), to predict fiber quality and yield in cotton. These estimates will be evaluated for their applicability within a cotton breeding program to perform selections and perform genetic analyses
- Developing a method to phenotype fusarium rot in cotton plots using unoccupied aircraft systems (UAS, "drones") so that disease scores can be assigned more easily and used for genetic improvement and breeding of the crop for resistance to the disease
- Developing machine learning models to estimate yield in peanut using growth parameters estimated via imagery collected by UAS. Growth parameters include traits derived from growth curves and growth rate curves for characteristics such as: canopy cover, vegetation indices, plot height, etc.
- Producing machine learning models to estimate yield in sorghum using growth parameters and deep learning methodologies, such as the use of convolutional neural networks (CNN) to detect panicles in images
- Assisting cotton, sorghum, and peanut breeding programs via the collection of remote sensing data and the use of machine learning techniques to allow for efficient, precise breeding and genetic improvement
- Developing methods to perform pre-harvest value capture and yield estimation using satellite and UAS data at production scale, particularly for dryland agricultural applications in cotton and sorghum. Work has been and will be conducted with a particular focus on Martin County, TX
- Using genetics and genomics techniques to characterize and utilize novel sorghum mutants, including novel dwarf mutants, multi-tillering mutant(s), and dhurrin free mutant(s)

# PUBLICATIONS

## Peer-Reviewed Publications (Reverse Chronological Order)

- Goebel, T. S., Mahan, J. R., Payton, P., Lascano, R. J., Young, A., Pugh, N. A., Baker, J. T., Xin, Z., & Stout, J. S. (*In preparation*). Using canopy temperature measurements to simulate thermal data collected by small unoccupied aircraft systems.
- 19. **Pugh, N. A.**, Young, A., Emendack, Y., Sanchez, J., Xin, Z., & Hayes, C. (*In review*). High-throughput phenotyping of stay-green in a sorghum breeding program using unmanned aerial vehicles and machine learning. *The Plant Phenome*.
- Pugh, N. A., Young, A., Ojha, M., Emendack, Y., Sanchez, J., Xin, Z., & Puppala, N. (2024). Yield prediction in a peanut breeding program using remote sensing data and machine learning algorithms. *Frontiers in Plant Science*, 15, 1339864
- 17. Hayes, C., Emendack, Y., Sanchez, J., Burke, J., **Pugh, N. A.**, & Xin, Z. (*In Review*). Evaluation of diverse sorghum for leaf dhurrin content and post-anthesis (stay-green) drought tolerance. *Crop, Forage, & Turfgrass Management.*
- 16. Xin, Z., Jiao, Y., Burow, G., Hayes, C., Chen, J., Burke, J., **Pugh, N. A.**, & Ware, D. (*In Review*). Registration of 252 sequenced sorghum mutants as a community reverse genetic resource. *Journal of Plant Registrations*.
- Pugh, N. A., Thorp, K. R., Gonzalez, E. M., Elshikha, D. E. M., & Pauli, D. (2021). Comparison of image georeferencing strategies for agricultural applications of small unoccupied aircraft systems. *The Plant Phenome Journal*, 4(1), e20026.

- Deng, X., Thomasson, J. A., Pugh, N. A., Chen, J., Rooney, W. L., Brewer, M. J., & Shi, Y. (2020). Estimating the severity of sugarcane aphids infestation on sorghum with machine vision. *International Journal of Precision Agricultural Aviation*, 3(2). DOI: 10.33440/j.ijpaa.20200302.89
- Hodnett, G. L., Ohadi, S., Pugh, N. A., Bagavathiannan, M. V., & Rooney, W. L. (2019). Sorghum bicolor x S. halapense interspecific hybridization is influenced by the frequency of 2n gametes in S. bicolor. *Scientific Reports*, DOI: https://doi.org/10.1038/s41598-019-53193-3
- Nelson, A. D. L., Ponciano, G., McMahan, C., Ilut, D. C., Pugh, N. A., El-shikha, D. E., Hunsaker, D. J., Pauli, D (2019). Transcriptomic and evolutionary analysis of the mechanisms by which P. argentatum, a rubber producing perennial, responds to drought. *BMC Plant Biology*, DOI: https://doi.org/10.1186/s12870-019-2106-2
- 11. **Pugh, N. A.**, Morgan, C. L. S., Horn, K., Pietsch, D., & Rooney, W. L. (2019). A statistical evaluation of replicated block designs and spatial variability in sorghum performance trials. *Journal of Crop Improvement*, DOI: https://doi.org/10.1080/15427528.2019.1627686
- Malambo, L., Popescu, S. C., Horne, D.W., Pugh, N. A., & Rooney, W. L. (2019). Automatic detection and characterization of individual sorghum panicles from terrestrial LiDAR data. ISPRS *Journal of Photogrammetry and Remote Sensing*, DOI: https://doi.org/10.1016/j.isprsjprs.2018.12.015
- Patil, N. Y., Pugh, N. A., Klein, R. R., Martinez, H. S., Martinez, R. S., Rodriguez-Herrera, R., Rooney, W. L., & Klein, P.E. (2019). Heritability and quantitative trait loci of composition and structural characteristics in sorghum grain. *Journal of Crop Improvement*, DOI:10.1080/15427528.2018.1536006
- Han, X., Thomasson, A. J., Bagnall, G. C., Pugh, N. A., Horne, D. W., Rooney, W. L., Jung, J., Chang, A., Malambo, L., Popescu, S. C., Gates, I. T., & Cope, D. A. (2018). Measurement and calibration of plant-height from fixed-wing UAV images. *Sensors*, DOI: https://doi.org/10.3390/s18124092
- 7. Pugh, N. A., Han, X., Collins, S. D., Thomasson, J. A., Cope, D., Chang, A., Jung, J., Isakeit, T. S., Prom, L. K., Carvalho, G., Gates, I. T., Vree, A., Bagnall, G. C., & Rooney, W. L. (2018). Estimation of Plant Health in a Sorghum Field Infected with Anthracnose Using a Fixed-Wing Unmanned Aerial System. *Journal of Crop Improvement*, DOI: 10.1080/15427528.2018.1535462
- Pugh, N. A., Horne, D. W., Murray, S. C., Carvalho, G., Malambo, L., Jung, J., Chang, A., Maeda, M., Popescu, S., Chu, T., Starek, M. J., Brewer, M. J., Richardson, G., & Rooney, W. L. (2018). Temporal Estimates of crop growth in sorghum and maize breeding enabled by unmanned aerial systems. *The Plant Phenome*, DOI: 10.2135/tppj2017.08.0006
- Malambo, L., Popescu, S. C., Murray, S. C., Putman, E., Pugh, N. A., Horne, D. W., Richardson, G., Sheridan, R., Rooney, W. L., Avant, R., Vidrine, M., McCutchen, B., Baltensperger, D., & Bishop, M. (2018). Multitemporal field-based plant height estimation using 3D point clouds generated from small unmanned aerial systems high-resolution imagery. *International Journal of Applied Earth Observation and Geoinformation*, 64, 31-42. DOI:https://doi.org/10.1016/j.jag.2017.08.014
- Pugh, N. A, Rodriguez-Herrera, R., Klein, R. R., Klein, P. E., & Rooney, W. L. (2017). Identification of Quantitative Trait Loci for Popping Traits and Kernel Characteristics in Sorghum Grain. *Crop Science*, 57(4), 1999-2006. DOI: 10.2135/cropsci2017.01.0029
- Pugh, N. A, Awika, J. M., & Rooney, W. L. (2017). Heritability of popping characteristics in sorghum grain. Crop Science, 57(1), 71-77. DOI: 10.2135/cropsci2016.04.0250
- Shi, Y., Thomasson, J. A., Murray, S. C., Pugh, N. A., Rooney, W. L., Shafian, S., Rajan, N., Rouze, G., Morgan, C. L. S., Neely, H. L., Rana, A., Bagavathiannan, M. V., Henrickson, J., Bowden, E., Valasek, J., Olsenholler, J., Bishop, M. P., Sheridan, R., Putman, E. B., Popescu, S., Burks, T.,

Cope, D., Ibrahim, A., McCutchen, B. F., Baltensperger, D. D., Avant, R. V., Vidrine, M., & Yang, C. (2016). Unmanned aerial vehicles for high-throughput phenotyping and agronomic research. *PloS one*, 11(7), e0159781. DOI: https://doi.org/10.1371/journal.pone.0159781

 Brennan Jr, R. E., Caire, W., Pugh, N. A, Chapman, S., Robbins, A. H., & Akiyoshi, D. E. (2015). Examination of bats in western Oklahoma for antibodies against Pseudogymnoascus destructans, the causative agent of White-Nose Syndrome. *The Southwestern Naturalist*, 60(2-3), 145-150. DOI: https://doi.org/10.1894/SWNAT-D-14-00030.1

#### Conference Proceedings (Reverse Chronological Order)

- Han, X., Thomasson, J. A., Bagnall, C., Pugh, N. A., Horne, D. W., Rooney, W. L., Malambo, L., Chang, A., Jung, J., & Cope, D. A. (2018). Calibrated plant height estimates with structure from motion from fixed-wing UAV images. In *Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping III* (Vol. 10664, p. 106640D). International Society for Optics and Photonics. DOI: https://doi.org/10.1117/12.2305746
- Shi, Y., Murray, S. C., Rooney, W. L., Valasek, J., Olsenholler, J., Pugh, N. A., Henrickson, J., Bowden, E., Zhang, D., & Thomasson, J. A. (2016). Corn and sorghum phenotyping using a fixed-wing UAV-based remote sensing system. In *Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping* (Vol. 9866, p. 98660E). International Society for Optics and Photonics. DOI: https://doi.org/10.1117/12.2228737

## PROFESSIONAL ACTIVITIES AND PRESENTATIONS

#### **Platform Presentations**

- 2022 ASA, CSSA, SSSA International Annual Meeting in Baltimore, MD (*Invited Speaker*); "Optimal Georeferencing of Aerial Photogrammetry Projects"
- 2022 Sorghum Improvement Conference of North America <u>(Invited Speaker</u>); "Optimal Georeferencing of Aerial Photogrammetry Projects"
- 2020 Arizona Postdoctoral Research Conference in AZ (*Remote*); "Optimal Georeferencing of Aerial Photogrammetry Projects"
- 2020 Phenome Conference held at University of Arizona in Tucson, AZ: "Georeferencing of Aerial Photogrammetry via Ground Control Point Optimization and Real-time Kinematic Positioning in Agricultural Fields at Breeding and Production Scale"
- 2018 Invited Presentation at the 'Sorghum in the 21<sup>st</sup> Century' Conference in Cape Town, WC, South Africa; "Validation and Implementation of Unmanned Aerial Systems in a Sorghum Breeding Program"
- 2018 Invited Poster Presentation at the Washington State University Plant Science Symposium in Pullman, WA; "Temporal Estimates of Crop Growth in Sorghum and Maize Breeding Enabled by Unmanned Aerial Systems"
- 2018 Seminar Presentation at Texas A&M University in College Station, TX; "Temporal Estimates of Crop Growth in Sorghum and Maize Breeding Enabled by Unmanned Aerial Systems"
- 2018 Student Speaker Award Oral Flash Presentation at the Texas A&M Plant Breeding Symposium in College Station, TX; "Temporal Estimates of Crop Growth in Sorghum and Maize Breeding Enabled by Unmanned Aerial Systems"

- 2018 Webinar Presentation for the Plant Phenome Journal Webinar Series; "Temporal Estimates of Crop Growth in Sorghum and Maize Breeding Enabled by Unmanned Aerial Systems"
- 2017 ASA, CSSA, SSSA International Annual Meeting in Tampa, FL; "Estimation of Biomass Yield and Plant Height in Bioenergy Sorghum Using Unmanned Aerial Systems"
- 2017 Invited Presentation at the University of Minnesota Plant Sciences Symposium; "Estimation of Plant Height in Sorghum Using Unmanned Aerial Systems"
- 2016 Keynote Presentation at the Texas A&M University Plant Breeding Symposium, College Station, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"
- 2014 Presentation at the Sorghum Improvement Conference of North America in Corpus Christi, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"
- 2014 Seminar Presentation at Texas A&M University in College Station, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"

#### **Poster Presentations**

- 2024 Sorghum Improvement Conference of North America in Oklahoma City, OK; "Assessment of growth and yield potential of a dominant multi-tillering sorghum mutant"
- 2020 Phenome Conference held at University of Arizona in Tucson, AZ; "Georeferencing of aerial photogrammetry via ground control point optimization and real-time kinematic positioning in agricultural fields at breeding and production scale"
- 2018 Texas A&M Plant Breeding Symposium in College Station, TX; "Temporal Estimates of Crop Growth in Sorghum and Maize Breeding Enabled by Unmanned Aerial Systems"
- 2017 Texas Plant Protection Conference in College Station, TX; "Estimation of Disease Presence and Severity in Sorghum Using Unmanned Aerial Systems"
- 2017 Texas A&M Plant Breeding Symposium in College Station, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"
- 2015 Tri-society Meeting in Minneapolis, MN; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"
- 2015 Texas A&M Plant Breeding Symposium in College Station, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"
- 2014 Texas A&M Horticulture Symposium in College Station, TX; "Heritability and Quantitative Trait Loci for Popping Characteristics in Sorghum Grain"

## AFFILIATIONS/ASSOCIATIONS/MEMBERSHIPS

North American Plant Phenotyping Network	Member (2024 – Present)
Crop Science Society of America	Member (2013 – Present)
American Society of Agronomy	Member (2013 – Present)
Soil and Crop Sciences Dept. Climate Committee	Student Member (2017)

## **GRANTS, HONORS, AND AWARDS**

2024	Performance	Award -	<b>USDA-ARS</b>
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2023 Performance Award – USDA-ARS

- 2022 Invited Speaker ASA, CSSA, & SSSA International Annual Meeting in Baltimore, MD
- 2022 Invited Speaker Sorghum Improvement Conference of North America in Dallas, TX
- 2019 Yuma Center of Excellence for Desert Agriculture (YCEDA) Seed Funding Program Grant for \$10,000 USD
- 2018 Special Achievement Award for Graduate Student Research in Plant Breeding Texas A&M Dept. of Soil and Crop Sciences
- 2018 USDA/NIFA Participant Support and Travel Scholarship to Cape Town, WC, South Africa
- 2018 Student Travel Award Washington State University Plant Science Symposium
- 2018 Oral Presentation Award Texas A&M Plant Breeding Symposium
- 2017 Invited Speaker University of Minnesota Plant Sciences Symposia
- 2016 Keynote Oral Presentation Texas A&M University Plant Breeding Symposium
- 2014 Student Oral Presentations (3rd Place) Sorghum Improvement Conference of North America
- 2011 Research Experience for Undergraduates Texas A&M University Dept. of Biochemistry
- 2011 Student Research, Creative, and Scholarly Activities (RCSA) Grant

Graduate Courses		
Genetics 603 (3.00 Cred)	Course involving basic genetics history and principles	
Biochemical Genetics 631 (3.00 Cred)	Biochemical/molecular genetics principles and techniques	
Statistics in Research I 651 (3.00 Cred)	Introductory frequentist statistics material	
Advanced Quant. Genetics 689 (3.00 Cred)	Quantitative and population genetics and Bayesian statistics	
Plant Breeding I (3.00 Cred)	Introductory crop breeding and applied genetics course	
Statistics in Research II (3.00 Cred)	Advanced statistical methods	
Plant Breeding II (3.00 Cred)	Advanced crop breeding and applied genetics course	
Mol and Quant Gen. Plant Breeding (3.00 Cred)	Advanced quantitative genetics and genomics in plant breeding	
Geographic Information Systems (3.00 Cred)	Introduction to use of GIS tools (QGIS)	
Applied Spatial Statistics (3.00 Cred)	Spatial statistics as applied to agricultural field research	
Remote Sensing of Env. (3.00 Cred)	Remote sensing history and techniques for drones and satellite, use of remote sensing paired with GIS tools	

#### COURSES COMPLETED

# **Undergraduate Courses (If Relevant)**

Plant Biology and Laboratory (4.00 Cred)	Introductory course for plant science and plant physiology
Genetics and Laboratory (4.00 Cred)	Introductory genetics course
Molecular and Population Genetics (3.00 Cred)	Population genetics and use of some molecular techniques as relevant to genetics research

# TEACHING

Undergraduate Students Mentored		
2017	Hector S. Martinez	
2016	Zachary Dickson	
Courses Taught (As Teaching Assistant)		
2016	Crop Biology and Physiology (SCSC 307)	
2014	World Food and Fiber Crops (SCSC 105)	
2012, 2013	Genetics (GENE 312)	
2010, 2011	Biology (BIO 1211)	
Courses Taught (As Guest Lecturer)		
2019	Plant Breeding and Genetics (PLS 415)	

# MEDIA AND OUTREACH

Crop Science Society of America; "Popping potential of sorghum" by Danielle St. Louis (<u>https://www.crops.org/science-news/popping-potential-sorghum</u>)

Agrilife Today, Texas A&M University; "Popped Sorghum Making its Way onto Snack Scene" by Kay Ledbetter (<u>http://today.tamu.edu/2016/03/07/popped-sorghum-making-its-way-onto-snack-scene/</u>)

# **PROFESSIONAL REFERENCES**

Zhanguo Xin	Research Molecular Biologist Plant Stress and Germplasm Development USDA-ARS	email: zhanguo.xin@ars.usda.gov phone: (806) 749-5560 ext. 5223
William L. Rooney	Regents Professor Department of Soil and Crop Sciences Texas A&M University	email: wlr@tamu.edu phone: (979) 845-2151
Naveen Puppala	Professor College of Ag, Consumer, and Enviro Sciences New Mexico State University	email: npuppala@nmsu.edu phone: (575) 693-9094
Nithya Rajan	Professor Department of Soil and Crop Sciences Texas A&M University	email: nrajan@tamu.edu phone: (979) 321-5936