

## Paulo Izquierdo

Great Lakes Bioenergy Research Center · Michigan State University · East Lansing, MI

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### EDUCATION

- 2023 Ph.D; Plant Breeding, Genetics, and Biotechnology – Crop and Soil Sciences, Department of Plant, Soil, and Microbial Sciences, Michigan State University, East Lansing, MI.
- 2022 Graduate certificate, Computational Plant Science, Department of Plant Biology, Michigan State University, East Lansing, MI.
- 2010 B. S; Biology, Universidad del Tolima, Ibagué, Colombia.

### RESEARCH AND PROFESSIONAL EXPERIENCE

- 03/2023-Present Research Associate. Investigate the genetic architecture of complex traits in plant species and incorporate these findings into genomic prediction models. Great Lakes Bioenergy Research Center, Michigan State University. **PI:** Shin-Han Shiu
- 01/2017-12/2022 Graduate Research Assistant. Exploring the genetic architecture and improving genomic prediction accuracy for yield and end-use quality traits in dry bean. Department of Plant, Soil and Microbial Sciences, Michigan State University. **PI:** Karen Cichy
- 06/2022-08/2022 Quantitative Genetics / Computational Biology Intern. Identified potential targets for genome editing using machine learning. INARI.
- 06/2016-12/2016 Visiting Scholar. Developed molecular markers linked to anthracnose resistance in dry bean. Department of Plant, Soil and Microbial Sciences, Michigan State University. **PI:** James Kelly
- 09/2013-06/2016 Research Assistant. Uncovered the genetic architecture of the mineral concentration in dry bean using GWAS and QTL approaches in a Multiparent Advance Generation Intercross population. CIAT. **PI:** Bodo Raatz
- 01/2011-08/2013 Research Assistant. Identified genomic regions associated with agronomic traits in sugarcane. Colombian Sugarcane Research Center (Cenicaña). **PI:** Jershon Lopez
- 07/2010-12/2010 Visiting Researcher. Implemented marker-assisted selection for resistance to anthracnose in dry bean. CIAT/Universidad Nacional de Colombia. **PI:** Matthew Blair
- 01/2009-06/2010 Undergraduate Research Assistant. Evaluated the use of wild germplasm to increase the mineral concentration of cultivars in common beans. CIAT. **PI:** Matthew Blair

### PUBLICATIONS

<https://scholar.google.com/citations?user=5sZkDtAAAAAJ&hl=en>

- 2024 Palande S, Arsenault J, Basurto P, Bleich A, Brown B, Buysse S, Connors N, Adhikari S, Dobson K, Guerra F, Guerrero M, Harlow S, Herrera H, Hightower A, **Izquierdo P**, et al. A data-driven evaluation of Arabidopsis-centric research and the model species concept. Applications in Plant Sciences. <https://doi.org/10.1002/aps3.11621>
- 2024 **Izquierdo P**, Sadohara R, Wiesinger J, Glahn R, Urrea C, Cichy K. Genome-wide association and genomic prediction for iron and zinc concentration and iron bioavailability in a collection of yellow dry beans. Front. Genet. 15, 1-12. <https://doi.org/10.3389/fgene.2024.1330361>

- 2023 **Izquierdo P**, Kelly J, Beebe S, Cichy K. Combination of meta-analysis of QTL and GWAS to uncover the genetic architecture of seed yield and seed yield components in common bean. The Plant Genome, 16, e20328. <https://doi.org/10.1002/tpg2.20328>
- 2023 Amongi W, Nkalubo S, Ochwo-Ssemakula M, Badji A, Dramadri I, Odongo T, Nuwamanya E, Tukamuhabwe P, **Izquierdo P**, Cichy K, Kelly J, Mukankusi C. Phenotype based clustering, and diversity of common bean genotypes in seed iron concentration and cooking time. PLOS ONE 18(5): e0284976. <https://doi.org/10.1371/journal.pone.0284976>
- 2023 Amongi W, Nkalubo S, Ochwo-ssemakula M, Dramadri I, Odongo T, Nuwamanya E, Tukamuhabwe P, **Izquierdo P**, Cichy K, Kelly J, Mukankusi C. Genetic clustering, and diversity of African panel of released common bean genotypes and breeding lines. Genet. Resour. Crop Evol. 70, 2063–2076. <https://doi.org/10.1007/s10722-023-01559-y>
- 2022 Sadohara R, **Izquierdo P**, Couto Alves F, Porch T, Beaver J, Urrea C, Cichy K. The *Phaseolus vulgaris* L. Yellow Bean Collection: genetic diversity and characterization for cooking time. Genet. Resour. Crop. Evol. 69, 1627–1648. <https://doi.org/10.1007/s10722-021-01323-0>
- 2022 Sadohara R, Long Y, **Izquierdo P**, Urrea C, Morris D, Cichy K. Seed coat color genetics and genotype × environment effects in yellow beans via machine-learning and genome-wide association. The Plant Genome 15:e20173. <https://doi.org/10.1002/tpg2.20173>
- 2020 Diaz S, Ariza-Suarez D, **Izquierdo P**, Lobaton J, de la Hoz J, Acevedo F, Duitama J, Guerrero J, Cajiao C, Mayor V, Beebe S, Raatz B. Genetic mapping for agronomic traits in a MAGIC population of common bean (*Phaseolus vulgaris* L.) under drought conditions. BMC Genomics 21, 799. <https://doi.org/10.1186/s12864-020-07213-6>
- 2020 **Izquierdo P**, Lopez M, Kelly J, Cichy K. Assessing genomic selection prediction accuracy for yield and end-use quality traits in a black dry bean breeding population. Annual report of the Bean Improvement Cooperative 63.
- 2020 Berry M, **Izquierdo P**, Jeffery H, Shaw S, Nchimbi-Msolla S, Cichy K. QTL analysis of cooking time and quality traits in dry bean (*Phaseolus vulgaris* L.). Theoretical and Applied Genetics 133, 2291–2305. <https://doi.org/10.1007/s00122-020-03598-w>
- 2018 **Izquierdo P**, Astudillo C, Blair M, Iqbal A, Raatz B, Cichy K. Meta-QTL analysis of seed iron and zinc concentration and content in common bean (*Phaseolus vulgaris* L.). Theoretical and Applied Genetics 131, 1645–1658. <https://doi.org/10.1007/s00122-018-3104-8>
- 2017 **Izquierdo P**, Shaw S, Berry M, Cichy K. A saturated genetic linkage map of common bean (*Phaseolus vulgaris* L.) developed using Genotyping by Sequencing (GBS). Annual report of the Bean Improvement Cooperative 61.
- 2016 Perea C, De La Hoz J, Cruz D, Lobaton J, **Izquierdo P**, Quintero J, Raatz B, Duitama J. Bioinformatic analysis of genotype by sequencing (GBS) data with NGSEP. BMC Genomics 17, 498. <https://doi.org/10.1186/s12864-016-2827-7>
- 2013 Blair M, **Izquierdo P**, Astudillo C, Grusak M. A legume biofortification quandary: Variability and genetic control of seed coat micronutrient accumulation in common beans. Front. Plant Sci. 4, 1–14. <https://doi.org/10.3389/fpls.2013.00275>
- 2013 Delgado H, Pinzón E, Blair M, **Izquierdo P**. Evaluation of bean (*Phaseolus vulgaris* L.) lines result of an advanced backcross between a wild accession and Radical Cerinza. U.D.C.A Act. & Div. Cient. 16(1), 79–86. <https://doi.org/10.31910/rudca.v16.n1.2013.861>

- 2013 **Izquierdo P**, Gutierrez A, Victoria J, Angel J, Avellaneda M, Lopez J. Molecular markers associated with resistance to Sugarcane yellow leaf virus. *International Society of Sugar Cane Technologists* 28, 1179–1188.
- 2012 Blair M, **Izquierdo P**. Use of the advanced backcross-QTL method to transfer seed mineral accumulation nutrition traits from wild to Andean cultivated common beans. *Theoretical and Applied Genetics* 125, 1015–1031. <https://doi.org/10.1007/s00122-012-1891>
- 2011 Blair M, **Izquierdo P**, Astudillo C, Monserrate F, Cortés M, Avila P, Felde T, Pfeiffer W. Utilization of near infrared spectrophotometry (NIRS) analysis for evaluation of mineral content in Andean bean samples. *Annual report of the Bean Improvement Cooperative* 57.

*In preparation:*

\*Authors contributed equally

**Izquierdo P**, Kelly J, Cichy K. Accelerating genetic gain in dry beans for yield and end-use quality traits using genomic selection and high-throughput phenotyping (Accepted).

Singhal R\*, **Izquierdo P\***, Ranaweera T, Segura K, Brown B, Lehti-Shiu M, Shiu S. Understand stress tolerance and design resilient crops with machine learning approaches (Submitted).

**Izquierdo P**, Segura K, Weng X, Juenger T, Lowry D, Shiu S. Unraveling the Genetic Landscape of Agronomic Traits in Switchgrass Through Transcriptomics.

**SCIENTIFIC PRESENTATIONS***Invited talks:*

- 2022 Nutritional Quality: An Essential Trait for New Crop Varieties, presented during the Webinar "Agriculture, Biodiversity, and Nutrition: Foundations for Sovereign, Sustainable, and Resilient Food Systems". Universidad Nacional de Colombia. April 22.
- 2021 Exploring the genetic architecture and improving genomic prediction accuracy for yield, mineral concentration, and canning quality traits in dry bean (*Phaseolus vulgaris* L.). presented during the Webinar "Phytopathology and Plant Breeding". Universidad de Nariño, Colombia. November 3.
- 2020 Graduate Studies: Do's and Don'ts, presented at the "Caribbean Microbial Meeting". October 29.
- 2020 Use of molecular markers in dry bean breeding, Universidad Industrial de Santander, Colombia. June 24.

*Contributed talks and posters:*

- 2024 **Izquierdo P**, Segura K, Weng X, Juenger T, Lowry D, Shiu, S. Unraveling the genetic landscape of biomass in switchgrass through transcriptomics. *Plant Biology*. **Poster.**
- 2024 **Izquierdo P**, Segura K, Weng X, Juenger T, Lowry D, Shiu, S. Uncover the genetic architecture of agronomic traits in a switchgrass diversity panel across two environmentally distinct locations: Michigan and Texas. Great Lakes Bioenergy Research Center - Annual Science Meeting. **Oral presentation.**
- 2019 **Izquierdo P**, Lopez M, Kelly J, Cichy K. Assessing Genomic Selection Prediction Accuracy for Yield and End-Use Quality Traits in Black Beans. Bean improvement cooperative. **Poster.**
- 2019 **Izquierdo P**, Katuramu D, Cichy K. Genomic selection for nutritional traits and cooking time in common bean) using Genotyping by Sequencing. *Plant & Animal Genome*. **Poster.**

- 2018 **Izquierdo P**, Astudillo C, Iqbal A, Blair M, Raatz B, Cichy, K. Meta-QTL Analysis in Common Bean to Uncover the Genetic Architecture of Iron and Zinc Concentration in Seed. Plant & Animal Genome. **Poster.**
- 2017 **Izquierdo P**, Shaw S, Berry M, Cichy K. A saturated genetic linkage map of common bean developed using Genotyping by Sequencing (GBS). Bean improvement cooperative. **Poster.**
- 2016 **Izquierdo P**, Lobaton J, Mayor V, Grajales M, Cajiao C, Duitama, J, Raatz B. Genome-wide association mapping for yield and other agronomic traits in a Multi-parent advanced generation inter-cross population of Mesoamerican common bean (*Phaseolus vulgaris* L.). IX Latin American and Caribbean Agricultural and Forestry Biotechnology Meeting. **Oral presentation.**
- 2016 De la Hoz J, Lobaton J, Perea C, Cruz D, Quintero J, **Izquierdo P**, Raatz B. Development of NGSEP as an open-source comprehensive solution for analysis of high throughput sequencing data. Bioinformatics Open Source Conference. **Poster.**
- 2015 Lobaton J, **Izquierdo P**, Cajiao C, Grajales M, Polania J, Duitama J, Raatz B, Beebe S. QTL mapping on a multiparent advanced generation inter-cross (MAGIC) population for dry bean using genotype-by-sequencing (GBS). Plant & Animal Genome. **Poster**
- 2013 **Izquierdo P**, Gutiérrez A, Victoria J, Ángel J, López J, Avellaneda C. Molecular markers associated with resistance to the sugarcane yellow leaf virus. XXVIII International Society of Sugarcane Technologists (ISSCT). **Oral presentation.**
- 2012 **Izquierdo P**, Gutiérrez A, Victoria J, Ángel J, López J, Avellaneda C. Molecular markers associated with resistance to the sugarcane yellow leaf virus. IX Association for Sugarcane Technology in Latin America and the Caribbean (Atalac-Tecnicaña). **Oral presentation.**
- 2011 **Izquierdo P**, Gutiérrez A, Victoria J, Ángel J, López J, Avellaneda C. Molecular markers associated with resistance to the sugarcane yellow leaf virus. Colombian and Latin American Phytopathological Association. **Oral presentation.**

## HONORS, AWARDS, AND FUNDING

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- 2022 Norman and Jessie Thompson fellowship in Crop and Soil Sciences (\$5,000).
- 2021 NSF Research Traineeship – Integrated training model in plant and computational sciences fellowship (\$29,781).
- 2021 Everett and Jane Everson fellowship in Plant Breeding (\$2,500).
- 2021 Jason and Dana Lilly fellowship in Plant Breeding, Genetics & Biotechnology (\$1,500).
- 2021 Norman and Jessie Thompson fellowship in Crop and Soil Sciences (\$4,000).
- 2021 College of Agriculture and Natural Resource fellowship, Michigan State University (\$6,000).
- 2020 Bayer Diversity Initiative Scholar.
- 2019 Everett and Jane Everson fellowship in Plant Breeding (\$2,500).
- 2019 Norman and Jessie Thompson fellowship in Crop and Soil Sciences (\$1,000).
- 2019 Graduate student language fellowship in undergraduate teaching and learning Residential College in the Arts and Humanities, Michigan State University (\$4,000).
- 2019 Council of Graduate Students, Conference Award, Michigan State University (\$300).
- 2018 The Crop and Soil Science Graduate award, Michigan State University (\$1,700).
- 2018 Jason and Dana Lilly fellowship in Plant Breeding, Genetics & Biotechnology (\$1,500).
- 2018 Elmer C. Rossman fellowship in Plant, Soil & Microbial Sciences (\$3,500).
- 2018 Everett and Jane Everson fellowship in Plant Breeding (\$2,500).
- 2018 Resilient and Nutritious Dry Beans for Africa fellowship, USDA-FAS (\$5,400).

- 2017 Doctoral Fellowship Program. COLCIENCIAS, Colombia's Administrative Department of Science, Technology, and Innovation (\$120,000).

## TEACHING EXPERIENCE

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### *Michigan State University:*

- 2019 Teaching Assistant: Department of Plant, Soil and Microbial Sciences, Introduction to Plant Genetics (CSS350), Michigan State University
- 2019 Spanish Language Assistant: Residential College in the Arts and Humanities, Program on Sustainability in Costa Rica, Michigan State University.

### *Workshops:*

- 2024 "Introduction to Machine Learning", Great Lakes Bioenergy Research Center - Annual Science Meeting. Organizer and lecturer for 1-session workshop, 60 participants.
- 2023 "Introduction to Machine Learning", Universidad Industrial de Santander, Colombia. Organizer and lecturer for 2-session workshop, 32 participants.
- 2021 "Quantitative Genetics", MSU-Feed the Future Innovation Lab for Crop Improvement (Eastern Africa). Organizer and lecturer for 9-session workshop, 123 participants. [https://pauloizquierdo.github.io/Quantitative\\_Genetics/](https://pauloizquierdo.github.io/Quantitative_Genetics/)
- 2021 "Quantitative Genetics", Universidad Industrial de Santander, Colombia. Organizer and lecturer for 1-session workshop, 52 participants. [https://compasscol.github.io/2021B\\_talleres-UIS.html](https://compasscol.github.io/2021B_talleres-UIS.html)
- 2021 "Data visualization with R", Universidad Industrial de Santander, Colombia. Organizer and lecturer for 2-day workshop, 40 participants. <https://compasscol.github.io/dataviz/>
- 2021 "Introduction to R", Universidad Industrial de Santander, Colombia. Organizer and lecturer for 2-day workshop, 40 participants. <https://compasscol.github.io/IntroR/>

## MENTORING

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- 2022 Yuranis Miranda, Graduate Research Assistant, Universidad Industrial de Santander, Colombia. Project: Genetic and Morphological Variability of *Vaccinium meridionale* Sw. Across the Central and Eastern Andean Regions of Colombia.
- 2021 Anisa Rashid, Undergrad researcher/hourly worker, Michigan State University. Project: Evaluation of canning quality in dry beans.
- 2018 Winnyfred Amongi, Visiting Scholar, Michigan State University. Project: High-Throughput genotyping and genomic prediction in dry beans. *co-authored paper*.
- 2016 Wilson Santiago, Biology Intern. International Center for Tropical Agriculture. Project: Genetic mapping for agronomic traits in a MAGIC population of common bean. *co-authored paper*.
- 2016 Laura Paz, Biology Intern. International Center for Tropical Agriculture. Project: Fine mapping of regions associated with Fe concentration in dry bean.

## STUDENT MENTORING COMMITTEES

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- 2023 Miguel Mendoza, Ph.D. Universidad Nacional de Colombia, Bogotá, Colombia. Project: Genetics of Nitrogen Use Efficiency in Plants.
- 2022 Hernán Maigual, MSc. Universidad de Nariño, Pasto, Colombia. Project: Variability Assessment of Fava Beans (*Vicia faba* L.) Originating from the Andean Region of Nariño, Colombia.
- 2021 Diego González, MSc. Universidad Nacional de Colombia, Bogotá, Colombia. Project: Analysis of the Fungal Microbiome in Cocoa Soils with Varying Cadmium Concentrations.

- 2021 Emili Garcia, MSc. Universidad Nacional de Colombia, Bogotá, Colombia. Project: Identification of Allelic Variants and Assessment of Candidate Gene Expression Linked to Bacterial Vascular Wilt Resistance in Cassava.
- 2020 Fabián Villamil, MSc. Universidad Nacional de Colombia, Bogotá, Colombia. Project: Expression of the polyhydroxyalkanoate (PHA) synthase enzyme from *Aeromonas caviae* in transgenic tobacco, lead to the synthesis of a poly (4-hydroxybutyrate)

## PROFESSIONAL SERVICE

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### *Ad Hoc Grant Reviewer:*

- 2023 Colombia's Administrative Department of Science, Technology, and Innovation (8).

### *Ad Hoc Reviewer:*

Scientific reports (1), GigaScience (2), Agronomy (1), PhytoFrontiers (1), Genetics (2), Agronomy Journal (1), The Plant Genome (2), Crop Science (1), Nature Communications (1), Communications Biology (1).

### *Conference/symposium organization:*

- 2021 Co-Organizer, Workshops series focused on data analysis in biology and agriculture. Universidad Industrial de Santander, Colombia. [https://compasscol.github.io/2021B\\_talleres-UIS.html](https://compasscol.github.io/2021B_talleres-UIS.html)
- 2021 Co-Organizer, Online seminar series on phytopathology and plant breeding. Universidad de Nariño, Colombia. [https://compasscol.github.io/2021A\\_Conferencias-UNar.html](https://compasscol.github.io/2021A_Conferencias-UNar.html)
- 2020 Co-Founder, Community Platform for Agricultural Sciences (COMPASS). Website: <https://compasscol.github.io/>
- 2020 Co-Organizer, Ciencia en línea: impulsando el uso de plataformas para la divulgación, colaboración e inspiración científica, symposium, SOCOLEN
- 2019 Co-Organizer, Phenomic Application in Plant Breeding, Corteva-PBGB symposium.

## MEMBERSHIPS

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American Society of Plant Biologists