MARINA LÓPEZ-POZO, PhD

Space Agriculture Scientist | Controlled Environment Biologist University of Colorado. Boulder. USA. marina.lopezpozo@colorado.edu

LinkedIn: https://www.linkedin.com/in/marina-1%C3%B3pez-pozo-012460b7/
Google Scholar: https://scholar.google.es/citations?user=GzKokDYAAAAJ&hl=es
ORCID: 0000-0002-0425-4062

SUMMARY

Plant biologist and space agriculture expert with 10+ years of research experience in controlled-environment crop production, stress physiology, and nutraceutical optimization for human space exploration. Specialized in photosynthetic efficiency, plant-microbe interactions, and biomass optimization under resource-limited conditions. Proven track record in NASA-funded projects (LEAF, NASA-TRISH) to develop sustainable space crop systems. Expertise in microbiological safety protocols for space crop production, including sterilization, pathogen monitoring, and contamination prevention—aligning with HACCP principles for closed-loop agricultural systems. Combines technical expertise in advanced plant analytics (HPLC, fluorescence, microbiome analysis, photosynthesis) with strategic leadership in cross-sector collaborations. Passionate about translating fundamental research into innovative solutions for Moon, Mars, and beyond.

- ✓ 10+ years leading **controlled-environment agriculture** including research for human spaceflight
- ✓ **Space Biology:** Direct experience with NASA projects (Artemis III LEAF, NASA-TRISH) and analog environments (Antarctica, Ecotron). Artemis III LEAF Project Scientist developing lunar crop protocols (NASA 2024-2027)
- ✓ **Thought Leadership**: 25+ publications in high-impact journals including **5 NASA-cited studies** on space crop optimization, invited talks, workshops, and editorial roles.
- ✓ **Technical Skills**: Advanced analytics for crop optimization in controlled environments (HPLC, spectrometry, gas exchange).
- ✓ Specialized skills in contamination prevention for closed-loop food processes
- ✓ **Stakeholder Engagement**: Collaborations with NASA, DOE Joint Genome Institute, and Moon Village Association.
- ✓ **Mentorship**: Trained students in space-relevant plant research.

SCIENTIFIC QUALITY INDICATORS

Indicator	Value*
h-index	14
Total publications	26
Total citations	643
First Author %	69%
Avg. Citations/Paper	28

^{*}Google Scholar

EDUCATION AND ACADEMIC POSITIONS

University of Colorado (USA)	2024- present	Postdoctoral Researcher
University of the Basque Country	2023- 2024	Postdoctoral Researcher
University of La Rioja	2022- 2023	Postdoctoral Researcher
University of the Basque Country	2021- 2022	Postdoctoral Researcher
University of Colorado (USA)	2020- 2021	Postdoctoral Research Associate
University of the Basque Country & Public University of Navarre	2020	International PhD Environmental Agrobiology
University of the Basque Country	2016	MS Environmental Agrobiology
University of the Basque Country	2015	MS Biodiversity, Functioning and Management of Ecosystems
University of the Basque Country	2014	BS Environmental Sciences
University of the Basque Country	2011	Student Research Assistant. Department of Zoology and Animal Cell Biology. Pharmacy faculty.

VISITING SCHOLAR

- 2022-2023. University of La Rioja. La Rioja. Spain
- 2020-2021. University of Colorado, Boulder. USA
- 2019. Ecotron Européen de Montpellier. Centre National de la Recherche Scientifique (CNRS), Montferrier- sur-Lez. France
- 2018. Spanish Antarctic Campaign. Juan Carlos I. Civil Base. Antarctica
- 2018. Plant Molecular Biology Laboratory, University of La República, Montevideo. Uruguay
- 2017/2018/2019. Royal Botanic Gardens. United Kingdom
- 2015. Department of Biology of Organisms and Systems, University of Oviedo. Spain
- 2014. Dpt of Agronomic Sciences and Natural Resources. Universidad de La Frontera. Chile

GRANTS AND SCHOLARSHIPS

- 2021. "Margarita Salas" European Next Generation Grant.
- 2017. Predoctoral travel grant. Basque Government.
- 2016-2020. Predoctoral scholarship. Basque Government.
- 2014-2015. Travel grant. International travel scholarship for university students. Basque Government.

RESEARCH PROJECTS

- The Lunar Effects on Agricultural Flora (LEAF). Deployed Instruments for Artemis III Mission. NASA. 2024-2027. *Postdoctoral Researcher*
- Co-optimization of duckweed biomass, nutritional quality, & input use efficiency. NASA-TRISH. 2019-2021. *Postdoctoral Researcher*
- Influence of rhizosphere microbes on duckweed transcriptome under elevated CO₂. Joint Genome Institute (USA, Department of Energy). 2021. *Principal investigator*
- Physiological basis of Outlier model systems in the Photosynthesis-multitolerance tradE off: learning from high Yields in extreme Environments (POPEYE) Spanish Government. 2023-2027. Postdoctoral Researcher
- Ecophysiological and evolutionary roots of stress tolerance in plants (EREMITA). Spanish Government. 2019-2021. Postdoctoral Researcher
- Uncovering the volatile nature of bryophytes (VolNaBry). Asociación Española de Ecología Terrestre. 2018-2019. Predoctoral Researcher
- Mechanistic bases for compensation between photosynthesis and stress tolerance: filling in knowledge gaps for evolutionary biology and plant biotechnology (TOPSTEP). Spanish Government. 2015-2018. Predoctoral Researcher

PROFESSIONAL TRAINING

- 2025 (in progress) "Industrial Biotechnology". Delft University of Technology
- 2024 "Spaceflight Technology, Applications, and Research (STAR)". NASA
- 2022 "Tradition and innovation in mushroom cultivation. How to increase vitamin D and other healthy compounds using sustainable techniques." UR.
- 2021 "Plant microbiome and its applications in crop promotion". USAL
- 2019. SPSS Statistics. Module I and II. Master and Doctoral School. UPV/EHU
- 2016-2019 Seminars of Advanced Studies in Environmental Agrobiology.
- 2018 "Evolutionary Plant Ecophysiology" University of Concepcion. Botany Department. Chile.
- 2018 "LiCor soil CO₂ flux installation training" (ECOTRON). Montpellier. France.
- 2010 "Hydrology of forest basins. Scientific and management challenges". University of Salamanca. Spain.

LEADERSHIP & SCIENTIFIC SERVICE

Committees & Evaluations

- Expert Evaluator: European Commission (Horizon Europe), Regeneron Science Talent Search, Sigma Xi Grants in Aid of Research (GIAR).
- Honors Defense Committee, Dept. Ecology and evolutionary Biology, CU Boulder.
- Master Thesis Committee, Environmental Agrobiology (UPV/EHU, Spain).

Editorial Roles

- Guest Editor:
 - o Frontiers in Plant Science (2023): Light quality effects on crop nutrition.
 - o Antioxidants (2025): Antioxidants for space missions.
- **Review Editor**: Frontiers in Photobiology.
- Reviewer SCI-Journals: Photosynthesis Research, Photosynthetica, Plants, Annals of Botany,
 Frontiers in Plant Science, International Journal of Environmental Research, Plant Science, Global Change Biology, Planta, Echography.

Professional Societies

- **Sigma Xi Member** (Grants in Aid of Research evaluator).
- Spanish Society of Plant Biology (SEBP)
- Moon Village Association: Contributed to space agriculture roadmaps.

OUTREACH

- Media: Interviews on space crops (Radio Popular, RTVE, ETB1, ETB2, EiTB, RNE, El Correo Newspaper).
- Public Lectures: Basque Science Week (2016–2018).
- Science Communication: Articles on plant-based nutrition (*Hogarmania.com*).

TECHNIQUES MANAGED

Controlled Environment Agriculture

- Sterilization (autoclave/UV/H₂O₂), pathogen screening (selective cultures), HACCP-aligned protocols.
- Hydroponic/aquaponic system design for space analogs. Culture media, cultivation, growth and nutraceutical compounds improvement, and biomass production.

Advanced Analytics

- HPLC, Western Blot, Thin Layer Chromatography (TLC), Spectrophotometry (nutraceuticals; pigments, vitamins, antioxidants, proteins and lipids), chlorophyll fluorescence, gas exchange, microscopy.
- Microbiome sequencing analysis (Joint Genome Institute collaboration/ PI funded project).

Food Safety & Quality Control

- Certified Food Handler
- Cross-contamination prevention in closed-loop systems.

Office, Statistical analysis, Image processing

TALKS

López-Pozo M et al. "Co-Optimization of Duckweed Biomass, Nutritional Quality & Input-Use Efficiency for Human Consumption in Space". Seminarios de Estudios Avanzados En Agrobiología Ambiental. UPV/EHU. 2021

B Demmig-Adams B, Stewart JJ, López-Pozo M, et al. "Leveraging Plant Stress Biology to Provide Anti-inflammatory Brain Food". Symposium on Stress for Space, American Society for Gravitational and Space Research Annual Meeting. 2020.

López-Pozo M et al. "Metabolites as convergent trait linkages between bryophytes and tracheophytes" International conference on Integrative Plant Physiology. Spain. 2019

López-Pozo M. "Esporas clorofilicas como modelo de tolerancia a la desecación". VIII Coloquio de Primavera de Ecofisiología Forestal. Spain. 2018

López-Pozo M "Anhidrobiosis: La vida sin agua" Seminarios de Estudios Avanzados En Agrobiología Ambiental. UPV/EHU. 2016

López-Pozo M "¿Cómo ser espora de helecho, secarse y no morir en el intento?" VII Coloquio de Ecofisiología Forestal. Spain. 2017

STUDENTS MENTORED IN RESEARCH

University of Colorado (Boulder, USA)

- Guided students in NASA-funded duckweed trials on biomass optimization and food safety protocols. Supervised research on:
 - Microbial contamination prevention and/or inoculation in hydroponic systems (Zenir, 2021).
 - Nutraceutical enhancement under space-relevant stressors (McNamara, 2020, Naiara Garcia 2021, Kendall Origer, 2024, Amy Hodges 2025, Daniel Lara, 2025).

University of the Basque Country (Leioa, Spain)

 Trained bachelor/master students in sterilization and growing protocols and plant stress physiology under extreme conditions (2017–2023).

PUBLICATIONS

López-Pozo, M.; McNamara, M.; Adams, W.W.A., III; Demmig-Adams, B. (2024). *A preharvest finishing procedure for Lemna to produce high levels of zeaxanthin that is retained post-high-light exposure*. Future Foods, 10, 100517

López-Pozo, M.; Adams, W.W.A., III; Demmig-Adams, B. (2023) *Lemnaceae as Novel Crop Candidates for CO2 Sequestration and Additional Applications*. Plants, 12, 3090. *Selected as a Title Story/Website rolling banner

- **López-Pozo, M**; Adams, W.W, III; Polutchko, S.K; Demmig-Adams, B. (2023). *Lemna Is Productive and Nutritious in Low Light*. E Scholarly Community Encyclopedia (contributed entry).
- **López-Pozo, M;** Fernández-Marín, B; García-Plazaola, J I; Seal, C; Ballesteros, D. (2023). Ageing kinetics of fern's chlorophyllous spores during dry storage is determined by the antioxidant potential of the cell, promoted by light and oxygen, and likely induced by the photosynthetic machinery (even in the dark). Environmental and Experimental Botany, 337: 111870
- **López-Pozo, M**; Adams, W.W, III; Polutchko, S.K; Demmig-Adams, B. (2023) *Terrestrial and Floating Aquatic Plants Differ in Acclimation to Light Environment*. Plants, 12: 1928.
- **López-Pozo, M;** Zenir, M; Polutchko, S; Stewart, J; Adams, WW III; et al., (2023). *Effects of Growth Environment on Lemna minor*. E Scholarly Community Encyclopedia (contributed entry).
- Gómez-Sagasti, MT; **López-Pozo**, M; Artetxe, U; Becerril, JM; Hernández, A; et al., (2023). *Carotenoids and their derivatives: A "Swiss Army knife-like" multifunctional tool for fine-tuning plant-environment interactions*. Environmental and Experimental Botany, 207: 105229 (co-authored with Gómez-Sagasti)
- Zenir, M.C.; **López-Pozo, M.**; Polutchko, S.K.; Stewart, J.J.; Adams, (2023). *Productivity and Nutrient Quality of Lemna minor as Affected by Microbiome, CO₂ Level, and Nutrient Supply*. Stresses, 3: 69–85.
- Polutchko, S.K.; Stewart, J.J.; McNamara, M.; Doherty Garcia, N.; López-Pozo, M; et al., (2022) Floating plants as sustainable, highly nutritious crops: Nutrient production in different light environments. Nutraceuticals, 2(4): 350-364.
- García-Plazaola JI, Arzac MI; Brazales L, Fernández J, Laza JM, Vilas JL, **López-Pozo M**, et al., (2022) *Freezing and desiccation tolerance in the Antarctic bangiophyte Pyropia endiviifolia: a chicken and egg problem?* European Journal of Phycology.
- García-Plazaola, J.I., **López-Pozo**, M. & Fernández-Marín, B. (2022) *Xanthophyll cycles in the juniper haircap moss (Polytrichum juniperinum) and Antarctic hair grass (Deschampsia antarctica) on Livingston Island (South Shetland Islands, Maritime Antarctica)*. Polar Biology, 45: 1247–1256
- Demmig-Adams, B.; López-Pozo, M.; Polutchko, S.K.; Fourounjian, P.; Stewart, JJ; et al., (2022). *Intersections: Photosynthesis, abiotic stress, and the plant microbiome*. Photosynthetica, 60 (1): 59-69
- Demmig-Adams, B.; **López-Pozo, M.**; Polutchko, S.K.; Fourounjian, P.; Stewart, J.J; et al., (2022) Growth and Nutritional Quality of Lemnaceae Viewed Comparatively in an Ecological and Evolutionary Context. Plants, 11: 145.
- Stewart, J.J.; Adams, W.W., III; López-Pozo, M.; Doherty Garcia, N.; McNamara, M: et al., (2021). Features of the Duckweed Lemna That Support Rapid Growth under Extremes of Light Intensity. Cells, 10: 1481.
- Nadal, M; Brodribb, TJ; Fernández-Marín, B; García-Plazaola, JI; Arzac, MI; **López-Pozo, M**; et al., (2021). Differences in biochemical, gas exchange and hydraulic response to water stress in desiccation tolerant and sensitive fronds of the fern Anemia caffrorum. New Phytologist, 231 (4): 1415-1430
- Fernández-Marín, B; Arzac, M; **López-Pozo, M;** Laza, JM; Roach, T; et al., (2021) Frozen in the dark: night activity of xanthophyll cycle and xylem attributes interplay in fern tolerance to winter. Journal of Experimental Botany, 72 (8): 3168–3184
- Polutchko S, Demmig-Adams B, Stewart J, **López-Pozo M**, Adams WW III (2020). *Zeaxanthin and photoprotection in plants*. E Scholarly Community Encyclopedia (contributed entry).
- Demmig-Adams, B; Stewart, JJ; **López-Pozo, M**; Polutchko, SK; Adams, WW III. (2020) *Zeaxanthin, a molecule for photoprotection in many different environments*. Molecules, 25: 5825
- Fernández-Marín, B; Nadal, M; Gago, J; Fernie, AR; López-Pozo M; et al., (2020) Born to revive:

molecular and physiological mechanisms of double tolerance in a paleotropical and resurrection plant. New Phytologist, 226: 741-759

Demmig-Adams, B; **López-Pozo**, **M**; Stewart, JJ; Adams, WW III. (2020). *Zeaxanthin and lutein: photoprotectors, anti-Inflammatories, and brain food*. Molecules, 25: 3607

Stewart, JJ; Adams, WW III; Escobar, CM; **López-Pozo, M**; Demmig-Adams, B. (2020). *Growth and essential carotenoid micronutrients in Lemna gibba as a function of growth light intensity*. Frontiers Plant Science. 11, 480

Fernández-Marín, B; **López-Pozo**, **M**; Perera-Castro, AV; Arzac, MI; Sáenz-Ceniceros, A; *et al.*, (2020). *Symbiosis at its limits: Ecophysiological consequences of lichenization in the genus Prasiola in Antarctica*. Annals of Botany, 124: 1211–1226

López-Pozo, M; Flexas, F; Gulías, J; Carriquí, M; Nadal, M; Perera-Castro, AV; Clemente- Moreno, MJ; Gago, J; Núñez-Olivera, E; et al., (2019). A method for the semiquantitative estimation of desiccation tolerance across different groups of photosynthetic organisms. Physiologia Plantarum, 167: 540-555

Gasulla, F, García-Plazaola JI, **López-Pozo M**, Fernández-Marín B (2019) *Evolution, biosynthesis and protective roles of oligogalactolipids: Key molecules for terrestrial photosynthesis?* Environmental and Experimental Botany, 164: 135-148

López-Pozo, M; Ballesteros, D; Laza, JM; García-Plazaola, JI; Fernández-Marín, B. (2019). *Desiccation tolerance in chlorophyllous fern spores: Are ecophysiological features related to environmental conditions?* Frontiers in Plant Science, 10: 1130

López-Pozo, M; Gasulla, F, García-Plazaola, JI; Fernández-Marín, B. (2019). *Unravelling metabolic mechanisms behind chloroplast desiccation tolerance: chlorophyllous fern spore as a new promising unicellular model.* Plant Science, 281: 251-260

López-Pozo, M; Fernández-Marín, B; García-Plazaola, JI; Ballesteros D. (2018). *Desiccation tolerance in ferns: From the unicellular spore to the multi-tissular sporophyte*. In: Fernández H. (ed) Current Advances in Fern Research. Springer, Cham. Pp. 401-427

POSTER PRESENTATIONS

García-Plazaola JI, Artetxe U, Hernández A, **López-Pozo** M, Fernández-Marín B, Martínez-Abaigar J, Nuñez-Olivera E, Carriquí M, Clemente M, J., Flexas J, Gulías J, Verhoeven A. *A method for the semiquantitative assessment of desiccation tolerance in bryophytes*. "7th International Workshop on Desiccation Sensitivity and Tolerance Across LifeForms". South Africa. 2016

López-Pozo M, Hernández A, García-Plazaola JI, Artetxe U, Fernández-Marín B, Martínez-Abaigar J, Nuñez-Olivera E, Carriquí M, Clemente M, Flexas J, Gulías J, Verhoeven A. *Hydric conditions of the microhabitats determine constitutive desiccation tolerance inbryophytes*. Congreso Europeo de Fisiología Vegetal. Czech Republic. 2016

Gago J, Clemente-Moreno MJ, Flexas J, Vivas M, Hernandez C, Cavieres L, Carriquí M, Nadal M, Mihoc MAC, **López-Pozo M**, Martínez-Abaigar J, Núñez-Oliveira E, Fernández-Marín B, García-Plazaola JI, Gulías J, Bravo LA. *Antarctica in the global earth system: from the poles to the tropics and how the changes that we are currently seeing in Antarctica will affect the rest of the world.* The Scientific Committee on Antarctic Research. Malaysia. 2016

García-Plazaola JI, Fernández-Marín B, López-Pozo M. Chlorophyllous spores, is "die or dry" a dilemma?

XIV MEDECOS & XIII AEET meeting. Human driven scenarios for evolutionary and ecological changes. Spain. 2017

López-Pozo M, Ballesteros D, Laza, JM, Fernández-Marín B, García-Plazaola JI. *Las cuatroestaciones de las esporas clorofilicas de los helechos. Cada una tiene su momento, cada momento sus condiciones.* Botánica Criptogámica. Spain. 2017

López-Pozo M, Fernández-Marín B, García-Plazaola JI. "¿Cómo ser espora de helecho, secarse y no morir en el intento?". VII Coloquio de Ecofisiología Forestal. Spain. 2017

López-Pozo M., Fernández-Marín B., García-Plazaola JI, Gasulla F, Ruibal C, Fleitas L, Vidal S. *Changes in fern spores during hydration-dehydration cycles*. EMBO Workshop.New Shores in Land Plant Evolution. Portugal. 2018

Esteban R, Vicente M, **López-Pozo M**, Javier Martínez-Abaigar M, Núñez-Olivera E, García-Plazaola JI. *Photosynthetic pigments adaptation to light environment: an evolutionary perspective*. EMBO Workshop. New Shores in Land Plant Evolution. Portugal. 2018

Fernández-Marín B, **López-Pozo M,** Perera-Castro A, Pintado A, Colesie C, Sancho LG, de los Ríos A, Pérez-Ortega S, García-Plazaola JI. *How does lichenization affect photosynthesis of* Prasiola? *A fascinating example of symbiosis for survival in extreme environments such as Antarctica*. The 1st European Congress on Photosynthesis Research. A Marcus Wallenberg Symposium. Sweden. 2018

Fernández-Marín B, **López-Pozo M**, Perera-Castro A, Pintado A, Colesie C, Sancho L, de los Ríos A, Perez-Ortega S, García-Plazaola JI. *Consecuencias ecofisiológicas de la liquenización en el macroalga* Prasiola *sp: un caso fascinante de simbiosis y supervivencia enambientes anfipolares*. IX Simposio de Estudios Polares. Spain. 2018

Gago J, Clemente-Moreno M., Fernández-Marín B, Carriquí M, Vivas M, Coopman R, **López-Pozo M,** Perera-Castro A, Nadal M, Hernandez C, Bravo L, Cavieres L, García-Plazaola JI., Gulias J, Flexas J. *Los desiertos polares: ¿una nueva oportunidad para entenderlos mecanismos de tolerancia a estrés en plantas?* IX Simposio de Estudios Polares. Spain. 2018

García-Plazaola JI, Gago J, Clemente-Moreno M, Flexas J, Gulías J, Porcar-Castell A, Olascoaga B, Atherton J, Kolari P, **López-Pozo M**, Fernández- Marín B. ¿Duermen las plantas al sol de medianoche?: una caracterización anfipolar. IX Simposio de Estudios Polares. Spain. 2018

López-Pozo M, Fernández-Marín B, García-Plazaola JI, Ballesteros D. "Dehydrated, illuminated and oxygenated: How do chlorophyllous ferns spores cope with light and oxygen during dry storage?" International conference on Integrative Plant Physiology. Spain. 2019.

García Plazaola JI, Fernández-Marín B, Gulías J, Perera A, **López-Pozo M,** Verhoeven A, Echeveste M. *Patrones globales de reactivación de la fotosíntesis tras la rehidratación en líquenes*" XV Congreso Nacional de la AEET. Spain. 2021.

Demmig Adams B, Stewart JJ, López-Pozo M, Escobar CM, Adams WW III. "Design of Plant Growth Environment as a Tool for Optimization of Duckweed as a Space Crop". NASA Human Research Program Investigators' Workshop. USA. 2021.

López-Pozo, M, Adams, WIII, Demmig-Adams, B. "Ameliorated duckweed growth under low nutrient supply and elevated CO2 after inoculation with rhizosphere microbes". Plant Science for Climate Emergency. Virtual event. 2021

Demmig-Adams B, Escobar CM, Stewart JJ, **López-Pozo M**, Zenir MC, WW Adams WW III. "Newly Defined Attractive Features of Lemna as a Space Crop" 2022 NASA Human Research Program Investigators' Workshop. USA. 2022.

De Agostini A, Juarez M, **López-Pozo M**, Martínez-Abaigar J, Núñez-Olivera E, Artexte U, Michelozzi M, Cencetti G, Loreto F, Pollastri S, Stanton D, Cogoni A, Cortis P, Perera-Castro AV, Luu HT, Le BT, Nguyen TL, García-Plazaola JI, Hernandez A, Esteban R. "*Biogenic Volatile Organic Compounds (BVOCs) around the world: does geography shapes BVOCs profiles in bryophytes?*" 117° Congresso della Società Botanica Italiana VIII International Plant Science Conference. Bologna. 2022

Zhang C, Porcar-Castell A, Miettinen I, Atherton J, Rissanen K, Aalto J, Heidi H, Tykkä Y, Fernández-Marín B, García-Plazaola JI, **López-Pozo M**, Kohl L, Bäck J. "Photochemical reflectance index to investigate shoot biogenic volatile organic compound emissions from scots pine and english oak saplings in response to warming". ACCC-FASN Science Conference 2023. Kuopio, Finland. 2023

García-Plazaola JI, Fernández- Marín B, Porcar-Castell A, Llerena M, **López-Pozo, M.** "How green was my valley: The challenge of measuring chlorophyll content in natural canopies". XVII International Colloquium on Plant Ecophysiology. Katalapi Park. Chile. 2024

Fernández- Marín B, Perera-Castro AV, Arzac MI, **López-Pozo M**, Díaz-Jimémez L, González-Rodríguez A, García-Plazaola JI. "Hidden aspects of photosynthetic organisms at the poles: looking on the wet, the frozen, and the bright sides of green life". X Simposio de Estudios Polares 2024. Salamanca. Spain.

Demmig-Adams B, **López-Pozo M**, Adams WW III. "Optimization of plant carotenoid production through manipulation of abiotic and biotic growth environment". Virtual International Carotenoid Conference. 2024