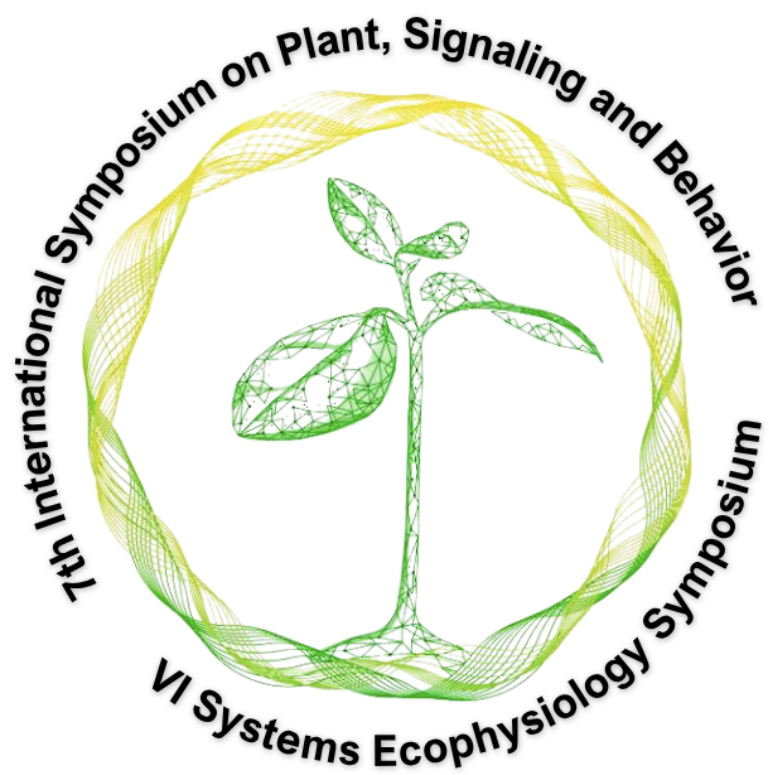




Proceedings of VII ISPS&B and VI SES

June 24 - 27th, 2025

Fortaleza - CE, Brazil

Presented by



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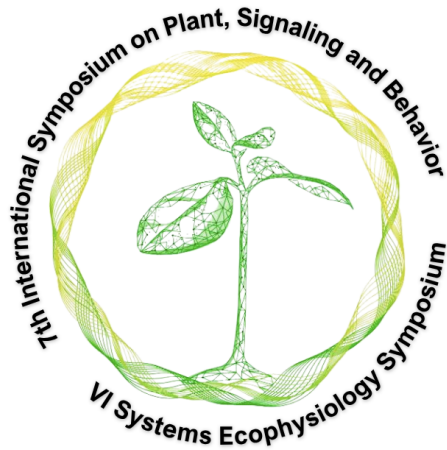


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Proceedings 2025



Report Prepared by:
Simone Ribeiro Lucho
Gustavo Maia Souza

Date: July 2025

Reviewed and Approved by:
Scientific committee of the VII
PS&B and VI SES



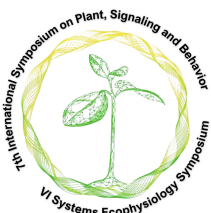
A Message from Organizers:

Brazilian Society of Plant Physiology &
Plant, Signaling & Behavior Society

The VII PS&B and VI SES Symposiums are characterized as spaces for discussing themes emerging from the study of interactions between plants and their environment from a multidisciplinary perspective. These events stand out as unprecedented events combining the fields of Plant Science, Cognitive Sciences and Philosophy in which multidisciplinary and unusual topics in technical-scientific events in plant biology are explored. For example, previous editions of SES and PS&B involved discussions that address cognitive aspects of plants, such as memory, learning, intelligence, and plant-plant communication, in addition to a deep theoretical discussion about how the plant works and how it influences and is influenced by the environment. The systemic perspective of SES and PS&B has contributed substantially to reducing botanical blindness and increasing our understanding of the physiological and ecological processes that regulate the dynamics of natural and agricultural ecosystems, influencing the way botanists, agronomists, plant physiologists and people in general observe and investigate plants.

Warm regards,

Gustavo, Danilo and Liz



Gustavo Maia Souza
Vice-President of the BSPP



Danilo de Menezes Daloso
Organizing committee



Elizabeth van Volkenburgh
President of the PS&B Society



Local organizing committee

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Ariel Novoplansky
 Ben-Gurion University of the Negev, Israel

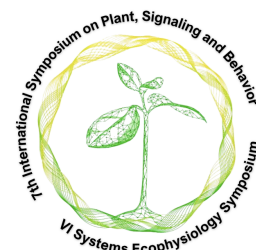
Danilo de Menezes Daloso
 Federal University of Ceará

Frantisek Baluska
 University of Bonn, Germany

Gustavo Maia Souza
 Federal University of Pelotas

José Feijó
 University of Maryland, USA

Satish Chander Bhatla
 University of Delhi, India





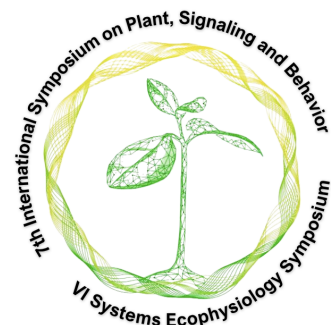
Honoree

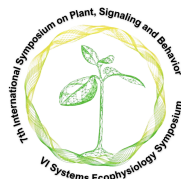
In recognition of his invaluable contribution to Plant Physiology in Brazil

This enduring dedication and inspiring legacy in the field of Plant Physiology continue to inspire generations of plant physiologists through leadership and scientific excellence.



Ph.D. Joaquim A. G. da Silveira
(UFC - Fortaleza, CE)





Schedule

June 24th

4:00 – 5:15 pm - Registration

5:30 pm - Opening Ceremony (by the local organizers, SBFV and PSB Society)

06:00 pm - Opening lecture

“Plant-life vocabulary as metaphors for post-normal planetary challenges”

Fabio Rubio Scarano (Museu do Amanhã & Federal University of Rio de Janeiro, Brazil)



7:00 – 9:00 pm - Welcome cocktail

June 25th

SESSION 1

Systemic signaling and integration in a complex environment

Coord. by José Feijó
(University of Maryland, USA)

Talk 1 (8:30 – 09:10 am)

Speaker: Masatsugu Toyota (Saitama University, Japan)

“From touch to snap: molecular mechanisms of mechanosensory transduction in the Venus flytrap”

Talk 2 (09:10 – 09:50 am)

Speaker: Matteo Grenzi (University of Milan, Italy)

“Osmotic changes at the crossroad of GLRs activation”



Coffee-break (10:00 - 10:30 am)

Talk 3 (10:30 – 11:10 am)

Speaker: Maria Teresa Portes (São Paulo University, Brazil)

“The electrical dance orchestrating fertilization in flowering plants”

Talk 4 (11:10 - 11:50 am)

Speaker: José Feijó (University of Maryland, USA)

“Evolution and function of plant glutamate receptors”



Lunch time (12:00 – 2:00 pm)

SESSION 2

Signaling molecules and associated mechanisms in stress alleviation

Coord. by Satish C. Bhatla,
(University of Delhi, India)

Talk 5 (2:00 - 2:40 pm)

Speaker: Neidiquele Maria Silveira (São Paulo State University, Brazil)

“Nitric Oxide and Nanobiotechnology in Plant Drought Tolerance”

Talk 6 (2:40 – 3:20 pm)

Speaker: Felipe K. Ricachenevsky (Federal University of Rio Grande do Sul, Brazil)

“Beyond the iron curtain: how plants regulate responses to iron deficiency and excess”



Coffee-break (3:20 - 3:50 pm)

Talk 7 (3:50 – 4:30 pm)

Speaker: Satish C. Bhatla (University of Delhi, India)

“Signaling Mechanisms Regulating Salt Stress Tolerance in Plants”

Flash talks (4:30 – 5:00 pm) – 10 min talks selected from the abstracts submitted



1 - Transgenerational phosphorus deficiency stress differentially modulates the phosphatase acid activity of soybean cultivars
Wanessa Almeida Souza e Lima*, Isadora Rodrigues Medina Santana, Eduardo Gusmão Pereira

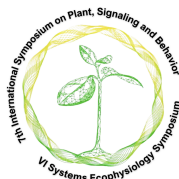
2- Salt tolerance mediated by endoplasmic reticulum stressor based in seed priming
Francisco Dalton Barreto de Oliveira, Francisco Lucas Pacheco Cavalcante, Stelamaris de Oliveira Paula Marinho*, Isabelle Mary Costa Pereira, Humberto Henrique de Carvalho

3 - Mechanical treatment promotes anatomical modifications, early flowering and increased yield in tomato through the action of ethylene and auxins
Jenifer Castro Estrada*, Elina Welchen, Raquel L. Chan



5:30 – 7:00 pm

Happy Poster (with free brew) and networking



June 26th

Schedule

SESSION 3

Plant Cognition and Intelligence driving behavior

Coord. by Frantisek Baluska,
(University of Bonn, Germany)

Talk 8 (8:30 – 9:10 am)

Speaker: Anthony Trewavas (University of Edinburg, UK) – **online**
"Plant intelligence dux"

Talk 9 (9:10 – 9:50 am)

Speaker: Umberto Castiello (University of Padua, Italy) – **online**
"Grasping the intelligence of plants"



Coffee-break (9:50 - 10:20 am)

Talk 10 (10:20 – 11:00 am)

Speaker: Michael Marder (University of the Basque Country, Spain) – **online**
"Toward a Distinction between 'Thin' and 'Thick' Versions of Plant Intelligence"

Talk 11 (11:00 – 11:40 am)

Marc-Williams Debono (PSA, France)
"The High Cognitive Power of Plants: Why and How?"

Talk 12 (11:40 – 12:20 pm)

Frantisek Baluska (University of Bonn, Germany)
"Evolution of Plant Neurobiology: From Darwins Until the 21st Century"



SESSION 4

Evolutionary Ecology of Plant Behavior

Coord. by Ariel Novoplansky
(Ben-Gurion University of the Negev, Israel)

Talk 13 (2:30 – 3:10 pm)

Speaker: Ariel Novoplansky (Ben-Gurion University of the Negev, Israel) – **online**
"Facilitating Plant Learning by Metaplasticity"

Talk 14 (3:10 - 3:50 pm)

Speaker: Carlos Ballaré (University of Buenos Aires, Argentina)
"Informational photoreceptors and plant intelligence"



Coffee-break (3:50 - 4:20 pm)

Talk 15 (4:20 – 5:00 pm)

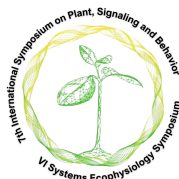
Speaker: Akira Yamawo (Kyoto University, Japan)
"Kin discrimination drives eco-evolutionary dynamics in plant communities"

Talk 16 (5:00 – 5:40 pm)

Speaker: Adrienne Nicotra (Australian National University, Australia)
"The heat is on: the complex world of sensing and responding to a warming world"



6:00 – 7:30 pm
Happy Poster (with free brew) and networking



Schedule

June 27th

SESSION 5

Plant behavior in the tropics: the many faces of Brazilian species

Coord. by Gustavo Maia Souza
(Federal University of Pelotas, Brasil)

Talk 17 (8:30 – 9:10 am)

Speaker: Rafael Oliveira (Universidade Estadual de Campinas, Brazil)
"From roots to forests: the diversity of water acquisition and drought resistance strategies in amazonian plants"

Talk 18 (9:10 – 9:50 am)

Speaker: Angela P. Vitória (Universidade Estadual do Norte Fluminense Darcy Ribeiro, Brazil)
"Functional Traits in the Atlantic Forest"



Coffee-break (9:50 - 10:20 am)

Talk 19 (10:20 – 11:00 am)

Speaker: Augusto C. Franco (Universidade de Brasília, Brazil)
"Functional diversity in life history traits of Cerrado trees"

Talk 20 (11:00 – 11:40 am)

Speaker: Mauro Guida Santos (Universidade Federal de Pernambuco, Brazil)
"Caatinga dry forest: mechanisms and implications for forest resilience"

Flash talks (11:50 – 12:20)– 10 min talks selected from the abstracts submitted



4 - The developmental and functional basis of stomatal adaptation to climate

Camila Dias B. Medeiros*, Thomas N. Buckley, Kevin Sartori, Cyrille Violle, Denis Vile, François Vasseur, Leila R. Fletcher, Matteo Pellegrini, Etienne Baron, Lawren Sack

5- What is it like to be a Tree? Intelligences in Dialogue
Alfonso Villanueva*, Ana Marcos

6 - Multi-location tracking for a network science approach to plant signaling: a case study on light stimuli
Yasmeen Hitti*, Shenyang Huang, Florian Golemo, Guillaume Rabusseau, Reihaneh Rabbany, Audrey Durand, Mark Lefsrud



Lunch time (12:30 – 02:30 pm)

SESSION 6

The complexity of plant behavior: chasing for a systemic perspective

Coord. by Danilo M. Daloso
(Federal University of Ceará, Brasil)

Talk 21 (2:30 – 3:10 pm)

Speaker: Flavia Winck (São Paulo University, Brazil)
"Amino acids in the control of lipid synthesis in microalgae: fluxomics and modulation of the arginine pathway"

Talk 22 (3:10 – 3:50 pm)

Speaker: Lars Wegner (Foshan University, China)
"The Thermodynamics of Living Systems: Do We need a Revision?"



Coffee-break (3:50 - 4:20 pm)

Talk 23 (4:20 – 5:00 pm)

Speaker: Sergey Shabala (University of Western Australia)
"Membrane transporters in sensing and signaling of soil salinity and hypoxia"

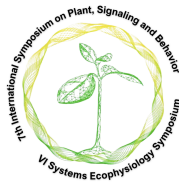
Talk 24 (5:00 – 5:40 pm)

Andrej Pavlovic (Palacký University Olomouc, Czechia)
"The Diversity of Digestive Systems in Carnivorous Plants"

6:00 – 7:00 pm – Closing: the future of PS&B Society and the next Symposium.



08:00 pm - Farewell dinner



Opening lecture

Fabio Rubio Scarano

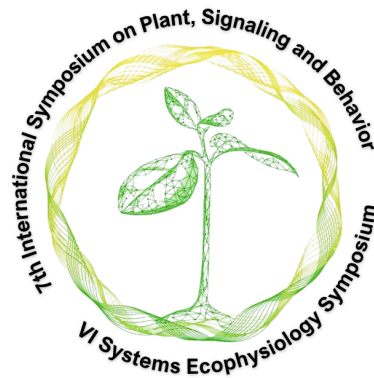
Curator of the Museum of Tomorrow, and
Federal University of Rio de Janeiro, Brazil

Plant-life vocabulary as metaphors for post-normal planetary challenges

Concepts, metaphors, and analogies are figures of speech that consist of special kinds of models related with general structures underlying reality, but that do not “touch” reality. They lack the power to completely represent an object. Hans Blumenberg’s theory of non-conceptuality claims that concepts are work in progress, transitional stages, rather than the fulfilment of the intentions of reason. As to analogies and metaphors, their difference is perhaps that analogies formulate a similarity that already exists, while metaphors make a hidden similarity come to light. However, metaphors in particular can expand reality, since the images and feelings they provoke have both informative value and constitutive function. Moreover, metaphors can eventually gain the status of concepts. It is the interactions between any given language and its environment – i.e., a language ecology – that often gives birth to analogies, metaphors, and occasionally new models and concepts emerge. My argument in this presentation is twofold: 1) much of the heated criticism to “plant intelligence” and associated attributes disregards language ecology; and 2) since language has an anticipatory nature, changes in the use of language precede changes in times.

To develop these arguments, I will use three examples:

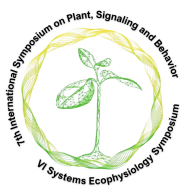
- 1) the currently dominant use of words such as nature and intelligence is a product of modernity and differ from their etymological roots;
- 2) some vocabulary once more often used in botany and biology is now shifting to a higher frequency of use in fields such as digitalization, technology, and business;
- 3) the relationship of memory, attention and anticipation in plants as metaphor and analogy for a way humans should deal with contemporary planetary challenges.



Oral Abstracts

Systemic signaling and integration in a complex environment

Coord. by José Feijó
(University of Maryland, USA)



Masatsugu Toyota

Department of Biochemistry and Molecular Biology, Saitama University, Japan
Suntory Foundation for Life Sciences, Japan
College of Plant Science and Technology, Huazhong Agricultural University, China

From touch to snap: molecular mechanisms of mechanosensory transduction in the Venus flytrap

Touch perception plays a vital role in the survival of living organisms, yet its molecular basis in plants remains largely unresolved. The Venus flytrap relies on specialized sensory hairs that detect mechanical stimuli and initiate long-range electrical and calcium signaling, culminating in rapid trap closure to capture prey. To investigate this signaling pathway, we developed an intracellular dual-recording system by integrating a two-photon microscope with electrophysiological techniques, allowing simultaneous measurement of calcium dynamics and membrane potentials. Through this approach, we identified a mechanosensitive ion channel in the Venus flytrap that serves as a highly sensitive receptor for mechanical stimulation. Loss-of-function mutants lacking this channel displayed defective propagation of touch-induced calcium and electrical signals, and a diminished ability to recognize and capture prey. Our results support a mechanosensory model in which the mechanosensitive ion channel contributes to generating receptor potentials in stretched sensory cells, initiating action potential firing and calcium signaling required for trap closure.

Grenzi Matteo

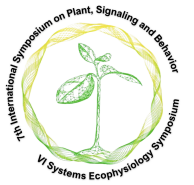
Department of Biosciences, University of Milan, Italy

Osmotic changes at the crossroad of GLRs activation

The perception of environmental stimuli in plants often triggers the systemic transmission of chemical and electrical signals, eliciting responses in unaffected tissues and coordinating developmental programs across various plant organs. Studies on *Arabidopsis* have underscored the pivotal role of Glutamate Receptor-Like channels (GLRs) in directing leaf-to-leaf electrical and calcium signals upon wounding, as well as the increase in Jasmonate levels, a key defense hormone, in undamaged systemic leaves. Whereas in response to wounding the glutamate-dependent activation of GLRs is mainly related to the apoplastic accumulation of this amino acid upon cellular disruption, it is not known if other less-invasive stresses can trigger similar effects. Here, we report that an osmotic shock applied to the roots of *Arabidopsis* soil-grown plants induces in leaf tissues: (i) a change in the surface potential, (ii) an accumulation of glutamate in the apoplast, and (iii) a calcium wave that is reliant on the phloem localized AtGLR3.3 activity. Differentially from wounding, Jasmonate signalling pathway is not activated by the osmotic shock, showing that AtGLR3.3 activity is necessary but not sufficient to induce this response.

Systemic signaling and integration in a complex environment

Coord. by José Feijó
(University of Maryland, USA)



Maria Teresa Portes

Biosciences Institute of the University of São Paulo, Brazil

The electrical dance orchestrating fertilization in flowering plants

Successful reproduction in angiosperms require pollen tubes to grow into the female tissue and steer towards the ovule. Ion signaling and homeostasis remain on the spotlight of pollen tube morphogenesis, intercellular communication and cell wall composition. Tip focused gradient of both Ca^{2+} and H^{+} are associated with pollen tube growth, often displaying highly synchronized oscillations with growth and tip influx. Intriguingly, a double mutant of $\text{H}^{+}/\text{K}^{+}$ exchangers in *Arabidopsis thaliana*, *chx21 chx23*, fails to target the ovules in vivo, growing straight through the transmitting tract towards the bottom of the ovary. Thus, we investigated alterations in the spatial temporal regulation of ion dynamics underlying this loss of guidance in the *chx21 chx23* compared to *CHX* single mutants and *Col-0*. Despite the lack of major differences on average growth rate, *chx21 chx23* showed significantly lower extracellular H^{+} fluxes at the tip and shank, accompanied by alterations in the spatio-temporal signature of H^{+} intracellular concentration, assayed with pHluorin. Remarkably, while the other genotypes responded to an externally applied attractant (LURE), *chx21 chx23* did not turn towards the source maintaining growth direction and a predominantly oscillatory regime. These results demonstrate that ion dynamics regulation, specially H^{+} , is fundamental for decoding and response to external cues, while the loss of modulation of intracellular regimes compromises cell guidance. Taken literally, our results suggest a H^{+} based control of chemotropism and cell morphogenesis.

José Feijó

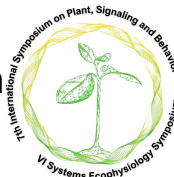
University of Maryland, Department of Cell Biology and Molecular Genetics, US

Evolution and function of plant glutamate receptors

Plant Glutamate Receptors are ionotropic channels which are increasingly recognized as crucial for a number of cell-cell communication processes in plants. Commonly referred in the literature as GLRs (GLutamate Receptor-Like) these channels various plant functions, such as reproduction, development, host-pathogen interaction, long-distance communication or wound repair. In contrast, progress in understanding the molecular features underlying these roles is lagging (Simon et al. 2023. *Ann. Rev. Plant Biol.* 2023. 74:415–52). I will review the critical data that established GLRs as Ca^{2+} -permeable channels (Michard et al. 2011. *Science*. 332:434-437) to the first Cryo EM structure (Green et al. 2021. *Mol. Cell*. 81:1-11), with an emphasis on their role in male function from mosses (Ortiz-Ramirez et al. 2017. *Nature*. 549:91-95) to flowering plants (Wudick et al. 2018. *Science*. 360:533-537.) I will further present new data regarding their evolutionary divergence from the mammalian canonical families, namely in terms of ligand and ion specificity that shapes their fundamental functions. I will present new data revealing a new primary function related to electric signaling through anion transport. Given the high number of glutamate receptor genes existing in flowering plants (20 in *Arabidopsis*, up to 50 in some species) and their functional redundancy, structural and protein-protein interaction data will be essential to further genetically dissect their functions in plants and provide clues about the evolution of their roles in plant biology.

Signaling molecules and associated mechanisms in stress alleviation

Coord. by Satish C. Bhatla
(University of Delhi, India)



Neidiquele Maria Silveira

Department of Biodiversity, Institute of Biosciences, São Paulo State University, Brazil

Nitric Oxide and Nanobiotechnology in Plant Drought Tolerance

Nitric oxide (NO) is a key signaling molecule involved in plant growth, development, and stress tolerance. While conventional NO donors boost endogenous NO levels, their instability often limits effectiveness. Nanotechnology offers a promising alternative, especially through NO-releasing nanomaterials like S-nitrosothiol-loaded chitosan nanoparticles, which provide greater stability and bioactivity. This presentation highlights results from studies using encapsulated NO to alleviate water stress in plants, showcasing its potential to advance both agriculture and environmental science.

Felipe Klein Ricachenevsky

Department of Botany, Institute of Biosciences; Center of Biotechnology;
Federal University of Rio Grande do Sul, Brazil

Beyond the iron curtain: how plants regulate responses to iron deficiency and excess

Iron (Fe) is essential to both plants and animals, including humans. Fe deficiency is one of the main dietary problems worldwide, affecting at least two billion people. In plants, Fe participates in key processes such as photosynthesis and respiration, as well as in chlorophyll synthesis. Therefore, plants suffer when Fe concentration in tissues are low, which commonly occurs in calcareous soils. On the other hand, Fe excess may occur in waterlogged, reductive soils, and become toxic. Fe toxicity is also harmful, since Fe generates reactive oxygen species by Fenton chemistry. We have been exploring how vacuolar Fe storage could be important to rice plants when exposed to varying Fe concentrations, using mutants lacking the function of two Vacuolar Iron Transporter (VIT) genes. We also explore low Fe classical symptom, leaf chlorosis, is alleviated depending on the combination of Fe deficiency with either aluminum toxicity or phosphorus deficiency, challenging the idea that symptoms are directly dependent on Fe concentration within leaves. Moreover, we are investigating possible molecular players involved in regulating the ionome's balance.

Satish C. Bhatla

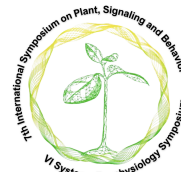
Department of Botany, University of Delhi, India

Signaling Mechanisms Regulating Salt Stress Tolerance in Plants

Achieving resilience in crop productivity is a manifestation of persistent focussed research in deciphering the causes and mechanisms of action of various biotic and abiotic factors affecting plant development. Salt stress is one of the major factors contributing to heavy losses among several crops world over. Research activities in Delhi University have, over the last four decades, focussed on understanding the signaling mechanisms regulating the development of sunflower plants exposed to salt stress. A rapid and long distance signaling of salt stress in seedlings and the adaptive biochemical changes, have been examined both in temporal and spatial terms at the subcellular and whole plant levels. For achieving these goals, quite a few novel methods have been designed to particularly understand the independent effects of nitric oxide and its cross talk with other biomolecules, in combating salt stress in plants. Novel findings on the possible role of N-nitrosomelatonin as a long distance nitric oxide carrier in plants are likely to bring in new concepts in our understanding of the ways plants scavenge reactive oxygen species and adapt themselves for growth in the conditions of salt stress. Proteomic analysis of oil body membrane proteins and lipidomic analysis of oil body constituents from sunflower seedling cotyledons has brought forward interesting new information to understand the impact of salt stress in modulating the longevity of plant. Models derived from these various investigations are likely help in better understanding of crop resilience at the biochemical level.

Plant Cognition and Intelligence driving behavior

Coord. by František Baluska
(University of Bonn, Germany)



Tony Trewavas FRS

University of Edinburgh, UK

Plant intelligence dux

My talk is based primarily on two papers; Gilroy and Trewavas (2002) *Biological Journal of the Linnean Society* 139; 514-529 ; Trewavas (2025) *Protoplasma* 262:255-266. Reading these first will avoid unnecessary questions. In 2003, I stated plant intelligence to be adaptively-variable behaviour during the lifetime of the individual. The definition of adaptive behaviour by Dobzhansky indicates such behaviour to be both intentional and therefore purposeful. Green plants evolved from bacteria and in turn protozoa whose behaviour is characterised by many as intelligent. Neural networks in both animal and plant cells are structured around protein kinase networks and underpin intelligent behaviour. A frequent misunderstanding arises from the failure to differentiate between adaptive biological intelligence and the psychologists' characterization of scholastic ability as human intelligence. Signal transduction is the molecular route used by plant and animal cells to learn about their environment. And the consequence of activation of transduction is the construction of long-term accessible memories via changes in chromatin topology. Learning and memory in animal and plant cells are based on similar mechanisms unsurprising because both evolved from the same amoebic ancestor. If time permits, I will outline Darwin's view of biological intelligence and the more astute definition produced by George Romanes, Darwin's research assistant.

František Baluška¹ and Stefano Mancuso²

¹Institute of Cellular and Molecular Botany, University of Bonn, Germany

²University of Florence, Italy

Evolution of Plant Neurobiology: From Darwins Until the 21st Century

In 2005, we organized the first symposium devoted to the of plant neurobiology in Florence. This gathering recognized that plants are truly living organisms with all features inherent to life. We published the proceedings of this symposium in the Springer Verlag in 2006 (Baluška et al. 2006) and also summarized the basic principles of the emerging field of plant neurobiology in *Trends of Plant Science* (Brenner et al. 2006). Nevertheless, the field of plant neurobiology has longer history and its modern version started with Charles and Francis Darwin and book the *Power of Movements in Plants* (Darwin 1880, Stahlberg 2006, Baluška and Mancuso 2007, Barlow 2008, Shepherd 2012, Minorski 2024). This second start of the plant neurobiology was also difficult and, in order not to place young participants under danger in their career, we have changed the name of society to the Plant Signaling & Behavior at the 5th Symposium of the Plant Neurobiology, again in Florence. Since this last symposium on the Plant Neurobiology in 2009, we organized six symposia on the Plant Signaling & Behavior from 2013 to 2023 (Vancouver 2013, New Delhi 2014, Paris 2015, St. Petersburg 2016, Matsue 2017, Seattle 2023). Now we gather at the 7th PSB symposium in Fortaleza, for the first time in the South America.

Michael Marder

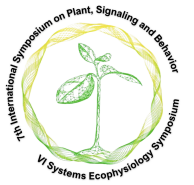
University of the Basque Country, Spain

Toward a Distinction between 'Thin' and 'Thick' Versions of Plant Intelligence

In this talk, I critically examine the concept of intelligence across diverse domains—human, artificial, and plant—highlighting the limitations of prevailing narrow definitions that emphasize calculative or algorithmic functions. Focusing on plant intelligence, I contrast “thin” instrumental views with a “thick” approach that integrates plant morphology, ecology, and symbiotic relations, especially in the rhizosphere, the dynamic soil-root interface. Drawing on interdisciplinary perspectives from plant physiology, philosophy, and phenomenology, the talk foregrounds the rhizosphere as a locus of vegetal unconscious—a living archive where roots, microbes, and soil engage in continuous feedback loops that underpin plant cognition. It argues that intelligence and consciousness are inseparable from an ever-present unconscious background, challenging reductionist models in both biological and artificial intelligence. This “soil unconscious” embodies a complex material and psychic life that transcends individual organisms and conventional cause-effect frameworks, inviting a rethinking of intelligence as emergent from diffuse, non-linear interactions within multispecies assemblages. Overall, I propose a novel ontology and epistemology of plant intelligence rooted in the relational, embodied, and unconscious processes of the rhizosphere.

Plant Cognition and Intelligence driving behavior

Coord. by Frantisek Baluska
(University of Bonn, Germany)



Marc-Williams Debono

PSA Research Group, France

The High Cognitive Power of Plants: Why and How? Electrome & Mesological Plasticity of Plants

Plants are highly integrated ecoplastic interfaces whose electronic complexity reflects wide-ranging cognitive interactions such as long-distance communication, proprioception, learning, memory, or attention-like processes. These capacities that have emerged over the course of evolution have enabled plants to accumulate precise knowledge of their singular milieu differentiated from the raw data of the environment, developing specific dynamical couplings and new forms of cognitive plasticity including perception-action loops, bio-semiotic exchanges, and high value-added complex behaviors. The essential question that will be addressed here is why and above all how modular and sessile organisms like plants came to develop such sophisticated cognitive mechanisms comparatively to animals and humans? To answer this question, we propose a comparative analysis of the protoneural dynamics of plant electromes and the modes of cognition associated with them. It will be developed on four axes: 1/ the fundamental role of spontaneous EPGs as early markers of all the physiological states of the plant subjected to constant flows of information and stimuli from the environment; 2/ the nonlinear dynamic processes observed in oscillatory or synchronized bioelectrical plant networks such as low band frequencies waves or the spatiotemporal course of EPG signals compared to neural systems; 3/ the efficiency of plant electronic plastic interfaces in different cognitive scenarios (on-line vs off-line, explicit vs non-explicit, extended vs focused..); 4/ the description of a new form of plasticity, neither phenotypic nor ontogenetic, but mesologic, i.e. linked to the medial structure of plant bodies and their dynamic coupling at the plant-milieu interface. This mesological plasticity involving active perceptions, affordances or umwelts and plasticity complexes is presented as the keystone to the apparent contradiction between the high cognitive power of plants and their apparent absence of coordination. Used as a model of evolutionary biology to study plants as self-eco-organized structures, it could lead to the adoption of a new index of ecosensitivity permitting a better understanding of the electrical and cognitive-sensory dimension of plant life. Finally, this exploration conducted within a bottom-up transdisciplinary framework, could permit to reassess the scales of perception and cognition of living systems, and have a direct impact on our understanding of the emergence and singularity of intelligent behaviors in non-human living beings.

Umberto Castiello

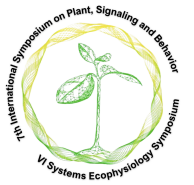
University of Padua, Italy

Grasping the intelligence of plants

If someone asked you to name an intelligent organism, it's unlikely that an orchid would come to mind. We tend to associate intelligence with organisms that can move independently—creatures that navigate through space and time with apparent intention, suggesting some form of cognition. Plants, on the other hand, appear immobile and are therefore often seen as incapable of intelligent behavior. However, there is a way to reveal plant movement: time-lapse videos. These compress hours or days of plant activity into seconds, bringing their subtle movements into the realm of human perception. Just as slow-motion videos of animals can uncover hidden behaviors, time-lapse footage of plants reveals meaningful variations and allows us to make comparisons across species. What emerges from studying both plant and animal behavior is the realization that the two complement each other in fascinating ways. If nothing else, these insights remind us of just how much plants and animals may have in common.

Evolutionary Ecology of Plant Behavior

Coord. by Ariel Novoplansky
(Ben-Gurion University of the Negev, Israel)



Ariel Novoplansky

Mitrani Department of Desert Ecology, Blaustein Institutes for Desert Research,
Ben-Gurion University of the Negev, Israel

Facilitating Plant Learning by Metaplasticity

Organisms utilize myriad plastic traits to cope with their ever-changing growth conditions and challenges. However, the complexity and costs of plasticity imply the involvement of higher-order controls over plastic responsiveness. To use a well-studied example, while the shade avoidance syndrome (SAS) in plants is a manifestation of multiple low-order phenotypic plasticities, the magnitude, timing, and complexity of these responses are expected to be modulated by higher-order metaplasticities reflecting the specific challenges, advantages, and costs of SAS under specific scenarios. Accordingly, metaplastic controls may rely on a variety of regulatory systems and morphogenetic contingencies that reflect the organism's evolutionary background, maternal and present physiological states, ontogenetic stage, size, phenology, and various external cues correlated with concurrent and anticipated stresses, disturbances, and biotic interactions. Studying the functional aspects and mechanistic controls of higher-level plasticities is expected to shed new light on the manifestation and coordination of multiple plastic traits and their evolutionary implications.

Carlos L. Ballaré

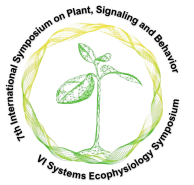
Universidad de Buenos Aires, Argentina

Informational photoreceptors and plant intelligence

Plants make "intelligent" decisions about growth and defense, particularly concerning competition and herbivory. Photoreceptor proteins, especially phytochrome B (phyB), act as crucial informational sensors that help the plant to make appropriate choices in complex environments. When plants grow in dense vegetation, they detect a reduction in the red to far-red (R:FR) light ratio due to neighboring plants absorbing R light for photosynthesis and reflecting FR radiation. This low R:FR ratio inactivates phyB, triggering the "shade avoidance syndrome". These growth-promoting shade avoidance responses increase the ability of the plant to compete for light and are often accompanied by a suppression of costly chemical defenses against herbivores and pathogens. Jasmonates, a group of lipid regulators, play a key role controlling plant growth and orchestrating the biosynthesis and accumulation of specialized metabolites. Photoreceptors modulate growth and defense responses in canopies in part by controlling jasmonate metabolism and signaling. I will discuss recent advances in our understanding of the underlying mechanisms, which involve changes in the activity and stability of key transcription factors of the PIF and MYC families. I will also present examples of how the modular architecture of plants and their diverse repertoire of defenses allows them to use the information acquired by their photoreceptors to fine tune plastic responses and increase fitness in complex environments.

Evolutionary Ecology of Plant Behavior

Coord. by Ariel Novoplansky
(Ben-Gurion University of the Negev, Israel)



Akira Yamawo

Kyoto University, Japan

Kin discrimination drives eco-evolutionary dynamics in plant communities

Plants can discriminate the genetic relatedness of conspecific neighbors and exhibit complex behaviors in response. In addition to interactions with conspecifics, plants often face interspecific competition simultaneously. How do plants behave under such conditions? To explore this question, I conducted growth experiments manipulating the genetic relatedness of *Plantago asiatica* neighbors in the presence of either a conspecific or heterospecific competitor. The results indicate that *P. asiatica* sibling pairs exhibit more collaborative behavior against interspecific competition than non-sibling pairs. The collaborative behavior may depend on the integration of information about the genetic relatedness of conspecific neighbors and the presence of heterospecific competitors. However, this collaborative behavior was not observed in intraspecific competition with genetically distant conspecifics. Instead, sibling pairs were at a disadvantage in such competition. Based on these findings, I will propose a hypothesis on the role of kin discrimination in the eco-evolutionary dynamics of plant communities.

Adrienne Nicotra

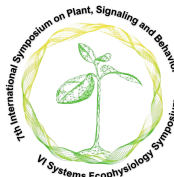
Australian National University, Australian

The heat is on: the complex world of sensing and responding to a warming worlds

Temperatures are rising and the thermal regimes of our ecosystems are changing rapidly, becoming warmer and more variable. Important questions revolve around what determines thermal tolerance or the thermal limits of a species distribution. Are they the same thing? And how best to measure or predict them? To assess the integrated response of plants and plant communities to changing thermal regimes requires systems level perspectives that draw together impacts at different scales – e.g., cell vs organ vs individual vs population. We must also appreciate the complexity of how plants sense their thermal environment to understand their responses. I will present work collaborators and I have been doing to better understand what plant thermal tolerance means and how plants respond to their environment to rapidly and actively acclimate that tolerance.

Plant behavior in the tropics: the many faces of Brazilian species

Coord. by Gustavo Maia Souza
(Federal University of Pelotas, Brasil)



Rafael Oliveira

Campinas State University, Brazil

From roots to forests: the diversity of water acquisition and drought resistance strategies in amazonian plants

The Amazon harbors not only an extraordinary diversity of species but also a remarkable variety of strategies for coping with water stress. In this talk, I explore how Amazonian plants respond to the region's complex hydroclimatic dynamics, including pronounced seasonal droughts and increasingly frequent interannual dry spells. I highlight alternative water acquisition mechanisms such as hydraulic redistribution and foliar water uptake, which allow plants to access water beyond their immediate root zone. I then examine how the interplay between climate and geological substrates shapes drought resistance, influencing both resource availability and plant strategies. Finally, I present evidence of the diversity in embolism resistance observed across topographic gradients and throughout the basin, underscoring how forest structure and function are tightly linked to plant hydraulic traits. This integrative perspective reveals the resilience, and vulnerability, of Amazonian ecosystems in the face of intensifying climate change.

Mauro Guida Santos

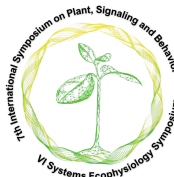
Department of Botany, Federal University of Pernambuco, Brazil

Caatinga dry forest: mechanisms and implications for forest resilience

The Caatinga dry forest in northeastern Brazil represents one of the most important dry forests in the world, as it is home to great biodiversity and a dense population. It has a dense population that relies heavily on the extraction of resources from this forest. Large herbivores feed on the native vegetation, and firewood is collected for cooking. Due to this intense and unsustainable use, the semi-arid environment is undergoing transformations driven by global climate change. In response to this anthropogenic disturbance and climate change, the forest has shown signs of degradation, with desertified areas as well as zones dominated by the vigorous regrowth of only a few species. This process depletes the flora, alters the landscape from a tree-dominated to a shrub-dominated system, and harms the sustainability of local biodiversity. In this context, the emergence of new seedlings from seeds is rare; most regrowth originates from cut stems or underground roots. Seedling planting is also challenging, requiring seedlings with long root systems, and exclusion of large herbivores. Once in the field, these new individuals face increasingly irregular rainfall during the three to four months of the rainy season, along with low nutrient availability in degraded lands. Mineral elements must be recycled from decomposing leaves, especially from deciduous woody species. Due to the difficulty in biomass production, most woody species form associations with mycorrhizal fungi to enhance their performance. Once a larger amount of carbon is assimilated during the rainy season, concentrating these sugars in different plant organs seems to be a key mechanism for successful regrowth and resumption of growth after the dry season. In this strategy, coarse roots have played a decisive role. Understanding the ecophysiological functioning of species in the semi-arid region, aiming at the recovery of degraded areas, and changing the way people coexist with the biome through sustainable practices, such as agroforestry, ecotourism, and expanding protected areas, appear to be actions that should already be underway.

Plant behavior in the tropics: the many faces of Brazilian species

Coord. by Gustavo Maia Souza
(Federal University of Pelotas, Brasil)



Augusto Cesar Franco

Department of Botany
University of Brasília, Brazil

Functional diversity in life history traits of Cerrado trees

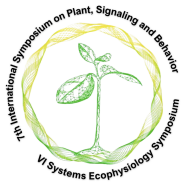
This presentation explores the functional diversity of traits related to survival, growth, and reproduction in tree species of the Brazilian Cerrado. I will begin by examining how dispersal modes are strongly linked to seed reserve composition and seed size, traits that influence seedling establishment and development. These traits are particularly relevant in the Cerrado, where a pronounced dry season from May to September imposes strong selective pressure on plant performance and is a major driver of ecosystem structure and function. I will highlight the diverse physiological and morphological strategies employed by Cerrado trees to cope with seasonal water limitation. Additionally, I will address how gradients of tree cover across the Cerrado—from open grasslands and savannas to closed-canopy forests—are shaped by environmental factors such as soil depth, groundwater availability, water table level, and rooting depth. These variables interact to influence species performance across topographic and hydrological gradients. Recent studies reveal that the Cerrado is becoming increasingly hotter and drier due to climate change. In this context, I will discuss the differential vulnerabilities of leaves and flowers to heat and drought, and how these may affect reproductive success and long-term population persistence. A conceptual model will be used to illustrate how climate change may reverse historical tree expansion in the region, accelerating tree canopy loss through feedbacks involving fire, resource limitation, and altered regeneration dynamics—despite potential CO₂ fertilisation effects. Finally, I will address how exotic invasive grasses amplify the effects of climate change by modifying fire regimes, altering ecological processes, and interacting with land-use change, further increasing the vulnerability of this already fragmented and degraded biome.

Angela Pierre Vitória

Centro de Biotecnologia e Biotecnologia,
Universidade Estadual do Norte Fluminense "Darcy Ribeiro, Brazil

FUNCTIONAL TRAITS IN THE ATLANTIC FOREST

After exploring the historical, climatic, topographical, and vegetational characteristics of the Atlantic Forest, the talk will focus on how the functional traits of tree species help reveal the inner workings of this complex biome. Drawing on research conducted by the speaker's group, the presentation will highlight key physiological processes and functional traits studied within the forest, examining how these traits interact, influence species richness, and are shaped by environmental pressures. It will also explore whether consistent patterns in trait distribution emerge across the biome. The talk will conclude with a functional mapping of the Atlantic Forest and an assessment of the conservation status of its functional regions in relation to existing protected areas.

**Flavia Winck**

São Paulo University, Brazil

Amino acids in the control of lipid synthesis in microalgae: fluxomics and modulation of the arginine pathway

The growing global demand for energy, food, and sustainable products poses the challenge of reconciling it with environmental preservation and restoration. In this context, photosynthetic microalgae emerge as promising organisms capable of contributing simultaneously to environmental bioremediation and the production of biomass applicable to the generation of bioproducts and renewable energy, such as biodiesel. However, the synthesis of triacylglycerols (TAGs), lipids applied for biodiesel production, is generally associated with the induction of a cellular quiescence state, which compromises microalgal biomass productivity. Integrative Omics analyses conducted by our group, combined proteomics, metabolomics, and regulatory genome region studies analyzing nitrogen-deprived microalgae responses (a classical condition for TAG overproduction), revealing a potential link between arginine metabolism and the regulation of this phenotype. Experiments using amino acids that inhibit ornithine synthesis and/or arginine catabolism (ornithine, valine, and norvaline) led to increased synthesis of neutral lipids. Fluxomic studies using labeled arginine (L-arginine- $^{13}\text{C}_6$, $^{15}\text{N}_4$) and ornithine supplementation indicated modulation of primary metabolism, favoring the glyoxylate cycle and reducing intermediates of the tricarboxylic acid cycle (Krebs cycle), along with transient accumulation of arginine. Ornithine supplementation was also associated with increased degradation of arginine and higher nitric oxide production in cells treated with arginine catabolism inhibitors, suggesting its role as a potential lipid synthesis inducer. These results demonstrate that amino acid supplementation can activate the synthesis and accumulation of neutral lipids in microalgae independently of cellular quiescence, paving the way for biotechnological applications targeting lipid and metabolite production without compromising biomass productivity.

Andrej Pavlovič

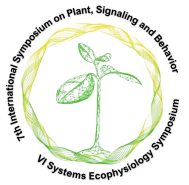
Department of Biophysics, Faculty of Science, Czech Republic

The diversity of digestive systems in carnivorous plants

Carnivorous plants have evolved at least 11 times independently in sunny, wet, and nutrient poor habitats and are thus an example of convergent evolution. For carnivorous purpose, they modified the photosynthetic leaves into functional traps, which produce digestive enzymes. Despite their independent origin, carnivorous plants surprisingly co-opted similar digestive enzymes from proteins involved in plant defence mechanisms. The plant phytohormone jasmonic acid, involved in regulation of plant defence, was also co-opted for regulation of expression of digestive enzymes in some genera of carnivorous plants. However, recent studies have shown that this happened only once in the oldest Caryophyllales order, and other lineages of carnivorous plants regulate enzyme activity differently. In this lecture, I will show you how different genera of carnivorous plants regulate digestive enzyme activity as well as molecular mechanism how such diversity in digestion may have evolved.

The complexity of plant behavior: chasing for a systemic perspective

Coord. by Danilo M. Daloso)
(Federal University of Ceará, Brasil)



Lars H. Wegner

School of Agricultural and Biological Engineering, Foshan University, China

The Thermodynamics of Living Systems: Do We need a Revision?

Complex systems, including organisms and technical artefacts, exhibit emergent properties that cannot be deduced to the properties of their parts, but rather result from their intricate interaction. It will be argued here that a complete revision of their thermodynamics is required. A paradigmatic thought experiment reveals that the assembly of a complex system being able to perform work is associated with a decrease in entropy once the emergent property is attained. Following Schrödinger [1], this entropy decrease, after reversing the sign, will be denoted as the 'negentropy bonus' (nb). It can be shown that the nb is not over-compensated by an entropy increase in the environment of the system, but rather comes with a net entropy decrease of the universe. This seems to be at variance with the 2nd law of thermodynamics, but the apparent conflict can be resolved on the basis of Stuart Kauffman's recent claim for a 4th law [2]; he has argued that the second law is only applicable to systems with a fixed number of dimensions, which is violated when a completely new property is introduced upon system assembly. These considerations have far-reaching consequences that will in the following be discussed. Among these are: (i) Emergence is not 'just' a philosophical concept but firmly roots in thermodynamics. (ii) From a physical viewpoint, evolution was thought to be associated with (or even driven by) a continuous net increase in entropy. The new concept casts doubts on this interpretation, though, and calls for a re-evaluation of the forces that drive evolution to ever increasing complexity.

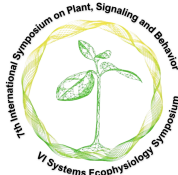
It should finally be emphasized that complex systems do follow the 2nd law of thermodynamics once they have obtained the emergent properties. According to the 'metaflux' concept [3], the operation of biological systems can be understood as an array of fluxes of matter, energy and entropy that is quantitatively described by the thermodynamics of irreversible processes.

Sergey Shabala

School of Biological Sciences, University of Western Australia, Australia
International Research Centre for Environmental Membrane Biology
Foshan University, China

Membrane transporters in sensing and signalling of soil salinity and hypoxia

Salinity and flooding are major environmental constraint to crop production. While the molecular identity and a functional expression of key ion transporters conferring plants adaptation to these stresses are studied in great details, much less is known about mechanisms by which plants sense salinity and low oxygen stress. In this talk, I summarize our current knowledge for the molecular identity of the possible candidates for these roles. I advocate for the model in which several transport proteins are clustered together to form a "microdomain" in a lipid raft, allowing a rapid change in activity of one of them be translated into stress-induced Ca^{2+} and H_2O_2 'signatures' through the operation of so-called "Ca-ROS hub" involving NADPH oxidase and ROS-activated Ca^{2+} permeable channels. I then discuss pathways of stress signalling to downstream targets and compare kinetics and specificity of salt stress signalling in various cell types, with the emphasis on modulation of cytosolic K^+ as a signal in plant adaptive responses to hostile environment. In the second part of my presentation, I talk about the mechanistic basis of plant sensing and adapting to hypoxia, resulting from soil waterlogging/flooding. I illustrate high tissue- and time-dependence of this process and discuss essential roles of the NADPH oxidase and CAX and ACA calcium transport systems for hypoxia response in plants. Finally, I summarise the current knowledge for identify of oxygen sensors in mammalian systems and use the identified key oxygen sensing domains (PAS; GCS; GAF; PHD) to predict the potential plant counterparts in Arabidopsis. Several plasma membrane and tonoplast ion channels (such as TPC; AKT; KCO) are suggested operating as oxygen sensors in plant roots. The importance of these findings for plant breeding for abiotic stress tolerance are discussed.



Flash Talks

Talks selected from the abstracts submitted

"Transgenerational phosphorus deficiency stress differentially modulates the phosphatase acid activity of soybean cultivars"

Wanessa Souza e Lima,
Isadora Rodrigues M. Santana
and Eduardo Gusmão Pereira

"Salt tolerance mediated by endoplasmic reticulum stressor based in seed priming"

Francisco Dalton B. de Oliveira,
Francisco Lucas P. Cavalcante,
Stelamaris de O. Paula Marinho,
Isabelle Mary C. Pereira and
Humberto H. de Carvalho

"Mechanical treatment promotes anatomical modifications, early flowering and increased yield in tomato through the action of ethylene and auxins"

Jenifer Castro Estrada,
Elina Welchen and
Raquel L. Chan

"The developmental and functional basis of stomatal adaptation to climate"

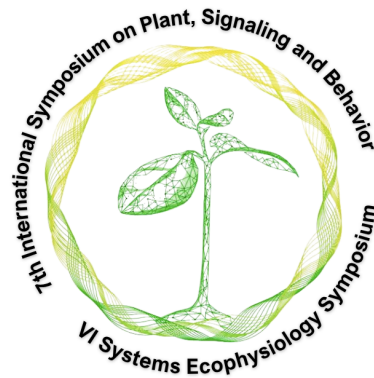
Camila Dias B. Medeiros,
Thomas N. Buckley,
Kevin Sartori, Cyrille Violle,
Denis Vile,
François Vasseur,
Leila R. Fletcher,
Matteo Pellegrini,
Etienne Baron and Lawren Sack

"What is it like to be a Tree? Intelligences in Dialogue"

Alfonso Villanueva and
Ana Marcos

"Multi-location tracking for a network science approach to plant signaling: a case study on light stimuli"

Yasmeen Hitti,
Shenyang Huang,
Florian Golemo,
Guillaume Rabusseau,
Reihaneh Rabbany,
Audrey Durand and
Mark Lefsrud



Poster Abstracts

MORPHOMETRIC RESPONSES OF ZEA MAYS L. SEEDLINGS UNDER SIMULATED HYPERGRAVITY CONDITIONS

Ygor Mota Soca Machado and Rafael Hansen Madail

Contact: machadoygor017@gmail.com

Gravity is an essential environmental factor in plant development, directly influencing gravitropism and the distribution of photoassimilates. The objective of this study was to investigate the effects of hypergravity on the initial growth of corn (*Zea mays* L.) seedlings. A centrifugal force simulator was used to simulate hypergravity. The gravitational force was calculated by the equation $F(g) = (w^2 \cdot r)/g_0$, where: F_g is the gravitational factor, w is the angular velocity of the pots (rad/s), r is the radius of the trajectory of the pots (m) and g_0 is the gravitational acceleration of the Earth (9.81 m/s^2). The experiment was conducted in a completely randomized design, with three treatments (horizontal and vertical controls, and hypergravity) and four replicates. The horizontal control was used as a parameter for comparison since the pots remained in this position in the simulator due to the centripetal force. Fourteen days after sowing, shoot and root lengths, as well as dry matter and stem robustness index, were evaluated. The results showed that hypergravity promoted significant increases in growth: shoots showed greater length, while roots and stems did not differ from the control in the vertical position. Shoot dry matter increased up to 114% compared to the vertical control. Root dry matter was also higher under hypergravity, suggesting an effect on resource allocation. Such responses may be associated with ecophysiological adjustments, such as modulations in auxin synthesis and amyloplast activity, mechanisms related to gravitropism. The results indicate that hypergravity stimulates initial growth of corn, possibly by changes in hormonal signaling and carbon partitioning. Future studies will be conducted to better elucidate the molecular and energetic mechanisms involved, contributing to the understanding of plant plasticity under altered gravity conditions.

Keywords: maize, gravitropism, gravity, G-force, growth

Acknowledgments: To the Instituto Federal Sul-rio-grandense Campus Bagé for granting the space to conduct the experiment.

**PHOSPHORUS AND SUSTAINABLE AGRICULTURE: THE IMPACT OF COVER CROPS ON ITS
EFFICIENCY AND AVAILABILITY**

Hanrara Pires de Oliveira, Paulo Sérgio Pavinato and José Lavres Junior

Contact: hpoliveira@usp.br

Phosphorus (P) plays a crucial role in the life cycle of plants, composing the structure of phospholipid membranes, in genetic storage and processing, and composing energy molecules. However, its availability is limited by the strong interaction with Fe and Al in the soil, causing the formation of oxides iron (Fe) and aluminum (Al) act as the P sink, allowing its accumulation throughout the soil profile. The search for mechanisms to reduce P adsorption is essential and has become increasingly important in recent years. Cover crops are an important management strategy that boosts nutrient cycling in the soil, and can contribute to better P management, reducing the use of phosphate fertilizers and maximizing absorption efficiency. Given the role of P in agricultural productivity and its low use efficiency, understanding how cover crops impact soil P-availability is essential to reduce dependence on phosphate fertilizers. Therefore, the aim of the study was to evaluate the effect of cover crops on P fractions in a long-term experiment (12 years). The experiment was established in randomized blocks, consisting of eight treatments and three replicates. The treatments consisted of six cover crops (vetch, white lupine, forage radish, ryegrass, black oats and rye), a fallow period with frequent desiccation of the spontaneous plants, all of which received soluble phosphate fertilization (single superphosphate) and an additional fallow period without application of phosphate fertilizers. The data were subjected to analysis of variance and the means compared by the Scott-Knott test ($p \leq 0.05$) and the Dunnett test was applied to compare the treatment without P to the others. In the P_i fractions, significant differences were observed among treatments and in comparison, to the fallow condition. We observed that lupine stood out with the highest mean values reaching 44.65 mg kg⁻¹ of P, promoting an increase of ~ 35% in relation to fallow, 28.92 mg kg⁻¹ in the 0 to 5 cm bed. In non-labile P_i , oats and turnip presented the highest levels, at approximately 892 and 890 mg kg⁻¹ of P. Regarding dry mass, black oats presented greater biomass production in both scenarios (7 with SPS and 5 years without SPS), highlighting that rye had greater production when fertilization was suspended. Regarding the P accumulated by the cover crops, in the P input scenario, both turnip and oat presented higher contents and, in contrast, in the years exploring the residual P, oat and rye stood out, with 130 and 129 kg ha⁻¹ of P. Finally, we observed that the cover crops altered the P fractions and consequently increased the P cycling in the system and subsequently increased the availability for the commercial crop.

Keywords: Cover crops, Nutrient Cycling, Available P.

Acknowledgments: ESALQ - USP and CNPq.

ANATOMICAL AND BIOCHEMICAL CHANGES IN AMARANTH SEEDLINGS UNDER SALINITY AND COLD CONDITIONS

Eliana Estefania Morales, Machado Rocha, Mariana, Nunes Nesi, Adriano, Ruiz, Ana Inés, Hilal, Mirna Beatriz, Albornoz and Patricia Liliana

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Amaranth (kiwicha) is a pseudocereal belonging to the Amaranthaceae family. The species *Amaranthus caudatus* L. and *A. hypocondriacus* L. are valued to produce high nutritional quality gluten-free grains. The biofunctional value of germinated seeds is known to have a higher biological quality due to increased total fiber content, phenolic compounds, and antioxidant activity, among others. On the other hand, it is known that abiotic stress due to salinity or low temperatures can induce anatomical and physiological modifications associated with acclimation mechanisms, which can enhance their functional properties. The aim was to analyse the effects of salinity and cold on the anatomy of cotyledons and proline content of seedlings of two amaranth species. Seeds of *A. caudatus*, obtained from mountain crops in Santa María (SM), Catamarca, Argentina, and *A. hypocondriacus*, acquired in a commercial center (CQ) in San Fernando del Valle de Catamarca, Argentina, were used. Seeds were germinated and grown in darkness at 26°C for 72 hours, with exposure to the following treatments: a) 2 exposures of 9 hours of cold (6°C) and b) salinity with NaCl 0.05, 0.10 and 0.15 M, using distilled water as a control. The histological structure of cotyledons was analyzed by histological techniques and conventional staining; proline content was evaluated by spectrophotometry. The results showed significant increases in the thickness of the mesophyll and cotyledon lamina in SM seedlings in the 0.05 and 0.10 M NaCl treatments, while these tissues decreased with the cold treatment. In CQ seedlings, cold and salinity treatments produced a decrease in the thickness of both epidermis, mesophyll and lamina. Regarding stomatal aperture, a remarkable increase was observed with 0.05 and 0.10 M NaCl in SM and CQ seedlings, while stomata size decreased with cold and 0.15 M NaCl in SM seedlings. Proline content increased only in SM seedlings, with exposition to cold and to 0.05 and 0.10 M NaCl treatments. These results suggest that the species studied show anatomical modifications due to cold and salinity treatments. The salinity treatments up to 0.10 M show changes associated with acclimation processes, possibly due to water potentials regulation, which is correlated with the increase in proline content in SM seedlings and with the opening of stomata in both species.

Keywords: Amaranth Seedlings, Salinity Stress, Anatomical Changes, Physiological Changes, Proline

Acknowledgments: This study was partly funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES: Programa Move La América). CNPJ:00.889.834/0001-08.

CONTRASTING ECO-PHYSIOLOGICAL RESPONSES TO MANGANESE TOXICITY IN *TABEBUIA AUREA* AND *TABEBUIA ROSEOALBA*

Ana Candida Fuentealba Ferezin, Laura Ramos Marião, Cendyi Izumi Moniwa,
Stephany Letícia da Silva and Marina Alves Gavassi

Contact: marinagavassi@hotmail.com

Manganese (Mn) is an essential metallic micronutrient for plant metabolism; however, at elevated concentrations, it can become toxic, particularly in acidic soils. Although acidic soils are characteristic of both the Cerrado and the Atlantic Forest—two biodiversity hotspots—Mn toxicity is more frequent and pronounced in the Cerrado due to edaphic characteristics such as lower organic matter content, higher sand content, low base saturation, and reduced buffering capacity. Differences in soil composition and dynamics between these biomes impose distinct selective pressures regarding Mn availability. Despite advances in studies with cultivated species, research on the effects of Mn toxicity in native tree species remains scarce. In this context, using congeneric species distributed across distinct phytophysionomies allows for the evaluation of contrasting physiological responses, contributing to conservation and ecological restoration strategies. This project aimed to assess the effect of high Mn concentrations on gas exchange and early development in *Tabebuia aurea* (Yellow Trumpet Tree of the Cerrado) and *Tabebuia roseoalba* (White Trumpet Tree), two species from the Bignoniaceae family, predominantly found in the Cerrado and Atlantic Forest, respectively. Young plants with six fully expanded leaves were exposed to 0.85 μM and 1.5 mM Mn in nutrient solution at pH 5.0 for 21 days. Gas exchange parameters (CO_2 assimilation, stomatal conductance, transpiration, and water use efficiency) were measured over time. At the end of the experiment, biometric variables (plant height, stem diameter, leaf number, leaf area, and primary root length) and organ biomass were assessed. In *T. aurea*, gas exchange remained stable across treatments, except for a decrease in water use efficiency at 21 days after treatment (DAT), and excess Mn did not significantly affect biometric parameters. In contrast, in *T. roseoalba*, excess Mn impaired CO_2 assimilation, stomatal conductance, foliar transpiration, and water use efficiency from 7 DAT onwards. These effects led to significant reductions in primary root length, leaf area, and root and leaf biomass. The significant interaction between species and Mn concentration demonstrated that *T. aurea* seedlings maintain gas exchange and exhibit greater physiological tolerance to Mn toxicity compared to *T. roseoalba*.

Keywords: *Tabebuia*, manganese toxicity, acidic soil, Cerrado, Atlantic Forest

Acknowledgments: DCB - FC/UNESP.

SUGARCANE AND ENERGY CANE PRESENT DIFFERENTIAL SENSITIVITY OF PHOTOSYNTHESIS TO CHANGES IN ROOT-ZONE TEMPERATURE

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We investigated the physiological responses of sugarcane and energy cane to gradual changes in root-zone temperature, evaluating also the recovery capacity after cooling and heating. Energy cane, known for its stress tolerance, was expected to perform better than sugarcane under varying root-zone temperature. Plants of sugarcane (IACSP95-5000) and energy cane (Vertix 3) were divided into two groups. One group underwent root-zone cooling, with temperature decreasing gradually from 25°C to 15°C, and then increasing to 25°C. The other group experienced root-zone heating, with temperatures increased gradually from 25°C to 35°C, followed by a return to 25°C. Each temperature step lasted two days and the entire experiment of cooling or heating took 10 days. Gas exchange and leaf water potential were measured after each temperature change. Cooling strongly reduced CO₂ assimilation in sugarcane due to declines in stomatal conductance, carboxylation efficiency, and photochemical activity. In contrast, energy cane maintained CO₂ assimilation at 20°C and showed only minor reduction at 15°C. Under heating, sugarcane sustained CO₂ assimilation even at 35°C, likely due to better stomatal conductance and carboxylation capacity. On the other hand, energy cane showed reduced photosynthesis from 30°C onwards, associated with declining carboxylation efficiency. Either cooling or heating reduced the leaf water potential in both crops, with full recovering after changing root-zone temperature to 25°C (initial condition). However, stomatal conductance remained reduced, limiting full photosynthesis recovery. Our findings reveal contrasting responses, with energy cane performing better under cooling, while sugarcane was more tolerant to heating. Importantly, neither crop presented full recovery of photosynthesis, indicating that root-zone temperature stress imposes persistent limitations to carbon gain by leaves.

Keywords: Leaf gas exchange, Low temperature, Heat stress, Saccharum,

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NPK FERTILIZATION IMPROVES PINTO PEANUT (*Arachis pintoi* Krapov. & W.C. Greg.) TOLERANCE TO BORON TOXICITY

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Anthropogenic activities have increased the concentration of boron (B) in the soil, which can lead to problems. Strategies such as phytoremediation, a technique that uses plants to remove contaminants, can be enhanced by fertilization. This study aimed to evaluate the effects of fertilization on the phytoremediation potential of pinto peanut (*Arachis pintoi* Krapov. & W.C. Greg.) in soils contaminated by B. The experiment was conducted in a greenhouse, under a completely randomized design and a 2x6 factorial scheme, using two cultivation methods (with and without NPK fertilization) and 6 concentrations of B in the form of boric acid: (control), 30, 60, 90, 120 and 150 mg B dm⁻³ in pots with a capacity of 5 L, using 6 replicates per treatment, in the period of 60 days of cultivation. The phytoremediation potential was evaluated by determining the tolerance index (Treatment Dry Weight/ Control Dry Weight); transfer factor (B Accumulation in roots + shoot accumulation/ B Concentration in the soil); translocation index (B accumulation in shoots/ (root accumulation + shoots accumulation) * 100) and B accumulation in total biomass (B accumulation in roots + shoots accumulation)/ Plant Dry weight). Data were analyzed following a factorial model and submitted to a Tukey test at 5% probability. Regardless of the culture medium, the control treatment showed the highest transfer of B compared to the other treatments, which can be explained by the fact that plants use strategies to efflux B and reduce its absorption in the roots under toxic conditions. There was a greater B accumulation in the unfertilized plants when compared to the fertilized ones, this indicates that NPK contributed to reduce B accumulation by the plant, leading to an attenuation of its toxic effects. Regardless of the culture medium, the control treatment showed the highest B transfer compared to the other treatments, which can be explained by the fact that plants use strategies for B efflux and reduce its uptake in roots under toxic conditions. There was greater B accumulation in unfertilized plants when compared to fertilized ones; this indicates that NPK contributed to reduce B accumulation by the plant, leading to an attenuation of its toxic effects. Regardless of the culture medium, all treatments with B showed high translocation values, which demonstrates the plants' ability to perform phytoextraction, as they have the ability to transport contaminants in aerial biomass. Plants without fertilization were tolerant up to 60 mg dm⁻³ of B. However, fertilized plants showed tolerance at all B concentrations, indicating that fertilization with NPK can reduce damage caused by excess boron and allow greater biomass accumulation. It is concluded that *A. pintoi* is characterized as a phytoextracting plant for boron. Unfertilized plants can accumulate more B than fertilized ones, but with reduced biomass; NPK allowed the maintenance of legume growth at higher B concentrations, thus increasing its tolerance.

Keywords: phytoextraction, soil recovery, plant metabolism

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LEAF THERMOTOLERANCE OF GRASSES FROM THE FERRUGINOUS CAMPO RUPESTRE IS ASSOCIATED WITH INCREASED PROTEIN CONTENT

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The rise in global temperature due to climate change, driven by human actions, has significant impacts on biodiversity, including areas of mountain ecosystems, such as the campo rupestre. The campo rupestre ecosystem, which is home to many endemic species, suffers from other challenges, such as the presence of exotic species and competition between them. This study evaluates the thermotolerance and physiological responses of native and exotic grass species in the ferruginous campo rupestre, to assess potential for competition success in a scenario of increasing global temperatures. The hypothesis evaluated is that exotic species, with C4 metabolism, exhibit better thermotolerance, improved physiological responses and greater competitive success in relation to climate change. The experiment was conducted in an area of ferruginous campo rupestre in Serra da Calçada, located in Serra do Espinhaço, in Minas Gerais, Brazil. Ten individuals of each species were found in the field, the native species - capim flechinha (*Echinolaena inflexa*) with C3 metabolism and the invasive species - capim gordura (*Melinis minutiflora*) with C4 metabolism. A thermotolerance analysis was performed by exposing leaf discs to temperatures of 35°C to 59°C with subsequent measurement of the maximum quantum yield of photosystem II (Fv/Fm). The critical temperatures resulting from the decrease of 15% (T15) and 50% (T50) of the Fv/Fm value were defined. Normally, C4 Species have morphophysiological attributes that favor their establishment in warm places, compared to C3 species. However, the result showed native species C3 presented higher values of T15 and T50 compared to the invasive C4 due to the slower decrease in the Fv/Fm values of *E. inflexa* with rising temperatures, due to a better termotolerance. This result was associated with the higher levels of protein, chlorophyll a, and relative water content in the leaf. In a scenario of increasing global temperatures, with a better response to heat stress and the physiological results, native species may be more successful in competing with native species in their areas of occurrence, reinforcing the importance of permanent conservation areas.

Keywords: Increasing temperatures, impacts on biodiversity, competition, native species,

Acknowledgments: CAPES, FAPEMIG, CNPq

WATER STRESS EFFECTS ON SUGAR DISTRIBUTION PATTERNS IN TROPICAL DRY FOREST VEGETATION

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Plant species inhabiting dry forests have evolved adaptations to withstand the harsh conditions of these ecosystems. One key survival strategy is deciduousness (leaf shedding), which helps plants tolerate water scarcity during dry periods. As climate change leads to more severe droughts and rising temperatures, this adaptation may become increasingly crucial for plant survival. During the rainy season, these plants produce and store sugars to support immediate physiological functions. When the dry season arrives, they strategically redistribute these sugars from leaves to stems and roots, enhancing their ability to survive water shortages. This study investigates how sugar allocation differs between more and less abundant plant species in a dry forest environment. The research took place in Catimbau National Park (Buíque, Pernambuco, Brazil), a region with an average annual rainfall of 500 mm. Three highly abundant species (*Peltogyne pauciflora*, *Cenostigma microphyllum*, *Pityrocarpa moniliformis*) and three less abundant ones (*Piptadenia stipulacea*, *Senegalia piauhiensis*, *Anadenanthera colubrina*) were selected based on prior floristic surveys. To assess water status, researchers measured water potential in five individuals per species each morning using a Scholander pressure chamber. In the afternoon (3:00 PM), they collected leaves, stems, and roots during the rainy season, and only stems and roots in the dry season, for soluble sugar analysis. Results showed no interspecies differences in water potential during the rainy season. However, in the dry season, more abundant species maintained significantly lower (more negative) water potentials than their less abundant counterparts. While sugar concentrations remained stable across seasons, rainy-season measurements revealed higher sugar levels in leaves compared to roots across all species. This pattern disappeared in the dry season, with no significant differences between stems and roots. These findings suggest that greater species abundance correlates with enhanced drought tolerance, evidenced by more negative dry-season water potentials. The seasonal sugar redistribution from leaves to woody tissues (stems and roots) points to a conservative resource management strategy that may contribute to these species' ecological success in water-limited environments.

Keywords: Dry forest, Sugar, Drought tolerance

Acknowledgments: CAPES, CNPQ, FACEPE.

TRANSGENERATIONAL PHOSPHORUS DEFICIENCY STRESS DIFFERENTIALLY MODULATES THE PHOSPHATASE ACID ACTIVITY OF SOYBEAN CULTIVARS

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Phosphorus (P) is essential for plant growth and development. Some species, such as soybean (*Glycine max* L.), are highly P-demanding. Understanding the strategies of transgenerational P absorption and translocation, even under deficiency conditions, is essential to achieve a higher sustainability in fertilizer consumption. The objective of this work was to elucidate how transgenerational memory regarding the different cotyledonary P reserves impacts the initial establishment and phosphatase activity of the soybean seedlings under P-deficient conditions. Seeds of two soybean cultivars with contrasting P-use efficiency were obtained from a previous field experiment in P-deficient and P-sufficient conditions. The seeds from the F0 and F1 generations were then sown in P-deficient and P-sufficient conditions in a greenhouse, achieving four P nutritional conditions: HP-HP (F0 high phosphorus/F1 high phosphorus); HP-LP (F0 high phosphorus/F1 low phosphorus); LP-LP (F0 low phosphorus/F1 low phosphorus); LP-HP (F0 low phosphorus/F1 high phosphorus). The acid phosphatase and P concentration analyses of cotyledons, leaves and roots were evaluated at three stages (VE- emergence; VC- cotyledonary and V1- first trifoliolate leaf). Only the cultivar with higher P-use efficiency (TMG7063) had its phosphatase activity modulated by the P nutrition of the plants that generated the F0 seeds. For this cultivar, the highest enzyme activity was associated with the seed development in P-deficient conditions. In the cultivar with low P-use efficiency (BRS1003), the phosphatase activity responded only to the soil P nutrition at F1, exhibiting higher activity under P-deficient conditions. In conclusion, the P-deficiency transgenerational memory governs phosphatase activity in the cultivar with high P-use efficiency, while the presence of P in the soil is paramount for the cultivar with low P-use efficiency.

Keywords: Cotyledonary reserve, Memory, Plant nutrition, P-use efficiency, Seedling establishment

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ULVAN-INDUCED RESISTANCE IN ARABIDOPSIS THALIANA AGAINST ALTERNARIA BRASSICICOLA REQUIRES COI1 BUT NOT JASMONIC ACID

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Plant defense mechanisms involve complex signaling networks, with salicylic acid (SA), jasmonic acid (JA), and camalexin playing central roles in resistance against pathogens. Natural elicitors such as ulvan, a sulfated polysaccharide derived from green algae, have shown potential to induce plant resistance, but the underlying signaling pathways remain incompletely understood. Understanding how ulvan modulates host defenses, particularly against necrotrophic pathogenic fungi like *Alternaria brassicicola*, can contribute to the development of sustainable disease management strategies. Thus, this study aimed to elucidate the defense mechanisms activated by ulvan in *Arabidopsis thaliana*, focusing on its protective effect against *A. brassicicola*. Specifically, we investigated the involvement of the SA, JA, and camalexin signaling pathways in ulvan-induced resistance. For this, wild-type (Col-0) and mutant *A. thaliana* plants impaired in key signaling components, i.e. SA pathway mutants (*eds5*, *NahG*, *sid2*), the JA-insensitive mutant (*coi1*), and the camalexin-deficient mutant (*pad3*), were grown at 22 °C/18 °C in growth chambers programmed for a 14-h light/10-h dark cycle with 85 $\mu\text{mol m}^{-2} \text{s}^{-1}$ light intensity. Plants were treated with ulvan by foliar spray three days before inoculation with *A. brassicicola*. Disease severity was assessed by measuring lesion diameters and necrotic leaf area. The levels of SA, JA, and camalexin were quantified before and after inoculation using HPLC, gas chromatography, and fluorescence spectroscopy, respectively. Additionally, the expression of defense-related marker genes (*PR-1* for the SA pathway and *PDF1.2* for the JA/ethylene pathway) was evaluated by Northern blot analysis in response to ulvan treatment and/or pathogen inoculation. Ulvan treatment reduced lesion size caused by *A. brassicicola* by approximately 55% in wild-type plants, as well as in mutants deficient in SA signaling and camalexin biosynthesis. However, this protective effect was absent in the JA-insensitive *coi1* mutant, indicating the essential role of the COI1 receptor in ulvan-induced resistance. Notably, ulvan application did not significantly alter SA, JA, or camalexin levels in any of the genotypes. Gene expression analysis showed that *PR-1* was induced only in response to pathogen infection, independent of ulvan treatment. In contrast, *PDF1.2* was strongly upregulated in ulvan-treated wild-type plants, even in the absence of pathogen challenge. These results suggest that ulvan-mediated resistance to *A. brassicicola* in *A. thaliana* operates through a COI1-dependent pathway that does not rely on increased JA levels, highlighting a novel mechanism of induced resistance.

Keywords: algal polysaccharides, phytopathology, interactions, pathogen, host defenses

Acknowledgments: CAPES, CNPq, DAAD.

VOLATILE-MEDIATED SIGNALING BETWEEN SOYBEAN PLANTS: EFFECTS OF BENZALDEHYDE APPLICATION ON DROUGHT TOLERANCE

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Plants, even in the absence of a nervous system, are capable of prioritizing stimuli and optimizing their metabolism, reducing energy expenditure. In scenarios of climate change and abiotic stresses, such as drought, chemical communication mediated by volatile organic compounds (VOCs) is crucial for plant adaptation. Benzaldehyde (BZ), an aromatic volatile, has emerged as a promising signaling compound in plant communication and defense. This study investigated the effects of exogenous BZ application on growth parameters and VOC profiles in both emitter and receiver soybean plants. For this purpose, a dual-chamber system using acrylic boxes connected by a continuous airflow was developed to direct the VOCs from emitter to receiver plants. BZ concentrations of 0, 1, and 5 mM were applied to emitter plants grown under irrigated and drought conditions. The 1 mM concentration was the most effective, promoting greater biomass accumulation (shoot, root, and total) in irrigated plants and partially mitigating the effects of drought in both emitter and receiver plants. Chromatographic analysis revealed a diversity of VOCs emitted by BZ-treated plants, such as nonanal and monoterpenes, compounds associated with defense responses and chemical signaling. The results suggest that BZ may act as a positive modulator of chemical communication and plant development. However, further studies are needed to clarify the metabolic pathways involved and their interactions with hormones and other endogenous metabolites. These findings reinforce the potential of BZ for improving plant growth and increasing crop tolerance to climate change.

Keywords: volatile organic compounds, plant-plant communication, water deficit, infochemicals, chemical signaling

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EFFECT OF BIOSTIMULANT ON THE ANTIOXIDANT SYSTEM OF SOYBEAN UNDER SALT STRESS

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Abiotic stresses are defined as environmental factors that negatively affect plant growth and development. Among these, salinity stands out, with its incidence progressively increasing in agricultural areas due to anthropogenic practices such as the excessive use of fertilizers and irrigation with saline water. The intensification of soil salinization compromises essential physiological processes, impairing plant development and reducing the productivity of economically important crops such as soybean (*Glycine max*). In this context, it becomes crucial to adopt strategies and alternatives capable of mitigating the effects of salt stress, particularly by stimulating the plant's antioxidant defense system. This system includes compatible osmolytes, photoprotective compounds, and a complex enzymatic network whose function is to neutralize free radicals and reactive species, preventing oxidative damage and supporting the maintenance of plant growth and vigor. Among the approaches currently employed, the application of biostimulants—such as those derived from the seaweed *Ascophyllum nodosum* combined with fulvic acids—stands out due to their ability to positively modulate the antioxidant response in plants under stress conditions. In this context, the aim of the present study was to evaluate the response of the antioxidant defense system in soybean under salt stress and biostimulant application. The experiment was conducted in a completely randomized design, using a 2×2 factorial scheme, considering two levels of irrigation water electrical conductivity ($0.5 \text{ dS}\cdot\text{m}^{-1}$, control; and $4.0 \text{ dS}\cdot\text{m}^{-1}$, salt stress) and the presence or absence of biostimulant application. The results showed that the biostimulant application significantly increased the activity of antioxidant enzymes: ascorbate peroxidase (APX) by 24.3%, catalase (CAT) by 53.1%, and superoxide dismutase (SOD) by 32.1%, compared to treatments without the biostimulant. In the non-enzymatic antioxidant defense system, a 40.0% increase in carotenoid content—pigments with photoprotective functions—was observed. Additionally, the content of proline, a key osmolyte for cellular osmotic adjustment, was 14.1% higher in plants under salt stress treated with the biostimulant. These findings highlight that the use of biostimulants is an effective strategy to enhance the soybean antioxidant system, helping to alleviate the deleterious effects of salt stress and contributing to the maintenance of the crop's physiological performance under adverse conditions.

Keywords: *Glycine max* (L.) Merr, *Ascophyllum nodosum*, abiotic stress, Oxidative metabolism, Osmotic adjustment

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STRATEGIES OF A GREEN-STEMMED AND DECIDUOUS SPECIES FROM THE CAATINGA

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The green stem of deciduous species may perform alternative functions in photosynthesis, especially in arid environments. *Commiphora leptophloeos*, a species widely distributed in the Caatinga, presents early deciduousness and a photosynthetic stem that has not yet been investigated. This study evaluated the photochemical activity of the green stem in comparison to the leaves, considering seasonal and edaphoclimatic variations in different areas of the Brazilian semiarid region. Three areas of the Caatinga in municipalities of Pernambuco with different conditions were selected: (i) drier, with crystalline soil; (ii) intermediate humidity, also with crystalline soil; and (iii) wetter, with sandy soil. Collections were carried out during the rainy and dry seasons. Chlorophyll fluorescence, photosynthetic pigment contents in leaves and main stem, and xylem water potential (Ψ_w) were determined. Data were analyzed by generalized linear models (GLM), with post hoc comparisons by Sidak's test, based on estimated marginal means (EMMs), and by principal component analysis (PCA). Ψ_w remained high, but presented more negative values at midday and in the driest area. The photochemical activity and pigments of the stem were, in general, similar to those of the leaves between the areas, with more expressive reductions under intense drought conditions. During the rainy season, the stem presented higher values of F_v'/F_m' , ϕ_{PSII} and ETR in the driest areas, when compared to the leaves. In the intermediate area, although no significant differences in photochemical activity were observed between the organs, the pigment contents were higher in the stem. In the wet area, higher q_p , lower a/b ratio and higher carotenoid content in the stem stood out. During the dry season, the stem presented: (i) reduction in F_v/F_m , q_p , ϕ_{PSII} and ETR in the driest area; (ii) decrease in F_v/F_m , F_v'/F_m' and ϕ_{PSII} , accompanied by an increase in Chl $a+b$ in the intermediate area; and (iii) decrease in F_v'/F_m' and ϕ_{PSII} , with an increase in pigments, in the wetter area. The PCA explained 75.9% of the total variation in the rainy season and 87.4% in the dry season. Soil and climate differences alone did not fully explain the observed patterns. These results demonstrate the photochemical efficiency of the green stem, even in the absence of leaves, and its ability to adjust under water stress. The findings contribute to the understanding of the functional role of the photosynthetic stem in semiarid environments and in view of future climate projections.

Keywords: *Commiphora leptophloeos*, chlorophyll fluorescence, photosynthetic pigments, semiarid

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OXR2: THE BEST OF BOTH WORLDS IN GROWTH AND STRESS TOLERANCE

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The aim of this study was to analyse why the overexpression of AtOXR2 confers to the plant higher biomass and greater tolerance to biotic and abiotic stresses (saline, UV-B radiation, oxidative, among others). Arabidopsis plants overexpressing AtOXR2 (oeOXR2 plants) exhibit beneficial phenotypic traits, including enhanced tolerance to UV-B radiation. This trait was primarily observed at the root level, where oeOXR2 plants showed less growth reduction after UV-B exposure than wild-type (WT) plants. Furthermore, reduced cell death in the root meristem and less DNA damage were noted, evidenced by decreased formation of pyrimidine dimers in irradiated seedlings. By analysing the UV-B response, we quantified an increased expression of the genes HY5 and RUP2 in oeOXR2 plants, along with increased DNA repair-related genes even before UV-B exposure. Changes in the expression of genes related to cell proliferation were noted in the root meristem. Specifically, there was a decrease in markers associated with the S-phase and an increase in markers linked to the G2-phase of the cell cycle. This indicates that oeOXR2 plants may possess a more effective antioxidant pathway and improved sensitivity to UV-B radiation, along with a modified cell cycle that allows efficient DNA repair. oeOXR2 plants also showed increased biomass and higher levels of cytokinin's (CKs) when compared to wild-type (WT) plants and knockout mutants (oxr2). Through crosses with different components of the CK signaling pathway, we demonstrated that the function of AtOXR2 relies on an active CK signaling cascade, which influences the activity of CKX enzymes and their interaction with ARR regulators. Our results indicate that oeOXR2 plants display important adaptive features to UV-B radiation, as well as other stresses, involving the regulation of antioxidant responses, DNA repair, and modulation of the cell cycle. This also involves an interplay with cytokinin signaling that contributes to their enhanced phenotype.

Keywords: OXR protein, Arabidopsis, Hormone, Oxidative stress

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MANGANESE PHYTOEXTRACTION USING TROPICAL LEGUMES: EVALUATION IN ACID OXISOL UNDER DIFFERENT LEVELS OF AVAILABILITY

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Climatic changes alter the bioavailability of manganese (Mn) in tropical soils, with variations in temperature, precipitation, pH and CO₂ affecting its available forms. High temperatures and increased CO₂ accelerate organic decomposition and oxidation-reduction reactions, while excess water and changes in pH elevate the solubility of Mn. The study of methods to control the concentration of this element is crucial. Native species and tropical cover crops improve soil quality and promote phytostabilization/extraction of potentially toxic elements (PTEs), increasing the functional diversity of the microbiome, especially of fungi. The present study had as its objective to evaluate the accumulation capacity of Mn in four legume species of high biomass production: *Cajanus cajan*, *Canavalia ensiformis*, *Stizolobium aterrimum* and *Crotalaria juncea*. The experiment was conducted in a greenhouse, utilizing an acidic Oxisol and 4 doses of Mn applied to the soil (0, 50, 100 and 150 mg kg⁻¹). The plants were cultivated for 60 days, and the accumulation capacity of Mn in these legumes were evaluated. The concentration of Mn in the roots (RMn) and aerial part (SMn) increased with the dose of Mn in the soil, without significant differences between the species. However, the accumulation of Mn in the aerial part (SAC) and in the roots (RAC) varied between the species in higher doses (100 and 150 mg kg⁻¹). *C. ensiformis* and *S. aterrimum* presented greater accumulation of Mn in the aerial part, with *S. aterrimum* showing a linear increase in absorption with greater availability of Mn in the soil. The capacity of absorption and translocation of Mn was similar between the species, suggesting that the soil cover with them can reduce the leaching of bioavailable Mn. The tendency of increase of the root/aerial part ratio under high concentration of Mn introduces organic material in the soil, influencing the oxidation and the formation of non-toxic Mn⁴⁺. *S. aterrimum* stood out as the most promising species for phytoextraction of Mn, with the potential to extract 18.4 kg of Mn per 10 hectares in 60 days, under high concentration of the metal. The understanding of the bioavailability of Mn is essential to optimize phytoremediation.

Keywords: Soil Remediation, Plant accumulation, Soil quality, Root-Shoot ratio, Climate change effects

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WOOD DENSITY AND WATER STATUS MODULATE SUGAR USE IN DECIDUOUS SPECIES OF THE SEMIARID REGION

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Water availability is a crucial factor for the growth and development of plant species. Understanding the strategies that species use in response to variability in water availability in the environment is fundamental to predicting future responses to drier climates. The aim of this study was to determine the dynamics of soluble sugars and gas exchange in two deciduous species with low and high wood density in different seasons in a Caatinga area. Individuals of the species *Commiphora leptophloeos* (Mart.) J.B. Gillett (Burseraceae), with low wood density, and *Cenostigma pyramidale* (Tul.) Gagnon & G.P. Lewis (Fabaceae), with high wood density, were selected in the Central Sertão of Northeastern Brazil. In addition, measurements were taken of xylem water potential (Ψ_x), CO₂ assimilation rate (A), transpiration (E), stomatal conductance (gs), and soluble sugar content in the different organs (leaf, stem and root) during the wet and dry seasons. During the dry season *C. leptophloeos* managed to maintain high Ψ_x values, with approximately -0.65 MPa. On the other hand, *C. pyramidale* has been shown to tolerate soils with low water availability, especially during the dry season, when its Ψ_x reaches values of -4.8 MPa in the early morning. Furthermore, during the rainy season, this species maintained high rates of A, E and gs, resulting in greater water use efficiency when compared to *C. leptophloeos*. This species has strong stomatal control, preventing the loss of water to the atmosphere, which could explain the high Ψ_x values. Expressively, *C. leptophloeos* was able to store large amounts of soluble sugar in its tissues, mainly in the leaves during the rainy season, with the stem and roots standing out in the dry season. *C. pyramidale*, on the other hand, had lower soluble sugar concentrations in its tissues than *C. leptophloeos*, regardless of the season. These results show that the species have different strategies to overcome the effects of seasonality observed in the semi-arid region. The strategies for using and storing sugars in woody species suggest that they play a decisive role in tolerating variations in water availability in deficit environments.

Keywords: Tropical dry forest, Water potential, Drought tolerance

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PHYSIOLOGIC CHARACTERISTICS OF GARLIC CULTIVARS SUBMITTED TO WATER DEFICIT

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Garlic (*Allium sativum* L., Amaryllidaceae), originally from Central Asia, has significant economic importance worldwide due to its spice and medicinal properties. The physiological characteristics of garlic contribute to selecting cultivars that are tolerant to water deficit and field performance when submitted to different irrigation levels. This study evaluated the physiological characteristics of six garlic cultivars submitted to four water conditions. The study was conducted in a 6×4 factorial scheme (garlic cultivars × water conditions), in a completely randomized design, with five replicates and three plants per pot (capacity of 5 L). The cultivars used were Caçador, Ito, Quitéria, Chonan, Lavínea, and Gravatá. The water conditions were 100, 75, 50, and 25% of the water retention capacity in the soil. The net rate of CO₂ assimilation (A_n) was evaluated at 87 days after planting. There was significant interaction between garlic cultivars and water conditions. Water restrictions of 25% and 50% allowed for reductions in A_n of all cultivars compared to those in the 100% condition. The water restriction of 75% did not change the A_n of cultivars Chonan and Lavínea. Comparing the cultivars in the 100% condition, Caçador was highlighted with higher A_n (4.60 μmol CO₂ m⁻² s⁻¹), while Lavínea and Gravatá presented lower A_n values (2.94 and 2.69 μmol CO₂ m⁻² s⁻¹, respectively). In the 75% condition, the Caçador cultivar presented higher A_n (3.77 μmol CO₂ m⁻² s⁻¹), while the lowest A_n were observed in Ito and Gravatá (2.50 and 2.38 μmol CO₂ m⁻² s⁻¹, respectively). Under the 50% condition, cultivars Caçador and Ito showed the highest A_n (2.27 and 2.13 μmol CO₂ m⁻² s⁻¹, respectively). In contrast, the lowest A_n value was observed in the cultivar Quitéria (0.88 μmol CO₂ m⁻² s⁻¹). At 25%, the highest A_n was observed in the Chonan cultivar (0.80 μmol CO₂ m⁻² s⁻¹) and the lowest A_n was found in the Lavínea cultivar (0.40 μmol CO₂ m⁻² s⁻¹). Cultivars Chonan and Lavínea showed no statistical difference between the 100% and 75% conditions, demonstrating that reducing 25% of water during their cycle did not affect their photosynthetic process.

Keywords: photosynthesis, drought, *Allium sativum* L.

Acknowledgments: FAPEMIG, CNPq, and Capes.

THE DEVELOPMENTAL AND FUNCTIONAL BASIS OF STOMATAL ADAPTATION TO CLIMATE

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Plant scientists have for centuries investigated how stomatal numbers and dimensions vary across species, ecotypes, leaf surfaces and ontogenetic stages, generating controversies at multiple scales. A major trait that captures the contribution of stomata to gas exchange and growth is the anatomical maximum stomatal conductance (g_{max}), a function of stomatal density (d) and size (s). Yet, the adaptation of g_{max} to climate and its genetic, developmental, and functional bases have remained unclear. Here, we report a cross-scale, integrative study of geographically diverse ecotypes of *Arabidopsis thaliana* grown in a greenhouse common garden. We measured epidermal traits s and epidermal pavement cell size (e), and calculated d , stomatal index (i) and stomatal area fraction (f) for the abaxial and adaxial surfaces of 145 ecotypes to quantify the developmental basis for variation in g_{max} and its relationship with the native climate of the origin across ecotypes. We used regressions, single-nucleotide polymorphism (SNP) associations and causal contribution (C) analyses to test how the variation in g_{max} can be explained by three dovetailing frameworks: (1) environmental adaptation, which includes the associations of g_{max} with macroclimatic variables, as a higher g_{max} would typically evolve under selection for higher productivity, (2) epidermal development, which explains g_{max} variation based on epidermal development, and (3) epidermal optimization, which explains g_{max} variation through constrained allocation of epidermal space to stomata. Across ecotypes, higher g_{max} had strong, polygenic associations with colder and drier macroclimates and shorter growing seasons ($r = 0.01-0.98$; $p < 0.01$), consistent with adaptation for stress avoidance. Developmentally, g_{max} was driven by both high i and small e ($C = 49.7$ and 50.3% , respectively), traits with strong polygenic associations with macroclimate ($r = 0.01-0.99$; $p < 0.05$). Further, a higher g_{max} was driven by higher f ($C = 100.1\%$) with little contribution from s ($C = -0.1\%$), indicating that the functional optimization of the epidermis in *A. thaliana* involved greater allocation of space to stomata to achieve higher g_{max} . The determination of high g_{max} by the differentiation of additional stomata highlights how the developmental pipeline not only of guard cells but of pavement cells surrounding the stomata influence gas exchange potential and productivity. Our results demonstrate the multi-tiered adaptation of g_{max} to climatic stress and its mechanisms across a wide-ranging model species. Our approach combining genetic, developmental, functional and macroclimate adaptation frameworks points to new avenues for clarifying the mechanisms and implications of variation in these traits within and among species.

Keywords: stomatal development, functional traits, climate adaptation, GWAS, *Arabidopsis thaliana*

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NEIGHBORHOOD EFFECTS OF METHYL JASMONATE-INDUCED VOLATILES RESPONSES IN SOYBEAN

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Plant communication involves the exchange of signals that induce metabolic adjustments in receiver plants. Among many physiological responses, stomatal conductance (g_s) is notably sensitive to volatile organic compounds (VOCs) emitted by plants under stress or elicitation. Methyl jasmonate (MeJa), a pivotal phytohormone, modulates plant metabolism during biotic and abiotic stresses, including drought. This study aimed to evaluate the influence of MeJa-elicited volatile emissions on the physiological behavior of soybean (*Glycine max*) receiver plants under water deficit. To test if number of elicited-emitter plants interferes on the responses of receiver's plants in a population, 16 plant populations were established, where half of them was maintained under irrigation and half subjected to drought stress. Within each population, the rate (%) of elicited emitter plants varied as 0% (no emitters), 4%, 16%, and 32%. Furthermore, the effect of the distance between emitting and receiving plants was evaluated in the population with 4% of emitters, comparing plants positioned closer and further away from the emitters. Measured parameters included stomatal conductance (g_s), transpiration rate (E), quantum efficiency of photosystem II (PhiPS2), and electron transport rate (ETR). Following MeJa elicitation and drought induction, g_s and E exhibited strong progressive reductions, whereas changes in PhiPS2 and ETR were less pronounced. Receiver plants exposed to MeJa-induced volatiles demonstrated greater reductions in water-related parameters compared to non-exposed controls. After rehydration, stressed plants without emitter influence (0% treatment) recovered g_s and E values, while plants exposed to MeJa-induced volatiles showed impaired recovery, indicating lasting on physiological modulation mediated by volatile signaling. Our findings reveal that volatile emissions from MeJa-elicited plants intensify drought effects on neighboring plants, particularly by suppressing water-related physiological functions. This highlights the critical role of volatile-mediated communication in shaping adaptive responses and reinforces the emerging view of plants as active, communicative organisms capable of influencing each other's physiology.

Keywords: Drought stress, Methyl jasmonate (MeJa), Plant behavior, Plant communication, Stress signaling

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VOLATILES INDUCED BY WATER DEFICIT MODULATE RESPONSES IN UNSTRESSED SOYBEAN PLANTS

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In response to environmental cues and stress signals, plants produce a wide array of specialized metabolites, including volatile organic compounds (VOCs). These VOCs encode information about the physiological condition of the emitter plants and modulate the stress-response capacity of neighboring plants. In this study, we investigated changes in the VOCs emission profiles of soybean (*Glycine max*) plants and the corresponding physiological responses triggered in neighboring plants. Emphasis was placed on growth and photosynthetic parameters – stomatal conductance (G_s) and transpiration rate (E) – as well as chlorophyll fluorescence indicators, including photosystem II efficiency (Φ_{PSII}) and electron transport rate (ETR). To achieve this, soybean plants were grown in transparent acrylic chambers connected in pairs through a unidirectional airflow system, which allowed VOCs accumulated in the headspace of emitter plants to be transferred directly to the headspace of receiver plants. At the same time, we changed the water conditions of the emitter plants relative to the receiver plants. Our results indicate that soybean plants under water deficit release a more diverse VOCs pool compared to well-irrigated plants. The increased synthesis and emission of VOCs acted as a chemical signal, and their effect on neighboring plants depended on their water status. This suggests that not only the type of signal emitted (the composition of the VOC pool) but also the physiological status of the neighboring plant influences the communication process. Furthermore, this extends the functional role of VOCs, which not only provide protection against a range of abiotic and biotic stresses but also act as highly specific infochemicals. According to our results, the differential VOC profiles modulated growth and photosynthetic parameters of the neighboring plants, reprogramming both primary and secondary metabolism to support metabolic reconfigurations that prime and/or enhance stress defense responses. Taken together, the results reveal that unstressed soybean plants can detect VOC signals emitted by neighboring plants under water deficit, enabling them to optimize their performance and survival. The complex "dialogue" revealed here was driven by VOC signals and/or environmental cues, which influenced the outcome of interplant communication and may potentially modulate soybean plant interactions in field conditions. Thus, the relationship between the type of emitted signal and the physiological condition of neighboring plants directly influenced the outcomes.

Keywords: *Glycine max*, infochemicals, airborne defenses, headspace sampling, GC-MS

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OPTIMIZING AN IN SITU/IN VIVO PASSIVE SYSTEM FOR ROOT VOLATILE COLLECTION IN PLANT-PLANT INTERACTIONS

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Plants are highly perceptive organisms, capable of sensing biotic and abiotic signals from the environment and adjusting their behavior, responding to these stimuli in the best possible way to ensure survival and success in resource use. Among these signals, volatile organic compounds (VOCs) released belowground have stood out as important mediators of plant-plant interactions. Root volatile organic compounds (rVOCs) composition can be modulated by neighbor identity and environmental conditions, such as soil salinity, affecting how plants communicate and perceive their surroundings. However, due to their belowground location, studying root-root interactions mediated by VOCs pose methodological challenges. In this study, we aimed (i) an experimental set-up development to investigate how the perception of different neighbors and exposure to saline soils influence the VOC profile of two species: soybean (*Glycine max*) and pearl millet (*Pennisetum glaucum*) and (ii) to validate an analytical method for root-emitted VOCs trapping. Overall, eight treatments were established, combining intra- and interspecific interactions under control and saline soil conditions. Plants were grown in systems composed of three pots connected by PVC tubes: the focal plant was placed in the central pot and exposed to two neighbors in the side pots, allowing volatile exchange between roots without physical contact or substrate mixing. For VOC collection, a system was adapted to allow the insertion of solid-phase microextraction (SPME) fiber through a tube made of inert plastic material placed near the root zone. The collected samples were analyzed by gas chromatography coupled with mass spectrometry (GC-MS). Preliminary data suggest distinct rVOC emission patterns among treatments. Constitutive compounds were detected under different conditions, while several molecules appeared exclusively in specific treatments. For example, in the comparison between soybean-soybean under control and salinity, both common and unique rVOCs were observed in the saline condition, suggesting stress-induced modulation. Furthermore, comparisons between soybean-millet and soybean-soybean under both soil conditions also revealed distinct profiles, with compounds exclusively emitted in each interaction. These specific rVOCs may act in neighbor differentiation, serving as interspecific recognition signals. Finally, this study validated an analytical and experimental method [headspace solid phase-microextraction (HSPME) followed by GC-MS analysis] with reproducibility and accuracy to explore root-root interactions mediated by volatile signals between soybean and millet.

Keywords: Root Interaction, Volatile organic compounds (VOCs), Neighbor recognition, Solid-phase microextraction (SPME), Gas chromatography (GC)

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ISOLATION AND SELECTION OF SOIL BACTERIA FOR HEAT STRESS TOLERANCE IN RICE

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Thermal stress is one of the main abiotic factors intensified by climate change, causing irreversible damage to plants when temperatures exceed critical thresholds. Rice, one of the most important staple crops worldwide, is highly sensitive to heat, especially during key developmental stages, such as pre- and flowering phases, being negatively affected by temperatures above 32°C. In this context, sustainable biotechnological strategies have been explored to enhance plant resilience under environmental stress conditions. Among these, the use of plant growth-promoting bacteria (PGPB) has shown promise due to their ability to synthesize phytohormones, fix nitrogen, solubilize phosphate, mobilize potassium, produce siderophores, and suppress phytopathogens. This study aimed to evaluate the potential of heat-tolerant PGPB in mitigating the effects of thermal stress in rice plants. Rhizosphere soil samples were collected from four different locations, leading to the isolation of 400 bacterial colonies. These colonies were screened for siderophore and indole-3-acetic acid (IAA) production, phosphate solubilization, and cellulolytic activity on carboxymethyl cellulose (CMC). Based on functional performance, 28 isolates were selected and re-exposed to 42°C for 3 days. Of these, 14 strains demonstrated high thermal tolerance. These strains were inoculated into rice seeds, and the plants were grown until the V5 stage before being subjected to thermal stress (40°C during the day/32°C at night) for 5 days. Samples were harvested immediately after stress and after a recovery period (11-days), and evaluations included growth parameters and levels of total soluble sugar and proline. Nine of the most promising isolates were selected for a second experiment, in which plants were exposed to prolonged thermal stress (42°C/32°C for 11 days). Sampling was performed after stress and after a 7-day recovery period. Isolates C14, C78 and C94 stood out, promoting greater dry mass of roots (increases of 100%, 82% and 73%, respectively) and shoots (increases of 11%, 36% and 37%, respectively) and increase in plant height (25%, 20% and 19%, respectively). After recovery, C78 and C94 maintained this superior performance when compared to the control. Additional biochemical analyses are currently underway and will support the selection of the most promising isolates for future trials during the reproductive stage.

Keywords: PGPB, Thermal stress, Biotechnology

Acknowledgments: CNPq, FAPERGS and Capes.

EFFECTS OF WATER DEFICIT ON STOMATAL CONDUCTANCE AND DENSITY OF SWEET POTATO GENOTYPES

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Sweet potato (*Ipomoea batatas* L.) is a tuberous root vegetable rich in bioactive compounds that benefit human health. This study evaluated the stomatal conductance and leaf stomatal density of four sweet potato genotypes under different water conditions. The study was conducted in a 4×4 factorial scheme (genotypes × water conditions) in a completely randomized design, with four replicates and one plant per pot, totaling 32 plants. The genotypes used were 1440, 1192, 1058, and 1153, with irrigated plants (field capacity) and water deficit (30% of field capacity). Adaxial and abaxial stomatal conductance (gs) was evaluated at 60 days after planting (40 days of moderate water deficit) using a portable leaf porometer (SC-1 Leaf Porometer) and paradermal cuts, following plant anatomy protocols. There was interaction between factors of studies for adaxial and abaxial stomatal conductance and abaxial stomatal density. The stomatal conductance on the adaxial face of genotypes 1440 and 1192 under water deficit was reduced by 42.75 and 39.93%, respectively. On the abaxial face, the stomatal conductance of genotypes 1192, 1058, and 1153, under water deficit, was reduced by 38.49, 19.40, and 86.03%, respectively. The water deficit increased the abaxial stomatal density of genotypes 1192 and 1058 (208.78 and 237.59 stomata mm⁻²) compared to the control (327.63 and 296.31 stomata mm⁻²). The adaxial stomatal density showed no significant interaction between factors. The highest stomatal density (98.77 stomata mm⁻²) occurred under water deficit compared to the control (74.07 stomata mm⁻²). Regardless of water conditions, no statistical differences were observed between genotypes, obtaining a general average of 86.42 stomata mm⁻². The water deficit did not alter the stomatal conductance of genotypes 1058 and 1153 (adaxial) and 1440 (abaxial) and allowed modifications in the stomatal density of genotypes 1192 and 1058, possibly by regulating the opening of the stomatal pore.

Keywords: Abiotic stress, *Ipomoea batatas* L., physiological processes, stomata

Acknowledgments: CAPES, CNPq, and FAPEMIG.

RESILIENCE TO WATER DEFICIT IN CONTRASTING WHEAT GENOTYPES: TRADE-OFFS BETWEEN STRUCTURAL AND PHYSIOLOGICAL MODIFICATIONS

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The growing water shortage requires the development of wheat (*Triticum aestivum* L.) cultivars with increased resilience to abiotic stress. This study characterized the response of six wheat genotypes (BRS 404, BRS 264, MGS Brilhante, ORS Feroz, Tbio Duque, and Aton) to two water regimes: controlled deficit (10% soil moisture) and full irrigation (24% soil moisture), through integrated analysis of morphophysiological and anatomical parameters. The experiment was conducted in a greenhouse, in a completely randomized design (2×6 factorial, five replicates). The plants were grown in rhizotrons with substrate and sand (1:1), under 26 °C ± 2 °C and a photoperiod of 12 hours, and with automated irrigation. Morphological (total dry mass), physiological (gas exchange, water use efficiency - WUE, leaf proline), and anatomical (mesophyll thickness, stomatal density, vascular bundle area) parameters were analyzed. All genotypes showed a significant reduction in biomass under stress (mean 60%), with BRS 264 being the most sensitive (-72.8%) and Feroz ORS the least affected (-58.1%), with no significant difference between them. WUE increased 24% under deficit (3.25 to 4.02 μmol CO₂ mmol⁻¹ H₂O), associated with average drops of 9% in photosynthesis and 36% in stomatal conductance, indicating water conservation adjustment for all genotypes. Different tolerance strategies were observed: BRS 404 altered anatomy (25.6% increase in adaxial stomatal density and 100% in vascular bundle area; Brilhante reduced 16.5% in mesophyll (no significance); and Tbio Duque elevated proline by 22.6%, suggesting osmoregulation. ORS Feroz stood out for the lower biomass loss, possibly due to stomatal regulation, while BRS 264 was the most sensitive. In conclusion, the genotypes exhibited contrasting mechanisms to water deficit: ORS Feroz (probably biomass tolerance), Tbio Duque (biochemical response), BRS 404 and Brilhante (structural modifications), and BRS 264 (greater sensitivity). These strategies provide subsidies for genetic improvement to adapt wheat to drought conditions.

Keywords: *Triticum aestivum* L., leaf anatomy, gas exchange, water use efficiency, water deficit

Acknowledgments: FAPEMIG, CNPq and CAPES.

POSSIBLE INVOLVEMENT OF THE OSMOTIN1 GENE IN RICE ADAPTATION TO HEAT STRESS

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Climate change has intensified abiotic stresses, such as rising temperatures, negatively affecting agricultural productivity. Rice, a staple food for half of the world's population, is particularly sensitive to heat. Temperatures above 28°C increase evapotranspiration, causing wilting, leaf chlorosis, reduced growth, and, in severe cases, seedling death. A strategy to reduce losses involves using cultivars that are more tolerant abiotic stresses. In previous studies, our group identified rice cultivars tolerant to mite infestation. It was observed that the Osmotin1 (OsOSM1) gene is involved in the defense response. Thus, we hypothesized that this gene might also be involved in rice thermotolerance. The OsOSM1 gene was overexpressed in the Xudao3 (WT) cultivar, generating the OsOSM1-OE1-3 lines. It was also knocked out in the Nipponbare (WT) cultivar, generating the mutant lines OsOSM1-KO1-5. When exposed to heat stress (40°C day and 30°C night for 5d), an increase in chlorophyll b and total chlorophyll was detected in OsOSM1-OE1 leaves. Biochemical analyses showed reduced lipid peroxidation in the leaves and roots of the OE lines, while total soluble sugars and H₂O₂ levels increased in the leaves of three (KO1, 3, and 4) and two (KO2, and 4) mutant lines, respectively. After 10 days of recovery at normal temperature, all analyses were repeated. OsOSM1-OE2 and OsOSM1-OE3 leaves showed a decrease in H₂O₂ levels, while OsOSM1-KO2 showed an increase in lipid peroxidation. Interestingly, all OsOSM1-OE lines showed increased proline levels in leaves, while KO1 and KO2 showed increased levels in roots. These results indicate that both overexpression and knockout of OsOSM1 in rice can alter the molecular and physiological responses to heat. However, the lack of consistent patterns across OE and KO lines prevents us from concluding that OsOSM1 plays a key role in heat stress response, as previously demonstrated for mite defense. New tests will expose these lines to heat during the reproductive stage. Differential proteomic analyses will also be conducted to better understand how these plants respond to thermal stress and to determine whether OsOSM1 plays an important role in activating heat defense responses.

Keywords: Osmotin, Heat stress, Lines

Acknowledgments: CNPq, FAPERGS and Capes.

POTENTIAL IMPACTS OF SPIRULINA-DERIVED CARBON NANOPARTICLES ON THE METABOLISM OF FIELD-GROWN RICE PLANTS

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The application of carbon nanoparticles (C-dots) has emerged as a promising technology to enhance agricultural performance, particularly in globally important crops such as rice. C-dots can positively influence the plant metabolic trade-off, leading to significant improvements in grain productivity and quality. This study aimed to investigate the effects of C-dots on the metabolism of field-grown rice plants, analyzing the biochemical behavior of treated plants over two different harvests (23/24 and 24/25). The research was conducted at the experimental area of the Federal University of Pelotas, where 0.2 mg mL⁻¹ C-dots synthesized from *Spirulina* biomass (S-CDs) were applied via foliar spraying at three different growth stages: V5, R1, and R4. In parallel, the same treatments were applied to another group of plants subjected to high temperature (HT) stress. Sample collection was carried out 24 hours after the third application (approximately at the R5 stage). The results indicated a 12%, 47%, and 22% increase in total phenolics, flavonoid, and carbohydrate contents in plants treated with S-CDs during the 23/24 harvest. This was followed by a 9% improvement in primary metabolism, specifically in sugar content, in the 24/25 harvest. However, an 11% decrease in amino acid content was observed in the first harvest, which was not present in the second one. The increase observed in the secondary and primary metabolism of the treated plants with S-CDs may indicate more robust growth, improving productivity and nutritional quality of the grains. However, the decrease in amino acid content suggests a redirection of these metabolites toward protein synthesis. Further studies are underway to strengthen this theory. There were no significant differences between treatments regarding antioxidant activity, carotenoid content, starch content, and protein levels in either harvest. In relation to HT stress, we were unable to detect any bioprotective effect of C-dots in rice plants. These preliminary results indicate that S-CDs are promising nanoparticles that may contribute to the plant trade-off. However, further field studies are necessary to validate the use of C-dots as a tool to enhance crop resilience, ensuring grain productivity and quality, especially under adverse climate change conditions.

Keywords: Climate change, Cyanobacteria, Carbon dots, Nanoparticles, Grain productivity

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VACUOLAR MEMBRANE TRANSPORTERS OSVIT1 AND OSVIT2 SUPPORT PHOTOSYNTHETIC PERFORMANCE IN RICE UNDER IRON DEFICIENCY AND EXCESS

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Iron (Fe) participates in numerous essential processes within plant cells, playing a particularly critical role in photosynthesis. It is indispensable for chlorophyll synthesis and is integral to the structure and function of the thylakoid electron transport chain, being a key component of its three major complexes: photosystem II (PSII), cytochrome b6f, and photosystem I (PSI). While Fe deficiency impairs photosynthesis, excess Fe can induce photoinhibition, which is the inactivation of PSII and/or PSI caused by photo-oxidative stress. Since both Fe deficiency and toxicity negatively affect plant growth, development, and productivity, plants have evolved mechanisms to maintain intracellular Fe homeostasis. Understanding how Fe availability influences different stages of photosynthesis is crucial for optimizing plant performance and agricultural yield. In this study, we tested the hypothesis that vacuolar membrane transporters, specifically VACUOLAR IRON TRANSPORTER 1 (OsVIT1) and VACUOLAR IRON TRANSPORTER 2 (OsVIT2) in rice, contribute to photosynthesis by regulating Fe homeostasis in chloroplasts. To investigate this, we used wild-type (WT) rice plants and two lines of CRISPR-Cas9-generated *osvit1osvit2* double mutants previously developed by our group. Plants were subjected to Fe-deficient and Fe-excess conditions, with Fe-sufficient conditions serving as the control. Under Fe sufficiency, *osvit1osvit2* mutants exhibited fluorescence and gas exchange parameters comparable to those of WT plants. However, under both Fe-deficient and Fe-excess conditions, *osvit1osvit2* mutants showed reduced net photosynthesis, lower carboxylation efficiency, and decreased maximum quantum efficiency of PSII (F_v/F_m) compared to WT. These findings suggest that vacuolar Fe compartmentalization plays a protective role in the photosynthetic apparatus by acting as a reservoir under Fe-limited conditions and as a sink under Fe excess. Ongoing experiments aim to further elucidate the extent of photoinhibition and/or limitations in the photosynthetic electron transport chain. Altogether, our results provide new insights into the physiological functions of vacuolar iron transporters in maintaining photosynthetic efficiency under fluctuating Fe availability.

Keywords: Photosynthesis, Fe toxicity, Fe starvation, *Oryza sativa*, Photoinhibition

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SEASONAL DYNAMICS OF NON-STRUCTURAL CARBOHYDRATES AND STOMATAL CONDUCTANCE IN TWO TREE SPECIES FROM THE CAATINGA BIOME

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In semiarid ecosystems such as the Caatinga, forest species exhibit distinct ecophysiological strategies to cope with drought. These responses involve the regulation of gas exchange and the storage of non-structural carbohydrates (NSCs), which may vary between species with low or high wood density (WD). This study aimed to evaluate the seasonal dynamics of NSCs and stomatal conductance (gs) in two native tree species from the Caatinga under seasonal influence. The research was conducted in a Caatinga area in Serra Talhada, Pernambuco (Brazil). The selected species were *Commiphora leptophloeos* (low WD) and *Cenostigma pyramidale* (high WD), assessed during the rainy and dry seasons of 2023. We collected leaves, stems, and roots to determine NSC content, and measured gs in the morning and afternoon once in each season. Differences between species and seasons were analyzed using ANOVA followed by the Student-Newman-Keuls (SNK) post hoc test. All statistical analyses were performed in R software. The results showed that *C. leptophloeos* exhibited higher overall NSC concentrations compared to *C. pyramidale*. During the rainy season, *C. leptophloeos* had higher soluble sugar (SS) concentrations in leaves and roots. However, in the dry season, *C. pyramidale* showed greater SS accumulation in roots, whereas *C. leptophloeos* accumulated higher starch content in stems. Starch acts as the main long-term energy reserve in tree species. Furthermore, *C. leptophloeos* displayed higher gs during the rainy season, promoting greater gas exchange. This aligns with its "drought-avoidance" strategy, as it sheds leaves early in the dry season. In contrast, *C. pyramidale*, a late-deciduous species, exhibited higher gs in the morning during the dry season. We conclude that these species adopt different strategies for gas exchange, NSC synthesis, and storage. These findings contribute to understanding how Caatinga tree species adapt to seasonal drought.

Keywords: sugars, deciduous species, wood density, semiarid, gas exchange

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METABOLIC RESPONSE OF COWPEA ROOTS TO FOLIAR SPRAY OF TUNICAMYCIN AS A PRIMING

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Cowpea (*Vigna unguiculata*) is a legume of significant socioeconomic value, especially in semi-arid regions, due to its adaptability to adverse conditions. However, abiotic stresses like salinity challenge its productivity. Priming strategies using chemicals, such as tunicamycin, are being explored to enhance plant resilience by activating stress-related signaling pathways. While tunicamycin's effects are well studied in vitro systems, its systemic impact in whole plants, particularly through foliar application, remains underexplored. Thus, this study aimed to investigate the metabolic responses and modulation mechanisms in cowpea roots subjected to saline stress after foliar priming with tunicamycin. V4-stage cowpea leaves were sprayed with 0.25 $\mu\text{g}\cdot\text{mL}^{-1}$ tunicamycin, and after 24 hours, plants were transferred to nutrient solutions with either 0 mM or 75 mM NaCl. After 14 days, root samples were collected for metabolite extraction and analyzed using gas chromatography-mass spectrometry (GC-MS), with data processed in MetabolAnalyst 6.0. To demonstrate differences in metabolic profiles between the 4 treatments, Partial Least Squares Discriminant Analysis (PLS-DA) of roots was carried out. Despite a slight overlap between TM + NaCl and NaCl-only treatment, the score plot indicated a clear separation between treatments was observed, where PC1 and PC2 were responsible for 41.0% and 30% of variance, respectively. VIP plot showed 8 significant metabolites with VIP scores higher than 1.0. Comparing the TM + NaCl and NaCl-only treatments, the VIP plot showed 8 significant metabolites with VIP scores higher than 1.0. These metabolites were divided into two main classes: amino acids (Pyroglutamic acid, beta alanine, glutamic acid and glycine) and organic acids (Butyric acid, lactic acid, succinic acid and malonic acid). The results suggest that priming treatment altered the response to salt stress, making it distinct from salt stress alone, yet still related. Although the priming treatment was closer to the NaCl treatment, it formed a distinct cluster, indicating that priming modulated the salt stress response. This modulation involved specific metabolic adjustments, such as changes in protein synthesis, cellular stress responses, and alterations in energy metabolism. The study highlights the significant metabolic impact of priming tunicamycin and its modification of both protein and energy-related pathways, providing deeper insights into the biological effects and mechanisms of tunicamycin priming at the cellular level.

Keywords: *Vigna unguiculata*, Metabolomics, ER stress, Saline stress

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THE VEGETATION OF THE SOUTHEASTERN BRAZILIAN RESTINGA EXHIBITS AN ECOLOGICAL STRESS-TOLERANCE STRATEGY

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The Restinga is an ecosystem of great importance due to its provision of ecosystem services, including provisioning, regulating, supporting, and cultural services. Although this ecosystem is protected by various laws, pollution, real estate speculation, and the weakening of legislation are the main negative pressures affecting the Restinga. In this scenario of negative anthropogenic impacts and the current climate emergency, our objective is to identify the ecological strategy of plant species in the Restinga. For this purpose, samples were collected in the Paulo César Vinha State Park, Guarapari, Espírito Santo, Brazil. The selected species were *Aechmea lingulata*, *Aechmea nudicaulis*, *Canavalia rosea*, *Centrosema virginianum*, *Chaetocarpus myrsinites*, *Gaylussacia brasiliensis*, *Monteverdia obtusifolia*, *Myrcia splendens*, and *Sophora tomentosa*. Branches and leaves without wounds or signs of deficiency from at least three individuals were collected and measured for fresh weight (g), dry weight (g) and leaf area (mm²). The three functional leaf characteristics used were leaf area (LA, mm²), leaf dry weight (LDW, mg) and leaf fresh weight (LFW, mg). These data were plotted in the StrateFy® table to define the ecological strategy as competitor (C), stress-tolerant (S) or ruderal (R). The RSC values were calculated for each species. The Restinga vegetation can be classified as predominantly stress-tolerant (over 80%). *M. obtusifolia* and *C. virginianum* were the only species with significant values for both competition and stress-tolerance strategies, leading to their classification as S/CS. These results indicate that Restinga species are stress-tolerant, which aligns with the edaphoclimatic conditions of salinity, high irradiance, temperature fluctuations, water deficit, and nutrient-poor soils. Understanding the ecological strategies of Restinga species is crucial for comprehending vegetation dynamics and is also fundamental in developing laws and projects that ensure the conservation and restoration of Restinga areas.

Keywords: Ecological strategies, sand coastal plan, Competitor, Stress-tolerant, Ruderal

Acknowledgments: CAPES, CNPq; FAPEMIG; Neotropical Grassland Conservancy; UFLA; Parque Estadual Paulo César Vinha.

HYDROGEN PEROXIDE AND VITEXIN IN THE SIGNALING AND DEFENSE RESPONSES OF PASSIFLORA INCARNATA UNDER DROUGHT STRESS

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Soil water deficit disrupts plant metabolic processes, enhancing the production of reactive oxygen species (ROS), notably hydrogen peroxide (H_2O_2). In the context of stress signaling cascades, H_2O_2 can induce the expression and activation of stress-tolerance genes involved in enzymatic and non-enzymatic antioxidant responses. This study investigated the role of exogenous H_2O_2 application in modulating the signaling pathways and defense mechanisms of *Passiflora incarnata* under drought and subsequent rehydration conditions. The experiment was conducted in a controlled-environment greenhouse (Pad-fan) at the Instituto de Biociências – UNESP, Botucatu, SP, Brazil. *P. incarnata* plants received foliar applications of 1.5 mM H_2O_2 or distilled water. Subsequently, half of the plants from each treatment were maintained at field capacity (FC), while the remaining plants were subjected to progressive drought stress until CO_2 assimilation rates declined to near-zero, 14 days post-treatment, when the plants were evaluated for the first time. Between the 14th and 19th days, all plants were kept in FC for recovery of plants subjected to water stress (second evaluation). Hydrogen peroxide content, lipid peroxidation, and vitexin concentration were quantified. Drought-exposed plants, independent of H_2O_2 treatment, exhibited elevated endogenous H_2O_2 concentration without an increase in lipid peroxidation, suggesting a role for H_2O_2 as a signaling molecule promoting metabolic adjustments. Drought-stressed plants, independent of H_2O_2 treatment, exhibited reduced vitexin concentrations, suggesting the consumption of this flavone to support antioxidant enzymes in neutralizing H_2O_2 and maintaining membrane integrity. These findings are consistent with previous reports demonstrating the protective role of vitexin supplementation in the nutrient solution, drought-stressed wheat. Plants treated with H_2O_2 and maintained at field capacity exhibited a lower vitexin concentration during the second evaluation, suggesting an acclimation response, as no significant differences in flavone levels were observed compared to the other plants. This decrease in vitexin concentration may once again reflect its consumption for membrane protection. Overall, our findings indicate that the application of H_2O_2 promoted stress signaling, with vitexin acting synergistically with the antioxidant system to enhance the drought stress defense in *Passiflora incarnata*.

Keywords: Passion fruit, water deficit, flavone, plasma membrane, lipid peroxidation

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**GENE EXPRESSION OF AQP TIP1:1 IN SEEDLINGS OF SCHIZOLOBIUM PARAHYBA
VAR. AMAZONICUM (HUBER EX DUCKE) BARNEBY (PARICÁ) UNDER DIFFERENT
CONCENTRATIONS OF CADMIUM AND 24-EPIBRASSINOLIDE**

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Cadmium (Cd) is a toxic metal widely present in ecosystems due to human activity, causing various phytotoxic effects in plants, such as leaf deformities and oxidative stress. Even in small amounts, Cd interferes with the cell cycle and induces genetic alterations. However, plants have developed efficient cell signaling and defense mechanisms, including hormones that coordinate rapid repair and detoxification responses. Among these hormones, brassinosteroids particularly 24-epibrassinolide (24-EBL) stand out for their role in regulating cell differentiation and target gene modulation. One key gene in this process is AQP TIP1:1, which encodes the TIP1 aquaporin responsible for the transport of H₂O and toxic ions between the vacuole and the cytoplasm. This protein contributes to cellular homeostasis and the elimination of Reactive Oxygen Species (ROS). The present study investigates the expression of this gene in Paricá seedlings (*Schizolobium parahyba* var. *amazonicum*) under different concentrations of CdCl₂ and 24-EBL. The experiment was conducted at UFRA using a 4x3 factorial design with 60 experimental units. Data were analyzed using ANOVA and Tukey's test ($p < 0.05$). In summary, regarding the regulation of the AQP TIP1:1 gene, notable expression is observed in root tissues, as roots are the first organs to come into contact with Cd ions. Additionally, a strong relationship is confirmed with the 0, 20, and 40 nM 24-EBL treatments throughout the experiment, with statistically significant differences ($p < 0.05$) compared to the control. In leaf samples, significant expression is detected at 20 and 40 nM concentrations across all CdCl₂ doses (0, 50, 100, and 150 μ M). Despite the phytotoxicity of Cd²⁺, the action of the AQP TIP1:1 gene in combination with the phytohormone 24-EBL promotes early cellular repair and osmotic balance. This epigenetic mechanism supports biological maintenance and helps reduce physiological stress in Paricá seedlings.

Keywords: Molecular Biology, Heavy Metal, 24-epiBL, Gene Regulation, Paricá seedlings

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ENDOPLASMIC RETICULUM IN RICE UNDER SALINITY STRESS

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Rice (*Oryza sativa*) is a crop of great economic importance. Salinity is a significant limiting factor for rice production, as it causes damage to biomolecules and induces secondary stress factors, such as osmotic and ionic stress, both closely linked to the endoplasmic reticulum (ER). Priming techniques using external agents have emerged as an alternative to mitigate these deleterious effects. One such technique, hydropriming (seed imbibition with water), can enhance seedling biomass and vigor, improving adaptation to field conditions. In this context, we hypothesized that tunicamycin (TM), an ER stress-inducing agent capable of activating the unfolded protein response (UPR), could act as a priming agent to improve rice tolerance to salinity. This study aimed to evaluate the effects of two types of priming on the metabolic modulation of rice plants exposed to 60 mM NaCl for 14 days. Sanitized rice seeds were pre-treated with ultrapure water (hydropriming) or a 0.25 µg/mL TM solution for 24 hours, germinated in vermiculite for 7 days, acclimated in half-strength Clark nutrient solution for 10 days, and then subjected to 60 mM NaCl for 14 days. Plants were harvested, and their metabolic profiles were assessed using gas chromatography-mass spectrometry (GC-MS). Data were analyzed using Orthogonal Projections to Latent Structures Discriminant Analysis (OPLS-DA), and metabolites were ranked based on relevance across treatments. Correlation networks among metabolites were constructed and analyzed for density, hubs (nodes with above-average connections), and heterogeneity. In non-primed plants, the five most significant metabolites were proline, valine, threonine, glutamic acid, and pyroglutamic acid. Both hydropriming and TM treatments shared common metabolites, including proline, valine, glutamic acid, and pyroglutamic acid, while leucine was specific to hydropriming and lactitol to TM. Metabolic networks revealed high connectivity among sugar and organic acid pathways across all treatments. In control plants, key metabolites included glucose, mannitol, urea, and valine. Hydroprimed plants showed prominence of shikimic acid, glutamic acid, fructose, and arabinose, while TM-treated plants exhibited increased levels of proline, ribose-5-phosphate, and inositol. Network heterogeneity was highest in the shoot tissues of control plants, followed by TM-treated plants, with a greater number of hubs observed in the latter, highlighting the central role of proline metabolism. In conclusion, under saline conditions, there is an increased accumulation of sugars involved in osmotic adjustment, a pattern also observed with hydropriming. However, in TM-treated plants, this response appears to be more tightly integrated with proline metabolism.

Keywords: Rice, Salinity, Priming, Metabolomics, Metabolic Networks

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SODIUM NITROPRUSSIDE ENHANCES TOLERANCE TO IRON EXCESS IN *Ceiba speciosa*

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Iron is a micronutrient essential for plant growth, but excess iron can disrupt oxidation-reduction reactions, damage the photosynthetic apparatus, and promote an excessive increase in reactive oxygen species. This impacts the growth and establishment of native plants, such as *Ceiba speciosa* (A.St.-Hil.) Ravenna, in restoration programs in mining-degraded areas. Therefore, it is crucial to understand the implications and explore alternatives that enhance the survival of these plants in iron-excess environments. The nitric oxide is being cited as an inducer of plant tolerance to drought, salinity, and heavy metals. However, there are few reports on the effects of foliar application of sodium nitroprusside, a nitric oxide (NO) donor, aiming to improve the photosynthesis of plants under Fe toxicity. Thus, this study aimed to evaluate whether seedling pre-treatment with sodium nitroprusside could mitigate the effects of excess iron in young *C. speciosa* plants. For this, *C. speciosa* seedlings were produced in tubes containing sand and commercial substrate (1:1). At 150 days, irrigation was suspended, and the seedlings were sprayed with sodium nitroprusside solution at different concentrations (0, 25, 50, 75 and 100 μM). After 24 hours up to 10 days, the seedlings were irrigated with 1/2 strength Hogland's solution containing either 0.0004 (control) or 5 mM Fe-EDTA (Fe excess), while maintaining the field capacity of the soil. We evaluated the net photosynthesis, the maximum (F_v/F_m) and effective (ΦPSII) quantum yield of photosystem II (PSII) and the chlorophyll index. Excess Fe resulted in a 90% decrease in net photosynthesis in water-sprayed plants, whereas the sodium nitroprusside pre-treatment (100 μM) mitigated the effects of Fe toxicity, increasing the net photosynthesis by 70%. In addition, treatment with the NO donor promoted higher net photosynthesis, and stomatal conductance increased by 50% in control plants. The F_v/F_m was not significantly affected by any treatments. Iron excess decreased the ΦPSII and the chlorophyll a and b indices, irrespective of sodium nitroprusside concentrations. The pre-treatment with sodium nitroprusside as an NO donor improved the tolerance to excess Fe in young *C. speciosa* plants and appears to be an alternative for mitigating metal toxicity during mining restoration initiatives.

Keywords: Atlantic forest, Nitric oxide, Photosynthesis, Restoration

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SALT TOLERANCE MEDIATED BY ENDOPLASMIC RETICULUM STRESSOR BASED IN SEED PRIMING

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Seed priming is a viable alternative to increasing salt acclimation, such as toxic ion regulation, contributing to maintenance of development and growth of plants under adversity conditions. In this context, studies have reported that the stress response may involve the endoplasmic reticulum (ER) for protein homeostasis through the unfolded protein response pathway (UPR). Therefore, the aim of this work was testing if seed priming with tunicamycin (TM), an ER inducer, promotes salt tolerance in rice (*Oryza sativa* L.) seedlings. The seeds were pretreated with 0.25 mg L⁻¹ TM for 24 h and, after drying at room temperature for the same period, they were sown under 150 mM NaCl. After 10 days of salt stress, the seedlings were harvested, and dry mass, Na⁺ and K⁺ content and gene expression (OsIRE1, OsbZIP50, OsbZIP60, SOS1 and NHX) were measured in shoots and roots. TM-treated seedlings showed higher dry mass and K⁺ content under salinity compared to untreated seedlings. Interestingly, Na⁺ accumulation was reduced by pre-treatment, which may contribute to attenuating the ionic stress resulting in better performance under salt stress. This response was confirmed by the lower intensity green emission in shoot and root tissues. However, it was not possible to find consistency in the amplification of OsNHX1, while the OsSOS1 expression seemed to increase under salinity, in comparison to control plants. Regarding the expression of ER genes, TM priming enhanced the expression of ER response gene markers OsIRE1 and OsbZIP50, in seedlings under salinity, that were related to one of the branches of activated UPR. From the other branch, the expression of OsbZIP60 (AtbZIP28 ortholog) increased in shoots of primed seed, but it decreased in roots. Therefore, our results suggest that the salt response has a relationship with sensibilization of ER, which can promote toxic ion regulation and consequently salt tolerance during the early growth stages of rice seedlings. However, further studies are needed to clarify other tolerance mechanisms induced by TM pre-treatment and to investigate the early molecular response to salt stress.

Keywords: Tunicamycin, Pre-treatment, gene expression, Ion regulation

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RUBBING SALT IN OUR WOUNDS: WHAT ARE WE REALLY LEARNING FROM PLANT SALT STRESS EXPERIMENTS?

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There have been recent concerns about how plant physiologists perform salt stress experiments, which are often biased by a reductionist approach which may not be realistic or relevant when we consider plant systemic integration or even its translation into field conditions and ecosystems. To contribute to the discussion, we performed a bibliometric survey in the OpenAlex database, considering plant salt stress experiments published in the last 10 years (2015-2025). We selected 311 open access papers for full-text analysis and Large Language Model-Assisted Data Extraction. These papers were sourced from the 10 journals with the highest number of experimental articles with “Salt Stress” and “Plant” as keywords, excluding reviews. Salt stress experiments are mainly performed using soil (32.5%), hydroponics (24.4%), artificially mixed substrates (18.0%), and agar (17.7%) as plant growth medium. Assays are run primarily under controlled environments, such as climate chambers or greenhouses, compared to field conditions (5.1%). NaCl is the predominant salt composition used in the studies (84.9%), mostly applied in the 100-200 mM range, being added to the hydroponic liquid medium (46.6%), applied by saline irrigation into the soil (26.8%) or incorporated into agar medium (13.8%). Crop and plant model species like wheat (*Triticum aestivum*, 20.3%), rice (*Oryza sativa*, 15.4%), *Arabidopsis thaliana* (15.4%), and tomato (*Solanum lycopersicum*, 11.2%) are the most commonly studied in salt stress experiments, as opposed to non-crop plants in general. These findings highlight that we are still studying plant salt stress from a very narrowed and reductionist perspective. Results may be hardly translated into field and natural conditions once experiments are still conducted in strictly controlled environments such as growth chambers, hydroponics and agar medium, focused on crop plants, and applying only NaCl as the source of salt stress, which limits a comprehensive understanding of the multifaceted salt stress effects on plant physiology.

Keywords: abiotic stress, bibliometry, NaCl, LLM

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GAS EXCHANGE AND EARLY DEVELOPMENT OF SOLANUM LYCOCARPUM IN RESPONSE TO Al^{3+}

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Aluminum (Al) is the most abundant metal in the Earth's crust and, in acidic soils—such as those of the Cerrado biome—it is predominantly found in its trivalent form (Al^{3+}), which is highly toxic to most plant species, especially cultivated ones. Native Cerrado plants that exhibit sensitivity to Al have evolved adaptive mechanisms to cope with its high availability in the soil, primarily through exclusion or avoidance strategies. Some species, however, are tolerant and capable of accumulating Al even in their leaf tissues, being classified as Al accumulators. Solanaceous species are generally considered sensitive to Al, particularly cultivated ones such as tomato (*Solanum lycopersicum*) and potato (*S. tuberosum*). Among the native species of the Cerrado, *Solanum lycocarpum* A. St.-Hil, commonly known as “lobeira,” stands out for its ecological, economic, and pharmacological relevance. This study aimed to assess Al tolerance in *S. lycocarpum* seedlings by analyzing gas exchange and biomass accumulation under increasing concentrations of Al^{3+} . Seedlings with an average of six leaves were grown under hydroponic conditions using a modified 1/7-strength Clark nutrient solution, supplemented with 0, 50, 250, 500, and 1000 μM Al, with pH adjusted to 4.0 every two days and nutrient solution renewed every five days. Gas exchange parameters— CO_2 assimilation rate (A), stomatal conductance (gs), transpiration rate (E), and water-use efficiency (A/E)—were measured at 3, 5, 7, 10, and 15 days after treatment (DAT). Biomass measurements were taken at the beginning and end of the experiment (15 DAT). The results revealed statistically significant differences only at 3 and 5 DAT, during which both E and gs were higher in the 1000 μM Al treatment compared to the control. No negative effects of Al were observed on biometric parameters, and notably, the primary root length was 35% greater in the 250 μM Al treatment than in the control, although this did not significantly affect total biomass. These findings support the hypothesis that *S. lycocarpum* exhibits traits associated with Al^{3+} tolerance.

Keywords: *Solanum lycocarpum*, acidic soil, metal, Cerrado

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**RESPONSES OF THE PHOTOSYNTHETIC APPARATUS OF CROTALARIA SSP. SPECIES
SUBJECTED TO COPPER STRESS**

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Excess trace elements in agricultural soils can cause metabolic and physiological disorders in plants, contributing to changes in nutritional status, as well as reduced development and productivity. Phytoremediation is a low-cost, low environmental impact technique that can help solve this problem. The aim of this study was to evaluate the photosynthetic apparatus of *Crotalaria* spp. species subjected to excessive doses of Copper (Cu) in the soil. The experiment was carried out in a greenhouse, in a completely randomized design, in a 4x5 factorial scheme and 4 replications (4 species of *Crotalaria*: *Crotalaria juncea*; *Crotalaria spectabilis*; *Crotalaria breviflora* and *Crotalaria ochroleuca* and 5 doses of Cu: 0 - control treatment; 30, 60, 120 and 240 mg kg⁻¹ of Cu). The soil was contaminated and left to stabilize for 30 days. Samples of this soil were taken to quantify the semi-total bioavailable Cu content before planting, obtaining the following levels: control = 1.6; 30 = 16.9; 60 = 50.9; 120 = 102.6 and 240 = 162.6 mg kg⁻¹. At 75 days of cultivation, the following photosynthetic parameters were analyzed: internal carbon (C_i, μmol mol⁻¹); water use efficiency (WUE, mmol CO₂ mol⁻¹ H₂O); photosynthetic rate (A, μmol CO₂ m⁻² s⁻¹); stomatal conductance (g_s, mol H₂O m⁻² s⁻¹) and transpiration (E, mmol H₂O m⁻² s⁻¹). Chlorophyll a, b and total and carotenoids were also quantified. After these analyses, samples were collected and separated into root and aerial part (AP) for Cu quantification. There was an interaction between the doses of Cu and the *Crotalaria* species for all the photosynthetic parameters evaluated, where C_i, WUE and E remained stable with the increase in doses in each species evaluated. For g_s, there was a decrease in its activity as the doses of Cu increased in all species, but *C. ochroleuca* and *C. breviflora* obtained higher averages. The rate of net photosynthesis (A) increased in *C. juncea* and *C. ochroleuca* as the doses of Cu in the soil increased. Photosynthesizing pigments decreased with increasing doses of Cu in all species, with *C. ochroleuca* having the highest averages. All the species accumulated more Cu in the roots, with *C. juncea* and *C. ochroleuca* standing out as the highest accumulators. The species *C. juncea* and *C. ochroleuca* have the potential to be used in phytoremediation programs for Cu-contaminated soils, as phytoextractor plants.

Keywords: accumulation, phytoremediation, photosynthesis, legume, toxicity

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MECHANICAL TREATMENT PROMOTES ANATOMICAL MODIFICATIONS, EARLY FLOWERING AND INCREASED YIELD IN TOMATO THROUGH THE ACTION OF ETHYLENE AND AUXINS

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Plants have evolved various strategies to perceive and respond to mechanical stress (MS) caused by physical forces and interactions with animals and other plants. Previous research in *Arabidopsis* showed that the application of mechanical treatment (MT) can increase xylem area and seed production. In this study, we applied a combined MT in tomato plants including weight force, stem bending, and tactile stimulation to 10-days-old seedlings. Specifically, we attached a defined weight to the upper end of the stem, for 48 h, inducing bending and forcing plants to return to an upright position. Upon completion of the mechanical treatment, treated plants exhibited a significant increase in stem diameter, accompanied by an expansion in both the number and cross-sectional area of xylem vessels. Furthermore, a clear advancement in flowering time was observed, which correlated with a higher fruit set and overall yield. These findings suggest that MT enhances vascular development and accelerates reproductive onset, ultimately contributing to increased agronomic productivity in tomato. The transcriptome of MT-treated plants revealed significant alterations in the expression of key genes associated with central metabolism, growth regulation, and components of the TOR-kinase signaling cascade, accompanied by alterations in the expression of hormone-related genes for the regulation of tomato growth and development. To further investigate the involvement of ethylene and auxins in MT responses, tomato mutants in the signaling pathways of these hormones were used. Epinastic (epi) mutants, which are overproducers of ethylene, were able to respond to MT increasing stem diameter, Never ripe (Nr) mutants, insensitive to ethylene, were unable to widen their stems by MT nor by exogenously added ethylene in the form of ACC. On the other hand, entire (e) mutants that have a mutated transcriptional repressor of auxin signaling, responded to MT by widening their stems, and that effect was lost in the presence of NPA. The diageotropic (dgt) mutant, which is less sensitivity to auxins, were unable to enlarge their stems in response to MT, even when exogenous auxins (IAA) were applied. We deepened the analysis by using the epi/dgt double mutant, these plants were also unable to respond to MT. We demonstrate that both hormonal pathways play essential roles in plant for the adaptive responses to combined MT. Our findings indicate that our combined MT induces beneficial mechanical stress in tomato plants, triggering morphoanatomical changes ultimately promoting early flowering and increased yield, positioning it as a promising strategy for more sustainable agriculture.

Keywords: Mechanical stress, mechanical treatment, xylem area, vascular bundles, tomato

Acknowledgments: IAL, UNL, CAPES, UFC.

SOLANUM AMERICANUM AS AN WEED MODEL: COMPARING INITIAL GROWTH BETWEEN CLIMATE-CONTROLLED AND GREENHOUSE CONDITIONS

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Weed species exhibit high plasticity across a wide range of environments, even under diverse growth and development constraints. Due to this trait, they can more readily access essential natural resources such as water, light, and nutrients resulting in a high competitiveness against cultivated species. *Solanum americanum* Mill. (Solanaceae), commonly known as “American black nightshade” or “maria-pretinha”, is considered a weed frequently found infesting both annual and perennial crops, being also recognized for its prolific nature. Owing to its medium-sized herbaceous habit, rapid growth, intense production of fleshy fruits, and high output of viable seeds, this species can be considered a putative model for studying weed physiology. In this context, the present study aims to compare the growth and development of *S. americanum* under different experimental cultivation conditions: in a controlled-environment growth chamber (30/20 °C, 60/70% RH, 12 h/12 h day/night, 25 $\mu\text{mol m}^{-2} \text{s}^{-1}$) and in a greenhouse under natural sunlight exposure (39.2/23.5 °C, 80/30% RH, 13 h/11 h day/night, 400 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Plants were cultivated in 550 mL pots filled with a 1:1 vermiculite:commercial fertilizer substrate, supplemented with 2 g kg^{-1} NPK 10:10:10 and 4 g kg^{-1} dolomitic lime. The plants were maintained at field capacity and assessed on the 28th day of the experiment ($n = 5$). Overall, plants grown in the growth chamber exhibited impaired development compared to those grown in the greenhouse, with a 30.4% reduction in total height ($p = 0.014$) and a 28.4% decrease in stem diameter ($p < 0.001$). Total dry biomass was 0.195 ± 0.048 g in the greenhouse and only 0.05 ± 0.02 g in the growth chamber, indicating a significant reduction in carbon photoassimilation capacity ($p < 0.001$). These results suggest that *S. americanum* has a high light requirement and is better suited for physiological studies under conditions of sunlight exposure, highlighting the need to adjust lighting conditions for successful indoor cultivation in climate chambers.

Keywords: American black nightshade, indoor growth, biomass

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DE NOVO DOMESTICATION OF A WILD DIPLOID POTATO SPECIE

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Climate change demands innovative strategies to ensure sustainable potato production. Wild *Solanum* species, such as *S. vernei*, represent a valuable reservoir of alleles with agronomically and nutritionally beneficial traits. However, their high content of steroidal glycoalkaloids (SGAs), which are toxic to humans, limits their use as food crops. Inspired by ancestral domestication processes, where reducing SGA content was a key step, we propose a gene-editing approach using CRISPR/Cas9 to implement de novo domestication, with *S. vernei* as a model species. To decrease SGA biosynthesis, we aim to knock out the 16DOX gene, which encodes the enzyme 2-oxoglutarate dioxygenase, a key player in the SGA biosynthetic pathway. This strategy has already proven effective in cultivated potato (*S. tuberosum*). Through bioinformatic analyses, we have identified and characterized the orthologous gene in the wild species. As a next step, we will assess allelic variation at the target locus, using ten genotypes collected from Los Cardones National Park (Salta, Argentina), which will be sequenced. Our work plan includes: (1) optimizing high-quality DNA extraction methods, (2) sequencing the wild gene from the collected specimens, (3) designing and validating CRISPR constructs, and (4) establishing regeneration and genetic transformation protocols. At present, we are progressing through the first stage of the project, focused on refining DNA extraction protocols, a critical phase for molecular characterization and the success of subsequent experimental steps.

Keywords: de novo domestication, steroidal glycoalkaloids, wild species, crispr-cas9, protocols

Acknowledgments: CAPES, UFV, Pós-Graduação em Fisiologia Vegetal, Fisiologia Molecular de Plantas, CONICET, INTA.

THE EFFECTS OF WATER STRESS DURING LETTUCE CULTIVATION CAN BE MINIMIZED BY USING CONDITIONED SEEDLINGS

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Water stress (WS) due to lack of water often occurs in cultivated areas and conditioning seedlings is a practice that can be used to adapt them to the growth environment. The aim of this study was to evaluate the effect of water stress conditioning of lettuce (*Lactuca sativa*) seedlings on commercial production. The work was carried out in a greenhouse. In the first stage, at 22 days after sowing (DAS), lettuce seedlings were subjected to the water stress conditioning treatment. The seedlings were divided into two groups, i.e. "control" with 100% replacement of the container capacity (gravimetric method) and the "conditioning" group, which received 50% of the volume applied to the control. The seedlings were transplanted at 37 DAS into pots (5.5 L) in the second stage. Cultivation was carried out with and without water stress, with 100 and 50% of the water volume being replaced to maintain pot capacity. The experimental design was a 2x2 factorial scheme with five replications. The resulting treatments were unconditioned seedlings grown under adequate water supply (UAW) and water stress (UWS); and conditioned seedlings grown under adequate water supply (CAW) and water stress (CWS). The water restriction began two days after transplanting. On the day before harvest, transpiration (TR) and leaf temperature (LT) were measured. On the day of harvest (63 DAS), the fresh mass of leaves (FML) and the number of leaves (NL) per plant were determined. Lettuce production was influenced by seedling conditioning in interaction with water stress during cultivation. The maximum FML production occurred in TCC (277.5 g/plant). On the other hand, TEE resulted in the lowest average production (103.78 g/plant). Although growing with water stress caused a reduction in FML in general, the impact on plants from conditioned seedlings was less. The NL was lower as a result of conditioning and cultivation with water stress, with no interaction occurring. TR was negatively influenced by water stress during cultivation, regardless of seedling conditioning. There was an interaction between the factors for LT, with conditioned seedlings grown without water stress showing lower TL (33.7 °C). The results indicate that plants from unconditioned seedlings are more sensitive to WS. Although WS during cultivation is more relevant to reducing lettuce production, conditioning seedlings was able to minimize production losses. The lower LT in conditioned seedlings indicates tolerance mechanisms associated with this characteristic. Metabolomic analyses are being carried out to better understand the results.

Keywords: Vegetable Crops, *Lactuca sativa*

Acknowledgments: UENF.

THERMAL SHOCK ANALYSIS IN SEEDLINGS OF VELLOZIA TUBIFLORA, A CAMPO RUPESTRE SPECIES

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Vellozia tubiflora (A.Rich.) Kunth is a native subshrub from Brazil, characterized by xerophytic traits, and found in the cerrado, campo rupestre, and the Amazonian savanna, mainly in rocky outcrops. It grows in temperatures of approximately 30°C; however, in the current climate changes and rising temperatures, there may be a risk to the survival in natural environments, as thermal stress impairs metabolism and induces oxidative damage to cells. This study aims to assess the tolerance of *V. tubiflora* to thermal shock. To achieve this, seed collection was carried out in a campo rupestre in the city of Florestal-MG (Lat. -19.8802915; Long. -44.41047326 and Lat. -19.88186072; Long. -44.4092894) during summer, time of seed dispersal. The seeds were collected in two areas predominantly occupied by *V. tubiflora*, with clusters fully covering the soil over the rocks, and two areas with species competition. Fruits of 25 individuals were collected to ensure distinct sampling. In the laboratory, the fruits were processed, and the seeds were sown in Petri dishes lined with filter paper and placed to germinate at ambient temperature, with a daily average of 21.9°C for 18 days. Twenty seedlings were used, with five replicates per treatment. The seedlings were subjected to thermal shock in a germination chamber at 45°C for 0, 10, 60, and 120 minutes. Subsequently, we analyzed cellular membrane stability (CMS) to understand whether there was membrane damage and electrolyte leakage. Seedlings from each treatment were placed in tubes containing 10 mL of distilled water for four hours, and the electrical conductivity was measured. The tubes were autoclaved at 121°C for 15 minutes at 1.5 atm, followed by a second conductivity measurement. The CMS calculation considered the initial and final conductivity values of the treatments relative to the control and was expressed as a percentage. First, the germination percentage was up to 90%. The results indicated that seedlings exposed to thermal shock for 10 minutes exhibited the highest CMS (110%). At exposure times of 60 and 120 minutes, CMS values remained below 100%, statistically aligning with the control group. Based on these findings, it is concluded that *Vellozia tubiflora*, in its seedling stage, can withstand high temperatures (45°C) for up to two hours, contributing to a better understanding of its ecology and physiology. Further studies are recommended to investigate the underlying mechanisms of increasing temperature in *V. tubiflora*.

Keywords: Increasing temperature, Seeds, Campo Rupestre, Velloziaceae

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EFFECTS OF REVIPOWER ON TABLE GRAPE PRODUCTION IN THE SUB-MIDDLE SÃO FRANCISCO VALLEY

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The Sub-Middle São Francisco Valley is a key region for table grape production, but its semi-arid climate poses challenges to productivity and cluster quality. The seedless variety Arra Sweeties, widely cultivated in the region, holds significant importance in the fine table grape market but exhibits high sensitivity to thermal and light stress, including leaf pigment photodestruction and the formation of "hard berries." ReviPower, a foliar fertilizer based on triacontanol, potassium, and boron, aims to enhance photosynthetic efficiency and mitigate abiotic stress effects. To evaluate the product's impact on viticulture, an experiment was conducted in Petrolina, PE, using a randomized block design with four ReviPower doses (0, 0.5, 1.0, and 2.0 L ha⁻¹) and five blocks. The studied variables included: operational efficiency of photosystem II (Fv'/Fm'), quantum yield of photosystem II (ΦPSII), electron transport rate (LEF), non-photochemical quenching (NPQ), leaf structure (thickness and chloroplast concentration), relative chlorophyll content (SPAD), photosynthetically active radiation (PAR), photosystem I redox state (PSI oxidized/reduced), and foliar soluble solids (°Brix). Doses of 1.0 and 2.0 L ha⁻¹ significantly improved photochemical efficiency (Fv'/Fm' of 0.80 and ΦPSII of 0.70), electron transport rate (LEF of 145 μmol e⁻ m⁻² s⁻¹), and reduced NPQ (0.65), indicating lower oxidative stress. Leaf thickness and chlorophyll content (SPAD 54.6) were also higher in these treatments. Chloroplast concentration increased by 620% at 2.0 L ha⁻¹, alongside higher photosynthetic activity reflected in foliar soluble solids (8.4 °Brix). The results demonstrate that ReviPower enhances photosynthesis and protects chloroplasts, with optimal responses at 1.0–2.0 L ha⁻¹, making it a promising tool for improving grape yield and quality in semi-arid conditions.

Keywords: Photosynthetic efficiency, Triacontanol, Chloroplasts, Abiotic Stress, photosynthesis

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GERMINATION RESPONSES OF THE PIONEER WEED *SOLANUM AMERICANUM* MILL. TO SALT STRESS

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Weeds are aggressive competitors that are able to outcompete other plants in their environment, due to their rapid growth and resistance mechanisms to various types of stress. *Solanum americanum* Mill. is a pan-American species with a herbaceous-shrubby habit and an annual life cycle, producing globose berry fruits with numerous seeds (30–50) of high viability. This species is considered a pioneer weed, developing in areas with sparse vegetation such as coastal sandbanks (restingas), forest edges, degraded and anthropized environments. Therefore, we hypothesize that it is a species resistant to salinity variations. This study aimed to evaluate the possible effects of salinity on the germination of *S. americanum*. Fruits collected from five matrix plants were processed, and their seeds were tested within 10 days. The experiment was conducted in a climate-controlled incubator (30/20 °C day/night, 12/12 h photoperiod) under different NaCl concentrations (0, 5, 10, 25, and 50 mM). Five replicates of 25 seeds per treatment were used, distributed in Petri dishes with sterilized filter paper moistened with 4 mL of either distilled water (control) or the corresponding NaCl solution. Germination was monitored daily for 21 days, and seeds were considered germinated when the radicle protrusion exceeded 2 mm. The germination parameters evaluated were total germination percentage (GRP), mean germination time (MGT), and synchrony (SYN). *S. americanum* exhibited high germinability, reaching 98% in the control treatment. A negative effect of NaCl was observed only at the 50 mM concentration, resulting in an 11% reduction in GRP compared to the control ($p = 0.048$). Under the control treatment, *S. americanum* showed a MGT of 6.01 days. From 25 mM NaCl onwards, MGT increased by approximately 3.3 days compared to the control ($p = 0.003$), reaching a further delay of 6.8 days under 50 mM NaCl ($p < 0.001$). SYN was the most sensitive germination parameter to NaCl concentration, showing a significant reduction starting at 10 mM ($p = 0.014$), which indicates greater variability in germination timing under increased salinity levels. Taken together, the results indicate that *S. americanum* is successful as a pioneer weed due to its high germinability even under saline conditions, although this comes at the cost of reduced speed and synchrony.

Keywords: American black nightshade, NaCl, salinity stress, seeds

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INTERGENERATIONAL MEMORY INDUCED BY HALOPRIMING: SPATIAL VARIABILITY IN THE PHYSIOLOGICAL RESPONSES OF RICE TO SALINITY

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Intergenerational memory in plants refers to the ability to transmit information about environmental stimuli from the parental generation (P) to the subsequent generation (F₁), thereby modulating their response to future stresses. In rice (*Oryza sativa*), this memory can influence salinity tolerance, affecting physiological and biochemical processes. Moreover, the modular organization of the plant results in a heterogeneous spatial distribution of responses, with different leaves and regions exhibiting variable sensitivities to stress. In this study, we evaluated the effect of intergenerational memory induced by saline halopriming, considering the spatial variability of responses in rice plants subjected to salinity in the parental generation. Seeds from the Nipponbare cultivar (*Oryza sativa* spp. japonica) were used, originating from parental plants (P), of which a subset was subjected to halopriming (150 mM NaCl) at the vegetative stage (V₅), while the remainder were maintained under control conditions. Seeds were germinated in pots containing sand and grown under Hoagland's nutrient solution. At the reproductive stage (R₃), part of the plants remained under standard nutrient solution, while another part was gradually subjected to salinity (50, 100, and 150 mM NaCl). Four experimental conditions were established: Pveg0F10 (no halopriming and no salinity in F₁), Pveg0F1150 (no halopriming and salinity in F₁), Pveg150F10 (halopriming and no salinity in F₁), and Pveg150F1150 (halopriming and salinity in F₁). After seven days of salt stress, photosynthetic parameters, including stomatal conductance, photosynthesis rate, transpiration rate, and water use efficiency, were measured using an infrared gas analyzer (LI-6400XT; LI-COR™, Lincoln, NE, USA). Leaf samples were collected for biochemical analyses (amino acid, sucrose, and total soluble sugar contents; lipid peroxidation; and hydrogen peroxide levels), relative water content (RWC), and electrolyte leakage. To assess spatial variability, samples were collected separately from the apical and basal portions of younger, intermediate, and older leaves. Principal Component Analysis (PCA) revealed a clear separation among treatments, with the Pveg150F10 group standing out by distancing itself from the others, suggesting intergenerational memory induced by halopriming in the parental generation. The Pveg150F1150 group, even under salinity in the F₁ generation, also did not fully overlap with the pure stress treatment (Pveg0F1150), further supporting this effect. Additionally, the segregation of responses among leaf ages and their apical and basal portions revealed the spatial heterogeneity in response to salinity, emphasizing the importance of integrative approaches for understanding plant stress physiology.

Keywords: *Oryza sativa*, Salinity, spatiality, memory, Intergenerational

Acknowledgments: Capes, Programa de Pós Graduação em Fisiologia Vegetal/Ufpel, Universidade Federal de Pelotas, LCTP.

SALICYLIC ACID AS AN ATTENUATOR OF HEAT STRESS IN THE EARLY DEVELOPMENT OF TOMATO PLANTS

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Global temperature increases have a direct impact on plant growth and development, influencing productivity. In the search for tools and methodologies to facilitate plant maintenance, the application of phytohormones as priming has emerged as a compelling alternative. Among these, salicylic acid (SA) has demonstrated positive effects against drought and salt stress, although the response for heat stress remains inconclusive. Thus, further research is necessary to ascertain the precise doses required for different stress conditions and species. To estimate the effective SA concentration to improve tomato development at elevated temperatures, the seeds were sanitized with hypochlorite (0.25%) and hydrated using increasing concentrations (0.0, 0.5, 1.0, 1.5, 2.0, and 2.5 mM) for 24 hours. Then, 50 seeds were placed on germitest paper, constituting one repetition, for a total of five repetitions per treatment. The paper rolls were enveloped in plastic bags and placed in growth chambers for 15 days, in a 12-hour photoperiod and temperature of 35°C. An evaluation was conducted to ascertain the fresh and dry weights of the leaves, stems, and roots. Additionally, the Germination Velocity Index (GVI) and the total germination (TG) were measured. The data were subjected to analysis using a one-way analysis of variance (ANOVA) followed by Tukey's mean comparison test ($p \leq 0.05$) and regression analysis. The analysis of variance indicated significance generated by SA in the parameters of GVI, TG, and in the fresh and dry weight measurements. Furthermore, a statistically significant increase in the fresh and dry weights of leaves, stems, and roots was observed at the 1.5 mM concentration of SA, while a decrease in TG and GVI was noticed at concentrations above 1.5 mM. A regression analysis was conducted for all variables evaluated, and the model with the highest degree of representation was GVI, presenting an R^2 value of 0.8176. The concentration of 0.6209 mM of SA was identified as the apex of the curve. In conclusion, higher SA concentrations benefit the seedlings in some parameters such as fresh and dry masses. However, it can delay germination or cause dormancy, making it necessary lower concentrations so it can be used as an agent to induce resistance to heat stress. Further biochemical studies are ongoing to elucidate the relationship between SA and heat stress.

Keywords: Phytohormone, Temperature, *Solanum lycopersicum*

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SEED GERMINATION AND METABOLIC FLEXIBILITY: PROTEIN TURNOVER REGULATION IN CONTRASTING BRAZIL NUT (*BERTHOLLETIA EXCELSA*) GENOTYPES

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Seed germination is critical for the establishment of ecologically and economically important species such as the Brazil nut tree (*Bertholletia excelsa*). However, its germination is constrained by a lignified seed coat and embryonic dormancy, necessitating studies on protein metabolism during this process. This study analyzed the mobilization of soluble proteins, free amino acids, and total proteolytic activity in two genotypes (SF and C606) across seven germination stages (Quiescent embryo = QE, Imbibed embryo = IE, Root protrusion = RP, Root elongation = RE, Secondary root = SR, Emission of eophyls = Eep, and Expansions of eophyls = Eex). Seeds collected in Itacoatiara, Amazonas, were sterilized with *Mansoa alliacea* extract and germinated under controlled conditions at INPA. Embryos and seedlings were lyophilized, defatted, and analyzed for soluble proteins, free amino acids, and total protease activity, using a completely randomized design (2x7) and two-way ANOVA ($p < 0.05$). Results revealed significant genotypic differences. SF exhibited higher soluble protein content at IE ($542.2 \pm 16.2 \mu\text{g.g}^{-1}$), RP ($474.7 \pm 15.6 \mu\text{g.g}^{-1}$), and Eep ($472 \pm 103.5 \mu\text{g.g}^{-1}$) compared to C606 (IE: 363.9 ± 14 ; RP: 337.6 ± 7.4 ; Eep: $363.8 \pm 2 \mu\text{g.g}^{-1}$). Amino acid levels were also higher in SF at the final stage (Eex: $65.8 \pm 3.8 \mu\text{mol.g}^{-1}$ vs. $57.5 \pm 1.4 \mu\text{mol.g}^{-1}$ in C606). Protease activity differed notably at SR, where C606 showed higher activity ($0.11 \pm 0.03 \text{ U.mL}^{-1}$ vs. $0.03 \pm 0.0 \text{ U.mL}^{-1}$ in SF), while SF maintained elevated activity in early stages (QE–RE: $0.06\text{--}0.09 \text{ U.mL}^{-1}$), declining thereafter. Distinct metabolic patterns emerged: SF displayed two protein synthesis peaks (IE and Eep) followed by degradation, indicating high energy demand for root and leaf development. In contrast, C606 exhibited gradual mobilization with continuous synthesis until SR, suggesting greater metabolic efficiency. Protease activity patterns also varied: in SF, activity correlated directly with protein synthesis during QE–IE and SR–Eep but shifted to catabolic roles at Eep–Eex. For C606, activity paralleled synthesis in QE–IE and RE–SR, except during RP–RE, where enzyme inhibition coincided with rising soluble protein levels. In conclusion, the genotypes employ divergent reserve mobilization strategies: SF prioritizes phased protein synthesis, whereas C606 demonstrates balanced metabolism. These physiological adaptations may reflect responses to environmental conditions, advancing understanding of Brazil nut germination and informing propagation techniques to overcome its constraints.

Keywords: *Bertholletia excelsa*, Seed germination, Protein metabolism, Proteolytic activity, Genotypic variation

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GRAFTING STUDIES SUGGEST THAT SHOOT METABOLISM COULD DETERMINE THE PROTEIN CONTENT OF SOYBEAN SEEDS

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Soybean is one of the most important oilseed crops, as its seeds provide large amounts of protein and vegetable oil as raw materials for food, feed, and industrial applications. Nitrogen accumulation in seeds, mainly in the form of proteins, begins in the roots, where nodules fix atmospheric nitrogen and nitrates are absorbed. This nitrogen is then transported as ureides to the leaves, where it is metabolized first into urea and then into ammonium. This nitrogen is storage in form of proteins and then they are degraded and remobilized to the developing embryos during senescence. To study which process has a greater influence on determining protein concentration in the seed, sister soybean lines with contrasting levels of this storage compound were used. Grafting was performed between genotypes, exchanging shoot and root parts, and the plants were allowed to develop seeds, which were later analyzed for nitrogen content in mature grains. The results show that the shoot of the plant determines the protein concentration in these soybean genotypes, opening the door to further investigation of the metabolism involved in nitrogen assimilation and remobilization in leaves.

Keywords: Soybean, Nitrogen, Grafting, seed quality,

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UNCOUPLED DYNAMICS OF GAS EXCHANGE IN CASHEW LEAVES UNDER DROUGHT STRESS AND RECOVERY

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Stomata play a central role in photosynthetic carbon assimilation (A) and water loss by regulating CO_2 uptake and water vapor exchange, especially under environmental stress optimizing this trade-off. For this reason, in this study, we aimed to investigate how the stomatal behavior of cashew plants in response to water deficit and rehydration limits A affects water use efficiency (WUE). Cashew grafted seedlings, BRS226 genotype, were provided by Embrapa, Brazil. These plants were grown under similar conditions at a greenhouse located at 3°44'44.2"S 4038°34' 29.2"W up to $\pm$ forty expanded leaves. After this period, plants were subjected to six types of hydric regimes: (0WD) control, non-water deficit; (4WD) four days of water deficit; (8WD) eight days water deficit; (12WD) twelve days of water deficit; (2REC) two days of recovery with water rehydration supply; (4REC) four days of recovery with water rehydration supply. From this experiment, we performed light and CO_2 kinetic curves. Our results demonstrate that stomatal conductance (g_s) strongly limits A during light induction phases under progressive water deficit. Interestingly, cashew plants under 4WD and 4REC treatments did not show A restriction, these plants instead, enhanced their photosynthetic performance by higher A compared to a well-watered regime. Under light induction routines, the g_s of 4WD treated cashew plants were remarkably increased. These responses increased WUE for 4WD-treated plants, which experienced water withdrawal and rehydrated treatments through altered stomatal closure dynamics. Moreover, cashew plants exhibited a distinct stomatal behavior during light induction kinetics, showing distinct maximum slope ($Sl_{\max}$) of g_s according to each hydric regime. These findings highlight the key roles of stomatal regulation in cashew plants to water deficit and suggest a species-specific mechanism optimizing gas exchange under fluctuating environmental conditions.

Keywords: *Anacardium occidentale*, water deficit, photosynthesis, stomatal conductance

Acknowledgments: UFC, CAPES, FUNCAP.

CHLOROPHYLL FLUORESCENCE AND ANTIOXIDANT ACTIVITY IN VERNALIZED AND NON-VERNALIZED GARLIC UNDER VARYING PHOTOPERIODS

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Garlic, originally from regions with cold climates and long days, exhibits compromised development outside when grown outside these optimal conditions. To overcome this limitation, techniques such as bulb vernalization and planting during milder seasons are essential to induce the transition from the vegetative to the reproductive stage. In this context, this study aimed to evaluate chlorophyll a fluorescence and the activity of the antioxidant system in four garlic cultivars two elite cultivars (Ito and Chonan; requiring vernalization) and two common cultivars (Amarante and BRS Hozan; not requiring vernalization) subjected to two distinct photoperiods. The experiment was conducted in a growth chamber under controlled temperature conditions (20/16°C, day/night). The garlic cultivars were exposed to two light regimes: long-day photoperiod (13h light/11h dark) and short-day photoperiod (11h light/13h dark). At 73 days after planting, chlorophyll a fluorescence parameters and antioxidant enzyme activities were analyzed. The electron transport (ET_o/RC) was higher in Amarante cultivar under short-day conditions (11h light). The Chonan cultivar showed greater activity of peroxidase (POX) and ascorbate peroxidase (APX) under the long-day photoperiod (13h light), along with increased levels of lipid peroxidation (MDA). Similarly, APX activity and MDA content were higher in BRS Hozan under 13h light. In contrast, the Ito cultivar showed higher POX activity under 11h light, without signs of lipid peroxidation. The Amarante cultivar had the highest MDA levels, associated with low antioxidant activity and no significant differences between photoperiods. The different light regimes did not impair the photochemical efficiency of garlic plants but differentially affected the antioxidant system. Vernalization did not completely eliminate photoperiod sensitivity in the elite cultivar Ito, suggesting that adjustments to planting schedules may help optimize yield. On the other hand, the common cultivar Amarante demonstrated greater resilience to both light regimes. These findings may support the selection of more suitable cultivars for regions with pronounced seasonal variations.

Keywords: Vernalization, bulbing, physiology, *Allium sativum*

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TEMPORAL ECO-PHYSIOLOGICAL SIGNATURES REVEAL PHOTOPROTECTIVE RESILIENCE TO ERYSIYPHE NECATOR IN A DISEASE-RESISTANT GRAPEVINE GENOTYPE CARRYING RUN1 AND REN1

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Powdery mildew, caused by *Erysiphe necator*, represents a major biotic constraint in viticulture, disrupting photosynthetic processes and diminishing grapevine productivity. This study assessed the temporal eco-physiological responses of three *Vitis vinifera* genotypes—Carménère, Chardonnay, and P09-Carménère, a conventionally bred resistant hybrid carrying the Run1 and Ren1 resistance loci introgressed from wild *Vitis* relatives following controlled pathogen inoculation. Evaluations were performed at six time points post-inoculation (2, 4, 8, 10, 12, and 15 DPI), combining chlorophyll a fluorescence transients (OJIPSM kinetics) and leaf gas exchange measurements. Thirteen JIP-test variables were analyzed to probe PSII photochemistry, including performance index (PI), maximum quantum efficiency (Fv/Fm), energy fluxes (Tro/Abs, Dio/RC), and structural indicators (RC/CsO, RC/Csm). Additionally, five gas exchange parameters: net assimilation rate (A), stomatal conductance (gs), substomatal CO₂ concentration (Ci), transpiration (E), and instantaneous water use efficiency (WUE) were quantified via IRGA. Inoculated Carménère and Chardonnay exhibited progressive impairments in PSII function, including declines in PI and Fv/Fm and disruption of OJIP kinetics, particularly at mid to late infection stages. In contrast, P09-Carménère maintained photochemical stability and exhibited minimal perturbations in PSII dynamics, suggesting robust redox homeostasis and functional preservation of the photosynthetic apparatus under biotic stress. Multivariate analyses (PCA and radar plots) consistently separated P09-Carménère from susceptible genotypes under pathogen pressure. This genotype retained superior values in PI, Tro/Abs, and RC-based metrics across all time points. Physiological measurements further supported these findings: while inoculated Carménère and Chardonnay showed significant reductions in A, gs, and WUE, P09-Carménère sustained photosynthetic performance and water use efficiency, particularly at 15 DPI. Correlation analyses revealed stress-induced coordination between WUE and stomatal traits in susceptible genotypes, a pattern absent in the resistant hybrid. The decoupling of gas exchange constraints in P09-Carménère underscores its enhanced physiological plasticity and resilience. This work highlights the functional advantages of resistance loci Run1 and Ren1, conventionally introgressed into an elite background, and supports the strategic deployment of such genotypes in breeding programs aiming to enhance disease resilience and reduce chemical inputs in sustainable viticulture.

Keywords: Powdery mildew, Grapevine resistance, Chlorophyll fluorescence, Photosystem II efficiency, Gas exchange physiology

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MITOCHONDRIAL CYTOCHROME C DEFICIENCY ENHANCES RESILIENCE TO EXTENDED DARKNESS IN ARABIDOPSIS

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Cytochrome c (CYTc) is a small heme protein involved in the mitochondrial electron transport chain, contributing to ATP synthesis. In *Arabidopsis thaliana*, CYTc-deficient plants exhibit shorter roots, smaller rosettes, and delayed growth, likely due to impaired mitochondrial function and reduced energy availability. Previously, we demonstrated that mitochondrial activity modulates SnRK1 α 1 function to regulate growth and stress responses. To investigate whether CYTc deficiency affects photosynthetic performance under stress, we subjected wild-type and CYTc mutant plants to extended darkness, a condition that imposes severe energy stress, leading to plastid degradation and extensive metabolic reprogramming. Remarkably, CYTc-deficient plants displayed enhanced chlorophyll retention and more effective recovery of green tissue upon reillumination compared to wild-type plants. Measurements of the maximum quantum efficiency of PSII (Fv/Fm) further indicated better maintenance of photosynthetic function in the mutants. These findings suggest that CYTc deficiency may enhance the plant's tolerance to energy stress, potentially through altered mitochondrial signaling pathways that modulate photosynthetic function. Our findings underscore a functional link between mitochondrial metabolism and chloroplast performance under energy-limiting conditions, indicating that mitochondrial impairment may reprogram photosynthetic responses to improve stress resilience.

Keywords: Cytochrome c, Mitochondrial signaling, Extended darkness, Photosynthetic resilience

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**METHYL JASMONATE AS A MITIGATOR OF THERMAL STRESS IN TOMATO SEED
GERMINATION**

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The rise in global temperature directly impacts the physiological functions of plants in general, inducing thermal stress. However, in recent years, a physiological strategy that has shown positive results is using conditioning agents as priming, which, by inducing mild stress, can promote improved acclimation of plant cells to cope with unfavorable conditions. In this context, the present study aimed to investigate the effect of increasing concentrations of the phytohormone Methyl Jasmonate (MeJA) at contrasting temperatures, to achieve adequate physiological conditioning of tomato seeds. Initially, the seeds were disinfected in a 0.25% sodium hypochlorite under agitation and rinsed with distilled water. The seeds were then immersed in MeJA solution (1.0 nM, 10 nM, 0.001 mM, 0.01 mM, 0.1 mM) or distilled water (Control) for 24 hours under agitation. Then, the seeds were germinated on germitest paper moistened with 40 mL of distilled water. Each treatment consisted of five replicates, each composed of one sheet of paper containing 50 seeds, which were rolled and placed in containers covered with plastic bags. They were placed in germination chambers under a 12-hour photoperiod at 15°C and 35°C for 15 days. Among the parameters subsequently evaluated using Tukey's test, it was observed that, under 15°C, there were no statistical differences in fresh mass of leaves, stems, or roots, although an increase in root biomass was noted at higher MeJA concentrations. Likewise, no significant differences were found in dry mass, Germination Speed Index (GSI), and Germination Percentage (GP), among treatments. At 35°C, fresh mass variables also showed no statistical difference, as well as GSI and GP. However, from the concentration of 1 nM MeJA onwards, a significant reduction in dry mass was observed in leaves and stems, although this was not observed for root dry mass. In conclusion, it is important to note that a standard concentration for Methyl Jasmonate could not be established for tomato seeds, and further experiments and corresponding analyses are required to define this more accurately.

Keywords: Methyl jasmonate, Priming, Thermal Stress, Tomato Seeds

Acknowledgments: CAPES; ForCe Metabolomics; UFC; CNPq; LabFiVe.

METABOLIC RESPONSE OF THE GREEN ALGAE *CHLAMYDOMONAS REINHARDTII* TO BACTERIAL VOLATILE COMPOUNDS

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Algae-bacterial interactions are a key area for nutrient exchange, signaling, algal growth, and health research. Volatile organic compounds (VOCs) emitted by bacteria can be sensed by multiple organisms and mediate one of the possible forms of interaction. The actinobacterium *Microbacterium* sp. strain 15 (MB15) isolated by our group has been shown to affect the growth and physiology of model plants, from moderate growth promotion to strong inhibition, in a dose-dependent manner. This study focused on evaluating the metabolomic response of the microalgae *Chlamydomonas reinhardtii* (CR) to total bacterial VOCs and to the particular effect of acetic acid (Ac) and ethanol (Et), previously found in volatile blends. Here, we tested the hypothesis that MB15 VOCs can affect the growth, profile and relative abundance of primary metabolites including carbohydrates, amino acids, organic acids and lipids. First, we performed solid medium assays using two-compartment Petri Dishes by exposing CR to two volatile bacterial volatile concentrations. Droplets of different concentrations of CR ($OD_{750}=1$; $OD_{750}=0.1$; $OD_{750}=0.01$) were placed equidistantly in the compartment of the septate plate containing TAP-AGAR medium. We observed that CR responded to VOCs blend, Ac, Et and Ac-Et combined. Under moderate bacterial inoculation, growth-promoting effects were observed. Growth inhibition effect was detected in high exposure. Metabolomic analyzes were made using gas chromatography-mass spectrometry (GC-MS), with data processed in MetabolAnalyst 6.0. The preliminary results of Principal Components Analysis (PCA) showed that the treatments presented a clear separation with 60.8% and 39.2% for PC1 and PC2, respectively. In relation to the Et, Ac and Et-Ac treatments, the Hierarchical Clustering Dendrogram analysis showed that the Ac and Ac-Et treatments are closer, indicating that the effect of separation between treatments is related to the effect of acetic acid on the microalgae, in coincidence with the growth modulation phenotype observed in Petri dish analyses. These results contribute to extend our knowledge on bacteria/microalgae interactions, and could potentially lead to novel or optimized biotechnological applications.

Keywords: *Chlamydomonas reinhardtii*, Metabolomic profile, Volatile compounds

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REFERTP, AN ALTERNATIVE PHOSPHATE FERTILIZER FROM IRON MINING WASTE, AND ITS EFFECTS ON BRACHIARIA DECUMBENS GROWTH AND PHOTOSYNTHESIS

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Understanding how plants respond to alternative fertilizer sources and how to apply these technologies is essential to ensuring food and nutritional security. This study evaluated the initial growth and the photosynthetic responses of a grass species (*Brachiaria decumbens*) using ReFertP, an alternative phosphate fertilizer produced from iron mining waste. The experiment took a place in a greenhouse at the Federal University of Viçosa, Campus Florestal, using three tropical soils (clay, clayey-sandy, and sandy) and three phosphorus (P) sources (no P addition, ReFertP, and single superphosphate fertilization), in a randomized block design with a 3x3 factorial scheme and five replications, totaling 45 experimental units. At the V3 phenological stage of the plants, dry mass accumulation and photosynthetic activity were quantified, and the data were statistically analyzed using ANOVA and Tukey's test ($p < 0.05$). The plants fertilized with ReFertP showed good performance in the clayey-sandy soil, where the gradual P release from ReFertP improved leaf expansion and increased the leaf area and plant mass ratio. On the other hand, single superphosphate resulted in greater total biomass production due to its high solubility and faster P absorption by plants, leading to vigorous growth. Single superphosphate was more effective for plant growth in clay soils, whereas the plants from the control treatment (with no added P) performed better in sandy and clayey-sandy soils, probably due to the presence of residual P and reduced nutrient leaching in the latter. The highest values of photosynthetic rates were observed in plants grown in clayey-sand soil, especially for control and ReFertP plants, while plants fertilized with single superphosphate showed constant rates in all soils. Plants fertilized with single superphosphate exhibited significantly higher transpiration rates in clay and sandy soils, associated with greater vegetative growth. Analyses suggest that the clayey-sandy soil favored plant growth due to its higher organic matter content, which may indicate interaction with microorganisms that enhanced phosphorus availability. Therefore, the choice of P source should consider the soil's physical and chemical characteristics. Slow-release fertilizers, such as ReFertP, may be strategic for soils with lower fertility.

Keywords: Photosynthesis, Phosphorus fertilizer, Soil fertility, Slow-release fertilizer

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MICROBIAL CONSORTIUM RHIZOBIA AND TRICHODERMA AS A MITIGATOR OF OXIDATIVE STRESS IN NODULES OF COWPEA SUBJECTED TO SALT STRESS

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Biological nitrogen fixation (BNF) is the process performed by diazotrophic bacteria (rhizobia) to provide nitrogen (N) to plants and is negatively influenced by salt stress. One of the proposed alternatives to mitigate the deleterious effects of salt stress is the use of beneficial microorganisms, such as *Trichoderma*, which ensure the maintenance of plant growth. The objective of this study was to evaluate the effects of inoculation with *Trichoderma asperelloides* (T02) on the response to saline stress of cowpea plants nodulated by *Bradyrhizobium yuanmingense* (BR 3267). The experiment was conducted under greenhouse conditions (CCN/UFPI). At sowing, cowpea seeds were inoculated with *B. yuanmingense* or coinoculated with *B. yuanmingense* and *T. asperelloides*. The plants were irrigated with a N-free nutrient solution throughout the experiment. Fifteen days after sowing, the N-free nutrient solution was supplemented with 100 mM sodium chloride (NaCl) to induce saline stress. Non-inoculated plants irrigated with N-free and NaCl-free nutrient solution were used as absolute control. At 35 DAS, the height, stem diameter, and dry mass of the roots and shoots of the plants were collected and quantified. The nodules were excised and used to determine the levels of hydrogen peroxide and lipid peroxidation and the activity of the antioxidant enzymes phenol peroxidase (POX), catalase (CAT), and superoxide dismutase (SOD). There was no increase in the growth parameters evaluated in the cowpea plants coinoculated under the control and salt stress conditions. Cowpea plants coinoculated with *B. yuanmingense* and *T. asperelloides* and subjected to salt stress showed lower levels of hydrogen peroxide and lipid peroxidation, as well as increased activity of POX, CAT and SOD enzymes compared to plants inoculated only with *B. yuanmingense* under the same conditions. The results indicate that the fungus *T. asperelloides* T02 was efficient in mitigating the deleterious effects of salinity and contributed significantly to the oxidative defense of cowpea root nodules, as well as to the development of these plants.

Keywords: Antioxidant enzymes, Hydrogen peroxide, Biomass, Beneficial microorganisms, Growth

Acknowledgments: CAPES, CNPq, UFPI and UFC.

EFFECTS OF GA₃ GIBBERELLIN ON THE PHYSIOLOGY OF SEEDLING PEPPER PLANTS

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Black pepper (*Piper nigrum* L.) is a globally significant spice, with Brazil ranking as the second-largest producer worldwide, and the state of Espírito Santo standing out as the main national producer. Despite its importance, the crop faces challenges such as uneven fruiting and a long vegetative period. In this context, the present study aimed to evaluate the effects of gibberellic acid (GA₃) on the physiology of black pepper seedlings, focusing on its impact on photochemical efficiency. The experiment was carried out at the experimental farm of INCAPER (Linhares-ES), using two cultivars – Bragantina and Kottanadan Broto Branco – in a randomized block design, in a 2×4 factorial scheme (two cultivars and four GA₃ concentrations: 0; 500; 1000; 1500 mg/L). Applications were made to the substrate, and physiological parameters were assessed. Chlorophyll a fluorescence was analyzed using a fluorometer according to the JIP protocol. Leaves were dark-adapted using leaf clips for 30 minutes to allow full oxidation of the photosystem. A saturating light pulse of 3000 μmol m⁻² s⁻¹ photons lasting one second was then applied, and the parameters established by the JIP test were measured. Data were subjected to analysis of variance and polynomial regression. Results showed that GA₃ did not significantly affect chlorophyll a fluorescence in the Kottanadan cultivar in either cycle, although the days after application (DAA) showed significant variation in the parameters. In the Bragantina cultivar, GA₃ did not significantly influence most variables in Cycle I; however, in Cycle II, significant effects were observed for the parameters ϕE_0 , ϕP_0 , and RE_0/CS_0 , with the linear model showing the best fit for the data. Nonetheless, the interaction between treatment and DAA was not significant in most cases. It is concluded that GA₃ influenced certain physiological aspects related to flowering in the Bragantina cultivar during the second cycle, indicating potential for its use in floral induction. However, the effects were limited and varied over time, highlighting the need for further studies to optimize GA₃ application in black pepper cultivation.

Keywords: Vegetative development, Chlorophyll fluorescence, Growth regulators, Photochemical performance, Seedlings physiology

Acknowledgments: INCAPER, UFES, CAPES.

**PHYSIOLOGICAL RESPONSE OF STRAWBERRY TO SPECTRAL MODULATION IN AN INDOOR
VERTICAL SYSTEM**

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Vertical urban agriculture has emerged as an innovative model for producing fresh and healthy food near urban centers. This study evaluated the effects of light spectral quality and artificial lighting regimes on the physiological performance and productivity of strawberry plants grown in an indoor vertical system. Seedlings were initially grown in a greenhouse for two weeks and then transplanted into isolated growth chambers equipped with an aeroponic system. LED fixtures with different spectral qualities were used: cool white, RBW (red, blue, and white), blue, and red, under two lighting regimes: constant and sinusoidal (with intensity variation), both with a 12-hour photoperiod and a Daily Light Integral (DLI) of $15.12 \text{ mol m}^{-2} \text{ day}^{-1}$. After 90 days of cultivation, chlorophyll a fluorescence, gas exchange measurements, and, following fruit harvest, bioactive compound quantification were performed. Results indicated that variations in light quality and regime significantly affected the physiological performance of the plants and fruit quality. RBW light promoted higher photosynthetic rates, carboxylation efficiency, and better water use efficiency. However, under constant light regimes—especially with RBW and red light—activation of photoprotective defense mechanisms (Y(NO) and NPQ) was observed, indicating excess light energy. In contrast, the sinusoidal regime (with gradual light intensity variation throughout the photoperiod) promoted better physiological responses regardless of the spectral quality used. This suggests that light modulation throughout the day may better mimic natural conditions and reduce plant stress. Regarding fruit nutritional quality, the concentration of bioactive compounds such as cyanidin and catechin increased under constant blue light, as well as under sinusoidal regimes of RBW, blue, and red light. These compounds are associated with antioxidant properties and potential health benefits.

Keywords: Artificial lighting, Daily light intensity, *Fragaria x ananassa*, Indoor cultivation, Vertical environment

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FROM SEA TO FIELD: FOLIAR APPLICATION OF KAPPAPHYCUS ALVAREZII MITIGATES DROUGHT STRESS IN SOYBEAN

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Water deficit is one of the main limiting factors for soybean productivity, highlighting the need for sustainable strategies to enhance plant tolerance to adverse conditions. This study aimed to evaluate the effects of *Kappaphycus alvarezii* macroalgae extract on the photosynthetic rate, photochemical efficiency, and chlorophyll a index in soybean plants under drought stress. The experiment was conducted in a greenhouse using a randomized block design with four replicates. At the R1 developmental stage (beginning of flowering), plants received foliar application of five doses of *K. alvarezii* extract (0, 1.25, 2.5, 5.0, and 7.5 mL L⁻¹). Following extract treatment, plants were subjected to two water regimes: irrigated (IR, 90% of the pot's water holding capacity—WHC) and water deficit (WD, 40% WHC). Fifteen days after treatment application, the following parameters were evaluated: chlorophyll a fluorescence (Fv/Fm, ΦEo, and ETo/RC), photosynthetic rate (A), and chlorophyll index, using FluorPen, IRGA, and Clorofilog, respectively. Drought stress significantly reduced the photochemical efficiency of photosystem II, as evidenced by decreases in Fv/Fm, ΦEo, and ETo/RC, and the photosynthetic rate. However, foliar application of *K. alvarezii* extract at 2.5 and 5.0 mL L⁻¹ significantly improved Fv/Fm, ΦEo, ETo/RC, and chlorophyll index, restoring them to levels comparable to those observed in irrigated plants, suggesting a protective effect of the extract on the photosynthetic apparatus. The 2.5 mL L⁻¹ dose was particularly effective in maintaining photosynthetic rate under drought stress, indicating enhanced photosynthetic performance. The results demonstrate that *K. alvarezii* extract functions as a biostimulant, enhancing soybean resilience to drought by optimizing photosynthetic processes and preserving chlorophyll content. It is concluded that intermediate doses, particularly 2.5 and 5.0 mL L⁻¹, show strong potential for use in sustainable soybean management under water-limited conditions.

Keywords: biostimulant, macroalgae, chlorophyll a fluorescence, *Glycine max*, photosynthesis

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EFFECT OF HIGH MANGANESE AVAILABILITY ON GROWTH AND GAS EXCHANGE IN LEGUMES WITH PHYTOEXTRACTION POTENTIAL

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The toxicity of manganese (Mn) is dependent on the concentration in the soil, being essential in low doses, but harmful in high ones. Concentrations of 8.45 mg kg^{-1} of available Mn in the soil can already reduce photosynthesis and biomass in soybeans, which seems to have a relation with damage by oxidative stress. The bioavailability of Mn is higher in acidic soils, common in tropical regions, and can be increased by agricultural activity. Phytoremediation is a sustainable alternative to remove potentially toxic elements (PTEs) present in soil, with biological diversity being crucial for its effectiveness. Tropical cover crops with high accumulation of biomass improve the quality of the soil and promote the phytostabilization/extraction of PTEs, increasing the functional diversity of the microbiome and influencing the properties of the soil. The present study had as its objective to evaluate the effect of Mn on the CIRAS-3 gas exchanges (Portable Photosynthesis System- PP Systems) and accumulation of biomass in cultivated legumes under 4 doses of Mn added to the soil (0, 50, 100 and 150), cultivated for 60 days. The production of biomass of the aerial part (SDW) varied between *C. ensiformis*, *S. aterrimum*, *C. juncea* and *C. cajan* with the increase of the dose of Mn. *S. aterrimum* presented greater root biomass (RDW). The length of the aerial part (SLE) and the volume of the root (RVO) diminished in all species in the highest dose of Mn (150 mg kg^{-1}). The gas exchanges (C_i , g_s , A, E, WUE) were also affected in a species-specific manner by the increase of the concentration of Mn. The tolerance to Mn allowed *S. aterrimum* to maintain photosynthesis and to equate the biomass of the aerial part of *C. ensiformis* in high doses, possibly due to the efficiency of the species in dealing with redox processes. The deficit in photosynthesis in other species may be linked to the optimization of the use of water or lower symplastic tolerance. In acidic soils, the concentration of available Mn normally varies between 0.042 and 4.226 mg kg^{-1} and the study indicates that concentrations above 78 mg kg^{-1} can be harmful even for tolerant species.

Keywords: Water use efficiency, over cropping, toxicity, tolerance mechanisms, soil acidity

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GROWTH OF CROTALARIA JUNCEA IN SOIL WITH TOXIC ALUMINUM IN RESPONSE TO MICROORGANISM INOCULATION

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Aluminum (Al) is a natural soil component that becomes mobile and toxic to plants in acidic conditions ($\text{pH} < 5$). The presence of toxic aluminum (Al^{3+}) generally inhibits plant growth, primarily affecting the root system and reducing agricultural productivity. Plant growth-promoting microorganisms (PGPMs) such as *Trichoderma harzianum* and *Bacillus subtilis* can mitigate these effects by enhancing plant development, nutrient uptake, and tolerance to abiotic stress. This study aimed to evaluate the growth responses of *Crotalaria juncea*, a species of agronomic and ecological interest, to inoculation with PGPMs in soil with toxic Al^{3+} . The experiment was conducted in a greenhouse using a randomized block design in a 2×3 factorial scheme with six replicates (36 samples). Treatments included the presence or absence of Al^{3+} and three inoculation conditions (*T. harzianum*, *B. subtilis*, and uninoculated control). The soil used was dystrophic Red Latosol, with lime amendment applied to the control soil. After liming, soil was transferred to 10 L pots, and *C. juncea* seeds were inoculated and sown. Plants were harvested 47 days after sowing, and biometric parameters were measured: stem and root length (cm), shoot and root fresh mass (g), and number of leaves. Inoculation with *T. harzianum* increased the number of leaves compared to other treatments. Stem length was not affected by Al^{3+} or inoculation. Root length and shoot fresh mass showed interaction between inoculant type and Al^{3+} presence. *B. subtilis* promoted root growth and shoot biomass in Al^{3+} -containing soil, while *T. harzianum* improved root growth in control soil. Additionally, *B. subtilis* increased root fresh mass in Al^{3+} conditions. These results indicate that *T. harzianum* and *B. subtilis* induce distinct growth responses in *C. juncea*, with *B. subtilis* showing potential to alleviate aluminum stress and support biomass production. CAPES (Financial Code 001); FAPESP (Grant No. 2020/12421-4).

Keywords: Acidic soil, Stress, Biomass, *Trichoderma harzianum*, *Bacillus subtilis*

Acknowledgments: CAPES (Financial Code 001); FAPESP (Grant No. 2020/12421-4).

INFLUENCE OF EXCESS NICKEL ON GROWTH OF CANAVALIA ENSIFORMIS: CHLOROPHYLL FLUORESCENCE AND BIOMASS ACCUMULATION

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Nickel (Ni) is an essential micronutrient for plants, whose availability depends on soil matrix characteristics. However, when present in excess, Ni induces oxidative stress, compromising the photosynthetic system and biomass production. Thus, understanding these effects can support the recovery of contaminated areas and the adoption of phytoremediation strategies. The present study evaluated the effects of nickel on the photochemical efficiency of photosystem II and biomass production in *Canavalia ensiformis* through chlorophyll a fluorescence analysis. The experiment was conducted in a greenhouse in Ilha Solteira (São Paulo, Brazil) between October and November 2024, under a completely randomized design with six replicates and three nickel concentrations (T0, T160, and T320 mg kg⁻¹), totaling 18 experimental units. The soil (Oxisol) was contaminated with nickel (II) chloride hexahydrate and stabilized for 30 days. Seeds were directly sown into the pots and cultivated for 36 days. Chlorophyll fluorescence parameters were measured using a FluorPen FP100, and for dry biomass determination, plants were oven-dried at 60°C for 72 hours in a closed circulation system. Data were subjected to analysis of variance (ANOVA) followed by Tukey's test ($p \leq 0.05$). In this study, root dry biomass was higher in T0 (2.22 mg/g fresh mass) compared to T320 (0.43 mg/g fresh mass). For the shoot, T0 (7.95 mg/g fresh mass) exhibited greater biomass accumulation than T160 (3.55 mg/g fresh mass), and T160 accumulated more than T320 (0.96 mg/g fresh mass), indicating that Ni exposure negatively impacted biomass production in both plant organs at the highest concentration (T320). Regarding photosynthetic parameters, no significant differences were observed among treatments for Fv/Fm, TR_o/RC, and DI_o/RC. However, for the electron transport chain (ET_o/RC), T0 (0.793) showed a higher value than T320 (0.566), suggesting that although the overall integrity of photosystem II remained stable, electron transport beyond the reaction center was compromised, possibly due to degradation or inhibition of electron carrier proteins. This limitation may impair the efficiency of light energy utilization, indirectly reducing biomass production. Therefore, excessive nickel reduced biomass accumulation, particularly at T320, while most chlorophyll fluorescence parameters remained stable, except for ET_o/RC at the highest nickel concentration.

Keywords: Legume, Metabolism maintenance, Heavy metal, Toxicity, Chlorophyll fluorescence

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AIRBORNE COMMUNICATION IN MAIZE: WELL-WATERED PLANTS REDUCE TRANSPIRATION WHEN NEIGHBOURING DROUGHT-STRESS PLANTS

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To adjust their physiological state during biotic and abiotic stresses, plants have developed an airborne communication system with their neighbours based on volatile organic compounds (VOCs). A specific stress can cause the emission of a unique blend of volatiles by an emitting plant, and these can trigger different responses in plants detecting the VOCs. We aim to investigate whether plants under optimal water conditions may respond to the VOC emission of neighbouring plants that undergo drought stress. We hypothesis that plants under water deficit can change their VOC emissions and that well-watered plants can detect these VOCs via air. We also expect that the well-watered plants respond to the VOCs by slightly closing their stomata to avoid excessive water loss, even if that is not required. To test our hypothesis, maize plants (*Zea mays*) were placed inside a growth chamber and subjected to two treatments: a well-watered condition and mild to severe drought. During the experimental period, leaf gas exchange was measured with an infra-red gas analyser and the gas composition inside the chamber was monitored using an electronic nose. With the electronic nose, it is possible to detect a pattern related to each sample odour composition. the identification of the VOCs involved in the communication will be performed in the next steps of this study. Our results showed that plants under well-watered conditions reduced their stomata conductance and transpiration by more than 30% when they were neighbouring plants under drought. In addition, the patterns detected with the electronic nose related to the gas composition inside the chamber differed depending on the treatment. This is the first evidence that maize plants can communicate under drought, with the stomata of well-watered plants closing even when they have enough water.

Keywords: Volatile Organic Compounds, VOCs, Water Deficit, Stomatal conductance, *Zea mays*

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LETTUCE PRODUCTION IRRIGATED WITH COFFEE GROUNDS

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The production and consumption of coffee have generated residues that can be harmful to the environment when improperly discarded. This study aimed to identify the effect of coffee grounds on the growth and yield of lettuce plants. The experiment followed a completely randomized design with five treatments and twelve replications, where the treatments consisted of irrigation with a solution containing coffee grounds at concentrations of 0%, 10%, 20%, 30%, and 40%. After 40 days of cultivation, the plants were evaluated. Coffee grounds induced changes in lettuce growth and yield and may serve as an important bio-input for producing this vegetable by promoting vigorous plants with good visual quality. Larger head diameter, leaf area, and fresh mass contributed to a better visual appearance, making these plants more desirable in the commercial market. Additionally, using coffee grounds represents a sustainable approach to managing a byproduct that frequently pollutes the environment when disposed of improperly. However, the direct application of coffee grounds without prior transformation into organic compost requires caution due to the potential phytotoxicity of lettuce plants. Long-term use may lead to soil accumulation, and further studies are needed to assess its viability.

Keywords: Bioinsumption, *Lactuca sativa* L., Sustainability

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IMPORTANCE OF ORGANOFERT AS A NEW SOYBEAN CULTIVATION TECHNOLOGY

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Brazil is the world leader in soybean production. This species is the main Brazilian agricultural commodity, with the Cerrado responsible for more than half of the national production. Despite the high technological apparatus used in soybean production, continuous studies are needed to develop new technologies that ensure increased productivity without opening new areas. The present study aimed to identify the effect of the commercial product Organofert on the growth and productivity of soybean plants. The experiment was conducted in a commercial soybean production field following a completely randomized design with six treatments referring to different doses of Organofert, a biological product with solubilizing bacteria and addition of *Bacillus* spp used in the seeds (0 ml ha⁻¹; 200 ml ha⁻¹; 400 ml ha⁻¹; 800 ml ha⁻¹; 1200 ml ha⁻¹; 1500 ml ha⁻¹) and five replicates. Organofert was applied to the seeds during planting using a micron sprayer in the planting furrow in a spray volume of 30 L ha⁻¹. Vegetative evaluations were performed at R5.3 and productive evaluations at R9, during the period in which the soybeans were desiccated. Organofert significantly stimulates the development of the main root of soybean plants, thus increasing the potential for extracting solution from the soil. Furthermore, it promotes the development of vegetatively vigorous plants. Organofert increases production per soybean plant by increasing the number of pods and the number of grains. The reduction in pod abortion with the use of Organofert indicates an increase in drainage force in plants treated with commercial products. The product is promising for use in commercial soybean plantations; however, more in-depth studies with Organofert are needed to determine the appropriate dose based on the effects on vegetative and reproductive development.

Keywords: Biofertilizer, bacteria, *Glycine max* L.

Acknowledgments: I thank the State University of Goiás for the promotion and support.

EFFECT OF BIOFERTILIZERS AND SOIL CONDITIONERS ON SOYBEAN PRODUCTIVITY

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Brazil stands out as the world's largest soybean producer, adopting advanced agricultural technologies. However, research is still needed to develop new technologies that ensure increased productivity without opening new areas. The present study aimed to identify the effects of commercial products used for inoculation on the productivity of soybean plants. The experiment was conducted in a commercial field using the NEO 820 variety following a completely randomized design, with seven treatments corresponding to the products provided by the company H2 Agroscience: 1-Control, 2-(H2-Root (200 ml ha⁻¹), 3-H2-Sollus (50 g ha⁻¹), 4-H2-Bioborum (500 ml ha⁻¹) and the mixtures 5-H2-Root (200 ml ha⁻¹)+H2-Sollus (50 g ha⁻¹), 6-H2-Sollus (50 g ha⁻¹)+H2-Bioborum (500 ml ha⁻¹), 7-H2-Root (200 ml ha⁻¹)+H2-Sollus (50 g ha⁻¹)+H2-Bioborum (500 ml ha⁻¹) and five replicates corresponding to 3mx2m plots. The applications occurred in the planting furrow in volume of 30 L ha⁻¹ of spray. The products used as inoculants and root system conditioners in the soil significantly influenced the vegetative and reproductive development of the plants. The mixture containing Root+Sollus+Bioboron provided higher values of height, number of trifoliates, biomass and dry mass of the soybean plant root, representing the treatment with the greatest positive interference in vegetative growth, while the plants subjected to treatment with application of H2-root had lower vegetative and reproductive development. The grain mass per plant, the number of pods and grains per plant were higher in the plants treated with sollus and in the mixtures of sollus+bioboron and root+sollus+bioboron. While H2-bioboron and H2-raiz present mineral elements and traces of plant hormones, sollus is the only one with soil conditioning characteristics with the presence of nitrogen-fixing bacteria and the ability to alter the soil microbiota. Therefore, it is recommended to use the products in a mixture to improve soil microbiology and supply mineral elements to the plant.

Keywords: Fertilizers, Soil microbiology, Glycine max L.

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INFLUENCE OF SORGHUM EXTRACT ON WEED GERMINATION

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The production cost of a crop is affected by approximately 30% by weed control. These plants can reduce productivity and harm the quality of the final production. The main technique used to mitigate and control weeds in agriculture is the use of herbicides. The use of herbicides poses risks to human health through increased incidence of diseases and contamination due to the toxic effects of the products. Contemporary agriculture seeks more sustainable methods of weed control with fewer risks to human health and environmental preservation. Studies show that sorghum extract can reduce weed germination by 60% to 90%. The present study aimed to identify the effects of sorghum extract on weed germination and development by studying the soil seed bank. The work was conducted in a vegetable production area covered with 50% radiation interception shade cloth at the State University of Goiás, South Campus, Ipameri Unit. The experiment followed a completely randomized design with five treatments and six replicates. The treatments consisted of the application of 200 liters per hectare of sorghum leaf extract at concentrations of 0%; 3%; 6%; 9% and 12%. The application was made to the soil and evaluations were performed 40 days after the treatments were applied. The variables analyzed did not show regression adjustment and the weed density and number of broadleaf weeds were higher in the treatments with sorghum extract. Although the sorghum extract demonstrated proven allelopathic action in inhibiting the development of some plant species, in the present study the sorghum extract at the applied doses did not promote adequate weed control. These results may be related to the inactivation of sorgoleone, the main allelochemical in sorghum leaves, by soil colloids. Thus, the results suggest that the use of the extract is more efficient in the post-emergence of weeds and presents low efficiency in the pre-emergence.

Keywords: Invasive plants, allelopathy, seed bank

Acknowledgments: I thank the State University of Goiás (UEG) for the support, as well as the professors and colleagues for their valuable contributions.

FITNESS OF INTERSPECIFIC HYBRID IN DIMORPHANDRA: SURVIVAL OF PARENTAL SPECIES AND HYBRIDS IN A COMMON GARDEN

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The fitness of the hybrids determines the evolutionary fate of natural hybridization. The survival of hybrid seedlings can be due to intrinsic genetic incompatibilities and/or genotype-environment interactions. In this study, we evaluated the survival after 180 days of growth of *Dimorphandra exaltata*, *D. mollis*, and its natural hybrid F1, identified as *D. wilsonii*. For the experiment, seeds of 5-6 plants of parental species and F1 hybrid plants were sampled in a hybrid zone located on the ecotonal zone between Cerrado and Atlantic Forest in Minas Gerais, Brazil. The progenies were grown in a common garden, under full sunlight or in shade conditions. Plants of *D. exaltata* grown under shade exhibited superior survival than in sunlight, but *D. mollis* presented higher survival under full sunlight. These results are consistent with their original habitats, the Atlantic Forest (*D. exaltata*) and Cerrado (*D. mollis*). Progenies of the F1 hybrid showed higher survival under full sunlight than shade. The survival of *D. exaltata* seedlings was higher than *D. mollis* independently of light conditions. The survival of the hybrid seedlings was like that of *D. mollis* for sun conditions and lower under shade. The results suggest that the fitness of the hybrid progenies and parental species depends on the environmental growth conditions (shade or full sunlight). Our findings showed that light availability was not a strong ecological filter preventing the establishment of the parental species, mainly for *D. exaltata*. However, the survival of progenies of F1 hybrids was compromised in shade growth conditions. The survival of the F1 hybrid progenies under full sunlight underscores the potential of the early generation of hybrids in contributing to gene flow between parental species, thereby enhancing genetic diversity in the *Dimorphandra* hybrid zone of the ecotonal area between the Atlantic Forest and Cerrado.

Keywords: *Dimorphandra*, common garden, interspecific hybrids, sun and shade, survival

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IMPORTANCE OF SORGHUM AS A BIOHERBICIDE IN WEED CONTROL

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Weeds have a high capacity to compete with agricultural crops for water, light and nutrients, causing production losses, in addition to hosting pests, spreading diseases and increasing production costs. Among the harmful weed species in crop production, *Amaranthus viridis* L. stands out, popularly known as caruru, caruru-de-mancha or amaranto-verde of the Amaranthaceae family. It is considered an aggressive weed that can cause great productivity losses in several crops. The present study aimed to identify the herbicidal effect of sorghum extract in the control of *Amaranthus viridis* L., as well as to discover the appropriate phenological stage of sorghum to obtain the extract. The work was carried out in a greenhouse covered with transparent plastic and the sides in shade with 50% attenuation of solar radiation. Polyethylene containers filled with 12 kg of substrate composed of soil, sand and manure in the proportion of 3:1:0.5 respectively were used. The experiment was conducted following a completely randomized design in a 4 x 4 factorial scheme using sorghum extract extracted at three phenological stages E1, E3, E6 and control (absence of extract) and four concentrations referring to the percentage of extract applied 0%; 25%; 50% and 100% of the extract diluted in water and three replicates. The application volume corresponded to 20 ml/plant distributed in three applications at 33, 39 and 43 DAE of *Amaranthus viridis* L.. The sorghum extract obtained at phenological stages E1, E3 and E6 present bioherbicidal action with strong reduction in the growth of the weed *Amaranthus viridis* L.. Thus, the grain sorghum leaves for extract production can be harvested at any of the phenological stages. The decrease in shoot and root growth of *Amaranthus viridis* L. occurs with the use of concentrations of 25%, 50% and 100% of sorghum extract; however, growth restriction is greater when the 100% concentration is used. This study supports the development of further research using sorghum extract in the field to identify the effect of sorghum extract on the development of greater diversity of weeds.

Keywords: Bioinput, sustainable agriculture, allelochemicals

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ACADEMICS DON'T SEE PLANTS IN THE SAME WAY

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Numerous experiments now show that plants possess mechanisms long traditionally attributed to animals. The ability to perceive environmental signals, their sensitivity and ability to make complex decisions, to memorize, allowing them to adapt to changing environment - how are these results perceived in the scientific community and elsewhere? The current plant turn, involving all scientific disciplines as well as civil society, could mark a real inflection point in our relationship with plants. By bringing together researchers from the humanities, life sciences and non-researchers in a single questionnaire, our work focuses on different perceptions and definitions of plant behaviour (perception, consciousness, agentivity). Previous works shows the influence of beliefs in perceptions of nature, we show that the vision of plants is built on oppositions between academics and non-academics. Perceptions of plants are associated with practices. Then researchers in the human sciences and life sciences do not attribute the same capacities to plants, and so the plant refers to conceptual issues.

Keywords: perception, academics, plants capacities

FILLING IN THE GAPS: PERCEPTUAL COMPLETION IN PEA PLANTS

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Pea plants are climbing plants that are able to detect a potential support and flexibly adapt their approach-to-clasp movement properly. In nature, however, the complete perception of potential supports could be hidden by several above- and below-ground elements. In such circumstances, plants need to perform some sort of perceptual “completion” to produce a unified perception of their target elements. Here, we tested the existence of perceptual completion process in pea plants by analyzing their approach behavior using three-dimensional (3D) kinematic analysis. Plants were tested in the presence of a support divided into two parts located in opposite positions. One part was grounded and only perceived by the root system. The other part was raised from the ground so that only the aerial part was accessible. Control conditions were also included. The results showed that the plants integrated the information coming from the two parts of the supports to clasp it properly. We suggested that perceptual completion in plants may be achieved by a complex signaling network between the root system and the aerial sectors, allowing the establishment of a unified percept. These findings extend our knowledge of plant behavior and cognition, and provide further insights into understanding the different behavioral strategies that plants use in response to different environmental cues.

Keywords: Approach-to-clasp movement, kinematical analysis, perceptual completion, *Pisum sativum* L., plant behavior

**CORRELATION BETWEEN VOLATILE ORGANIC COMPOUNDS AND GROWTH KINEMATICS IN
PEA PLANTS**

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Volatile organic compounds (VOCs) are known to play crucial roles in plant communication, defense, and development. In climbing plants, growth kinematics - comprising twining, circumnutation, and directional growth - represent a dynamic interplay between internal physiological processes and environmental cues. This study investigates how VOCs emission correlate with the unique kinematic and growth behaviors of climbing plants, emphasizing their modulation with a potential support in the environment. We performed continuous VOCs monitoring using a Vocus 2R (by ToFwerk), which is a state-of-the-art Time Of Flight - Mass spectrometer (TOF-MS) for untargeted VOCs analyses using a reactor with novel technology termed Adduct Ionization Mechanism (AIM). Continuous kinematic parameters were extracted using a consolidated motion analysis system using pairs of IP cameras (with day and night mode) working in stereovision that allows the reconstruction of three-dimensional trajectories of key kinematic landmarks on the plant. These continuous measurements were applied to *Pisum Sativum* plants growing in two different conditions: 1) a condition in which a potential support was present in the environment; 2) a condition in which the plants grew in an environment lacking potential supports. Raw data generated by the Vocus 2R was post-processed using Tofware v3.2.5 software using the workflow for untargeted analysis. Postprocessing and statistical analysis on VOCs and kinematic data was performed using R and Python. We identified a set of molecular masses that showed difference in their intensity between the two growing conditions (with and without a support) and such differences in intensity appear to be correlated with kinematic parameters. The interplay between VOCs and growth kinematics in climbing plants represents a nuanced and underexplored area of plant biology. VOCs likely play a pivotal role in the dynamic movement strategies of climbers, that are connected to both internal hormonal states and external environmental cues. As we deepen our understanding, we will unlock potential for innovative applications in ecology, agriculture, and biomimetic design.

Keywords: VOCs, plant movement, cognition

WHEN THINGS DON'T GO TO PLAN: LESSONS FROM A MICROCOSM EXPERIMENT ON ECTOMYCORRHIZAL SIGNALLING

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Ectomycorrhizal fungi are known for enhancing nutrient acquisition and stress tolerance in host plants, but their potential role in conveying structural information about the soil environment remains largely unexplored. In this study, we aimed to test the hypothesis that ectomycorrhizal hyphae could guide root growth to avoid physical obstacles, thereby providing a form of belowground spatial signalling. To investigate this, we employed *Pinus sylvestris* seedlings inoculated with *Suillus granulatus* in transparent Perspex microcosms, placed above fitted U-shaped silicone mazes. Our prediction was that due to hyphal signalling, inoculated seedlings would exhibit altered root architecture, avoiding the maze dead end, whereas controls would show more root mass within the maze. Despite initial success in achieving ectomycorrhizal colonisation (88% of inoculated seedlings), the experiment encountered multiple technical setbacks. Extensive and unexpected root growth occurred prior to transplanting, leading to root systems unsuitable for this experiment. Moreover, structural issues in the microcosms—such as bending Perspex plates and substrate desiccation—likely hindered fungal development and hyphal growth, preventing the testing of our hypothesis. Although our results were inconclusive, the experiment yielded several valuable insights. First, we compiled and synthesised methods from classical ectomycorrhizal studies, offering a comprehensive protocol for in vitro synthesis of ectomycorrhizas and experimental set-up—an area often lacking in detail in the literature. Second, we identified key limitations of the classical microcosm approach and proposed a set of practical recommendations to improve reproducibility and experimental efficiency, including substrate optimisation, better microcosm sealing techniques, and a suggested technique for recovering root biomass. This study illustrates the importance of reporting negative or inconclusive results, particularly when they involve methodological hurdles that may be common but rarely documented. We argue that classical microcosm systems still hold potential for advancing ectomycorrhizal research—particularly in the context of plant behaviour and root foraging—but require careful methodological refinement. By sharing both our failures and successes, we hope to support the design of more robust and insightful experiments in the future.

Keywords: Ectomycorrhizas, plant signalling, structural information, *Suillus granulatus*, *Pinus sylvestris*, negative results, hyphae, microcosm

WHAT IS IT LIKE TO BE A TREE? INTELLIGENCES IN DIALOGUE

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This paper presents an interdisciplinary project that investigates plant signaling and cognitive-like states in trees and forests through the combined lenses of scientific research and artistic expression. Drawing on principles of electrophysiology, the project explores the plant "electrome"—the complex patterns of bioelectrical activity produced by plants in response to environmental stimuli—and translates these into immersive artistic installations designed to engage public imagination. Central to the project, — the first milestone we have completed and what sets this project apart — is the development of custom hardware and software tools. Unlike traditional lab-based electrophysiological setups, our tools are portable, non-invasive devices that enable us to move beyond the confines of the laboratory and into the forest, where trees respond to stimuli and presence. Building on research from scientific groups around the world, our software decodes and visualizes these patterns, offering a glimpse into the hidden. We present results from field experiments demonstrating significant correlations between tree electrical activity and external stimuli, such as marked changes in the electrome when individuals walk near the trees. Statistical analyses, including multiscale entropy and power spectral density, indicate increased information processing in response to these stimuli, suggesting attention, capacity for adaptive responsiveness or even a form of awareness. These findings highlight the complex and dynamic nature of tree electrophysiology and contribute to emerging discussions on plant perception and intelligence. Recognizing such capabilities may inform new frameworks for understanding human–plant interactions, grounded in mutual recognition and respect, collaboration, and the acknowledgment that intelligence, rather than being something that sets us apart from the rest of the natural world, can be the very link that connects us to other species, intrinsic to life itself, not merely a position on the evolutionary scale. Beyond its technical and scientific dimensions, the project positions art as a powerful medium for translating plant behavior into experiences accessible to a broader audience. Through artistic installations, the invisible electrical lives of plants are made perceptible—transformed into soundscapes, light compositions, and responsive environments that foster emotional and intellectual connections between humans and the vegetal world. We conclude with a reflection on the value of cross-disciplinary collaboration between artists and scientists. This synergy not only enriches the research process—encouraging novel questions, methods, and interpretations—but also plays a crucial role in science communication. Artistic dissemination makes plant cognition research more approachable, emotionally resonant, and socially impactful, thus broadening its reach and relevance.

Keywords: Art-science collaboration, electrome, plant cognition, emotional engagement through art

DEVELOPING A METHOD FOR MIMICKING MICRO- TO ZERO GRAVITY TO ENABLE TESTING MODELS FOR GRAVITY PERCEPTION

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There are two dominant models for the perception of gravity by plant cells: the starch-statolith model (in which sedimenting starch grains act as the gravity sensor) and the gravitational pressure model (in which the entire protoplast acts as the gravity sensor). While previous physiological studies have demonstrated that the gravitational pressure model better explains the observed phenomena, we would like to follow up with further tests between the models for plant gravity perception with physiological and genetic experimentation with a model organism to allow a comparison of plant responses in an environment that the gravitational pressure model would predict to mimic microgravity, to reported plant responses on the International Space Station. To do this, we developed two methods for comparing the physiological responses of *Arabidopsis* grown on the ISS with those grown on Earth in liquid media of different densities. First, *Arabidopsis thaliana* (Landsberg erecta) seeds were germinated, and the roots were grown into media of various densities. Once roots had grown into the liquid medium parallel to the vector of gravity, they were illuminated with blue light perpendicular to the vector of gravity. Curvature toward or away from the vectors of gravity and blue light was measured from time-lapse images collected over 24 hours. Second, we developed a novel rotatable root observation box (RROB), allowing observation of gravitropic response in *Arabidopsis* roots rotated perpendicular to the gravitational axis in liquid media of various densities over 24 hours. ImageJ was used to calculate the change in root tip orientation by measuring the initial and final orientation relative to the vector of gravity as well as the growth rate. Preliminary results from both physiological experiments indicate that gravity perception is reduced as the density of the external medium increases. We observe a 22° increase in phototropic curvature away from blue light perpendicular to the vector of gravity when the density of the external medium is increased from 1001 kg m⁻³ to 1128 kg m⁻³. Additionally, gravitropic curvature after 90° rotation away from the gravitational axis is reduced as the density of the external medium is increased. These physiological responses to dense external media on Earth mimic the responses reported from the ISS in microgravity and are consistent with the gravitational pressure model for gravity sensing.

Keywords: *Arabidopsis*, gravitropic response, phototropic response, gravity perception, microgravity, international space station

MULTI-LOCATION TRACKING FOR A NETWORK SCIENCE APPROACH TO PLANT SIGNALING: A CASE STUDY ON LIGHT STIMULI

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Electrical signals have gained interest within the plant science community as a valuable source of data for better understanding plant responses to various stimuli. Current techniques used to evaluate such signals often lack a systemic view of how plants integrate electrical activity across the entire organism. In this study, we present a novel sensor capable of measuring electrical signals at multiple points along a plant and in both directions. We combine this with a temporal network analysis to explore how light stimuli affect signal behavior. Our results show that different lighting conditions influence signal dynamics over 72 hours: light/dark cycles induce fluctuations, constant light maintains lower voltages, and constant darkness results in sustained higher voltages. Network analysis revealed that continuous light alters the average weight degree in both measurement directions, while continuous darkness has a significant directional effect. Pea plants also displayed direction-dependent electrical coordination: under light stress, signals initially diverged across the plant body but became more synchronized over time, suggesting adaptation. In contrast, darkness produced stronger dissimilarity from root to shoot, while shoot-to-root signals resembled the control. These findings highlight the importance of measurement direction and show that plant vascular tissues can signal distinct responses based on light conditions. Node-level differences across the day further emphasize localized responses. Our study provides a comprehensive method for examining how electrical signals propagate through plants and identifies which areas are most responsive under light stress.

Keywords: Network science, direction, electrical potentials, light stress