Abstract Book

International Conference on:
Eco-smart Agriculture Harnessing Stress Resilient Plants for Food Security and beyond

Edited by:
Prof. Dr. Salman Gulzar
Dr. Abdul Hameed

January 28-30, 2026

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Message from the Conference Patron-in-Chief and Vice Chancellor



It is my profound honor and distinct privilege, as the Vice Chancellor of the University of Karachi and the Patron-in-Chief of the conference, to extend a warm welcome to the International Conference on "Eco-smart Agriculture: Harnessing Stress Resilient Plants for Food Security and Beyond" at Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization (MAK-ISHU), University of Karachi. This landmark event, which is being held in the vibrant city of Karachi, in an important contribution in our collective journey to address one of world's most pressing challenges: ensuring global food security in the face of global climate changes. Water scarcity, aggravated by over-extraction of groundwater and erratic/low rainfall patterns, now plagues regions from the arid plains of sub-Saharan Africa to the fertile deltas of South Asia. Soil degradation, particularly from salinity, which often results from mal-irrigation practices and rising sea levels, is also rendering vast tracts of farmland infertile, while droughts and extreme weather events are becoming increasingly frequent and severe. Projections indicate that by 2050, we could face a 50% shortfall in crop yields if we do not act decisively. In this context, the development and utilization of stress-resilient plants (i.e. plants capable of thriving under harsh environmental conditions) appear a ray of hope. They promise not just higher yields but sustainable ones: reducing chemical inputs, conserving water, and enhancing biodiversity. For nations like ours, dealing with climate challenges is more than science—it's survival. This conference, therefore, is not just an academic gathering but a call to action and a platform to forge transdisciplinary collaborations, share field-tested innovations, and design a roadmap for sustainable agricultural practices. It brings together over 9 foreign experts along with large gathering of Pakistani experts to explore breakthroughs in plant biotechnology, stress physiology, agroecology, and climate-adaptive farming. These innovations align perfectly with the UN Sustainable Development Goals, particularly Zero Hunger and Climate Action. I am delighted to congratulate MAK-ISHU for organizing this important and timely event. By prioritizing sustainability research and innovations, this event by MAK-ISHU exemplifies how academia can bridge the gap between global challenges and local solutions. I believe that with unity and innovation, we will secure a resilient tomorrow. I look forward to actionable outcomes from our discussions, with a firm resolve to turn knowledge into impact.

Prof. Dr. Khalid Mehmood Iraqi
The Vice Chancellor, University of Karachi

Message from the Dean and Conference Patron Prof. Dr. Bilquees Gul



It is my great honour and privilege, in my capacity as Dean, Faculty of Sciences, Patron of this conference, and as one of the co-founding Directors and Senior Professor of the Dr. Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization (MAK-ISHU), to welcome you to this international conference on "Eco-smart Agriculture: Harnessing Stress Resilient Plants for Food Security and Beyond".

Today, climate change, soil salinity, water scarcity, land degradation, and population growth place unprecedented pressure on our ability to feed the world safely, sustainably, and equitably. Traditional approaches alone cannot meet these complex challenges. We urgently need new ideas, new partnerships, and new ways of working with nature rather than against it.

In this context, eco-smart agriculture is not just a fashionable term; it is an imperative. It calls on us to design agricultural systems that are productive yet resource-efficient, resilient yet environmentally responsible, and innovative yet socially inclusive. Central to this vision is the exploration and deployment of stress-resilient plants: crops and wild species that can thrive under high salinity, drought, heat, and other harsh environmental conditions that are becoming increasingly common, especially in regions like ours.

The Dr. Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization, or MAK-ISHU, was established with precisely this mission in mind. Inspired by the pioneering work of the late Professor Dr. Muhammad Ajmal Khan, whose contributions to halophyte biology and saline agriculture are recognized globally, the Institute has aimed to convert what we often perceive as "marginal" or "wastelands" into landscapes of opportunity. By studying halophytes and other stress-tolerant species, and by developing technologies to integrate them into farming, rangeland, and coastal systems, we seek to make salinity and aridity part of the solution rather than only part of the problem.

This conference advances MAK-ISHU's mission of harmony with nature, uniting scientists, agronomists, ecologists, biotechnologists, policymakers, and young researchers from Pakistan and beyond. Over the coming days, you will share cutting-edge research on the physiology, genomics, and breeding of stress-resilient plants; climate-smart and ecosystem-based approaches to food production and other economic benefits; and policy frameworks and community-based strategies that can support the large-scale adoption of eco-smart agriculture.

My sincere thanks to the Vice Chancellor, University administration, keynote speakers, and the Organizing Committees for making this important event possible.

I am confident that the knowledge generated and the networks strengthened here will contribute meaningfully to making agriculture in Pakistan, our region, and the world more resilient and sustainable. With these words, I once again warmly welcome all participants and wish a productive, inspiring, and memorable conference.

Prof. Dr. Bilquees Gul
Dean Faculty of Sciences
University of Karachi

Message from Director, MAK-ISHU and Conference Convener Prof. Dr. Irfan Aziz



I am deeply honored and privileged as a convener to welcome all the dignitaries to the International Conference on "Eco-smart Agriculture: Harnessing Stress Resilient Plants for Food Security and Beyond" at the Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization (MAK-ISHU), University of Karachi. The distinctiveness of this event is to gather biologists, biotechnologists, soil scientists, environmentalists, and policymakers to promote climate-smart agricultural systems adaptable to arid and saline ecosystems. In view of the impact of global climate changes such as periodic drought, excessive flooding due to intermittent rains and increasing salinity, food scarcity has become a major concern specially for the third world countries like Pakistan. Therefore, the aim of this conference is to provide a multidisciplinary platform for to scientists, researchers, academicians, and professionals to exchange ideas, research findings, and technological advancements in the field of sustainable and Eco-smart agriculture. I am delighted to share that the conference is being attended by foreign faculty from 6 different countries and several faculty members from all over the country. Due to its diverse themes, the scope of the conference extends from crop improvement to the exploration of stress-resilient plants as future resources for food and environmental security. The deliberations / recommendations given by field experts would help in developing salt-tolerant, water-efficient, and climate-resilient crops for sustaining agricultural economy of the country and supporting its farming communities. The exchange of innovative ideas among the leading scientists would help in developing sustainable livestock, quality products and agricultural commodities in extremely arid and saline environments. I would like to thank the Sindh Higher Education Commission, Higher Education Commission, Islamabad, our worthy Vice Chancellor and our sponsors for generously helping us to arrange this conference. I hope that the scientific discussion during the event will go a long way in advancing research and fostering sustainable utilization of conventional as well as non-conventional cash crops for food security.

Prof. Dr. Irfan Aziz
Director, MAK-ISHU
Convener, ESA 2026

***ABSTRACTS*:**

Oral Presentations

Next-Generation Plant Biotechnology for Multi-Stress Resilience and Food Security

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Abstract
Climate change, environmental degradation, and increasing biotic and abiotic stresses are major constraints to global food security and call for advanced biotechnology-driven solutions for sustainable agriculture. The presentation shall focus on next-generation biotechnological strategies that facilitate the development of crops resilient against both the environmental stresses and biological attacks from insect pests and plant diseases. The talk will outline the role of modern plant biotechnology, including functional genomics and molecular breeding, in finding the genetic mechanisms underlying resistance to drought, salinity, heat, insect herbivory, and pathogen infection. Improvements in genome sequencing, haploid and doubled-haploid technologies, marker-assisted selection, and genomic selection have remarkably hastened the identification and deployment of genes and quantitative trait loci associated with multi-stress tolerance. Systems-level omics approaches, including transcriptomics, proteomics, and metabolomics, provide critical insights into stress-responsive signaling networks, defense pathways, and host–pathogen interactions. The emerging genome engineering tools, such as CRISPR-based gene editing, provide a means for precise modification of resistance genes, susceptibility loci, and regulatory elements, thus bringing in broad-spectrum disease resistance, insect tolerance, and yield stability without the insertion of foreign DNA. The presentation will also consider the biotechnological potential of plants from unconventional and stress-adapted species, including halophytes, as genetic reservoirs of value for both abiotic and biotic stress resilience. It supports the development of eco-smart, resilient cropping systems through the integration of advanced molecular biology, genome engineering, and translational breeding technologies in this biotechnology-centered framework. An approach of this kind is imperative to realize sustainable food security with minimal dependence on chemical inputs under present and future global challenges.

Keywords: Climate Change, CRIPSR, Food Security, Systems-Level Omics Approach, Disease Resistant Crops

Eco-smart biochar solutions: Enhancing crop resilience to salinity and drought

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Abstract
Soil salinity and drought are major abiotic stresses that limit crop productivity and threaten food security under changing climatic conditions. Eco-smart agricultural interventions are the need of hour that enhance crop resilience while ensuring environmental sustainability. Biochar, a carbon-rich material produced through biomass pyrolysis, has gained considerable attention as a soil amendment due to its multifunctional benefits and making plants resilient to different environmental stresses. Biochar application improves soil physicochemical properties by enhancing water-holding capacity, cation exchange capacity, and microbial activity, while reducing sodium toxicity and improving nutrient availability in saline soils. Under drought conditions, biochar contributes to improved soil moisture retention and root zone aeration, supporting sustained plant growth. The findings of our research have indicated that eco-smart biochar solutions represent a sustainable, low-cost approach to enhance crop resilience against salinity and drought stress. The biochar interventions support soil health, and advance long-term food security. However, the effectiveness of biochar depends on its feedstock source, pyrolysis conditions, and application rate. Hence, Eco-Smart Biochar Solutions are helpful in supporting climate-resilient agriculture and long-term food security.

Keywords: Biochar, Environmental Stress, Drought, Salinity, Food Security

Green extraction and enrichment of bioactive phytochemicals for sustainable development of phytomedicines

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Abstract
Berberine is a major bioactive compound of *Berberis lyceum*, a medicinal plant which is extensively used in various traditional systems of medicines. However, its isolation involves a time-consuming, energy-intensive, multi-stage process that requires a large amount of toxic organic solvents, ultimately increasing its production costs. Commercially berberine is very expensive. An alternative approach that presents the possibility of synergistic effect is to prepare active berberine-rich extract (BRE) using green extraction microwave assisted technology and enrichment by using biodegradable resin columns. BRE has been prepared from *B. lyceum* root bark, having 58% w/w of berberine using microwave and hydrophobic resin Diaion® HP-20 column. BRE was compared with commercially available pure berberine (more expensive) in various pharmacological models including, anti-inflammatory (*in vitro* chemiluminescence technique and *in vivo* carrageenan and formaldehyde-induced rodent inflammation models), anti-Alzheimer ($AlCl_3$ induced rat model) and antidiabetic (nicotinamide-streptozotocin induced diabetic rat model). In all of the pharmacological models, BRE shows dose dependent, potent and significant bioequivalent effects to pure commercial berberine. The undertaken study suggests that BRE can be used as a therapeutic alternative to berberine.

***Keywords*:** Berberine, Medicinal Plant, Anti-Inflammatory, Green Extraction, Pharmacology

Chlorophyll Fluorescence as a High-Throughput Phenotyping Tool to Accelerate Crop Improvement for Climate Resilience

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Abstract
Chlorophyll fluorescence has emerged as a powerful and non-destructive physiological tool to assess plant responses under diverse environmental stresses. It provides critical insights into the functional status of photosystem II (PSII) and associated energy partitioning mechanisms that directly influence plant growth and productivity. Because of its sensitivity to stress-induced changes, chlorophyll fluorescence has been increasingly used as a selection criterion in screening and breeding programs aimed at developing stress-tolerant cultivars. Recent advances in portable and high-throughput fluorescence measuring systems have broadened its application from controlled pot and greenhouse experiments to field-scale phenotyping platforms. Various protocols, including fast fluorescence kinetics (OJIP transients) and quenching analyses, allow detailed evaluation of photoinhibition, photoprotection, and recovery dynamics. These approaches not only help to dissect physiological mechanisms of tolerance but also provide rapid, reliable, and cost-effective tools for large-scale screening in breeding pipelines. By integrating high-throughput ChlF with genomics and other omics technologies, we can significantly accelerate the identification of superior genotypes. This integration will facilitate the development of crops that are better adapted to climate change, thereby contributing to sustainable agriculture and global food security.

***Keywords*:** Crop breeding, High-throughput phenotyping, OJIP, JIP-test, NPQ, PAM, Stress tolerance, Photosystem II, Climate change

Nano-enabled strategies in agriculture: Enhancing plant growth, mineral nutrition and stress resilience

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Abstract
The integration of nanotechnology with conventional farming practices has provided new frontiers for optimizing resource use, reducing agrochemical dependence, and achieving food security. This presentation focuses on how different carbon nanomaterials (e.g., fullerenes, nano-biochar) and metal-based nanomaterials (e.g., Fe and Zn) could improve plant performance under abiotic stress conditions (particularly drought, salinity and oxidative stress). Our findings suggest enhancements in nutrient uptake, crop yield and biofortification in various crops (wheat and rice) and vegetables (spinach, cauliflower, radish and turnip). In addition, nanomaterials have shown promising results in mitigating the negative impacts of salinity and drought by improving plant water relations and photosynthetic activity. This presentation will also address the role of nanotechnology in promoting soil and plant health, making it a key player in modern agriculture's push toward environmental sustainability.

***Keywords*:** Abiotic Stress Tolerance, Crop Biofortification, Nano-Biochar, Nanotechnology in Agriculture, Soil Remediation, Sustainable Agriculture

Impact Assessment of Nematodes on the Selected Crops of Yasin Valley, District Ghizer

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Abstract
A field-based study was conducted during 2024–2025 in Yasin Valley, District Ghizer, Gilgit-Baltistan, Pakistan, to assess the diversity of plant-parasitic nematodes in agricultural soils and evaluate their impact on major crops, including wheat (*Triticum aestivum*), maize (*Zea mays*), and potato (*Solanum tuberosum*). Yasin Valley is located within the Hindu Kush mountain range and is characterized by high agricultural productivity under a predominantly single-cropping system. A total of 66 soil samples were collected from agricultural fields and barren lands across three villages Hundur, Barkolti, and Umalsat covering wheat, maize, potato, vegetable crops, and non-cultivated soils. Nematode extraction and taxonomic identification revealed a diverse assemblage of plant-parasitic genera, including *Aphelenchus*, *Aphelenchoides*, *Helicotylenchus*, *Psilenchus*, *Pratylenchus*, *Quinisulcius*, *Tylenchus*, *Tylenchorhynchus*, and cyst-forming nematodes. Detailed analysis resulted in the documentation of eight new nematode species records, one new host record, and ten new locality records from Yasin Valley. Among the identified taxa, *Helicotylenchus urobelus*, *Xiphinema basiri*, and *Aphelenchoides sparsus* were recorded in high population densities across multiple hosts. *Helicotylenchus urobelus* and *X. basiri* were predominantly associated with potato fields, with *X. basiri* also commonly occurring in wheat crops. *Heterodera avenae* was widely distributed in maize fields, while species of *Helicotylenchus* were frequently observed in barren soils. To assess the perceived impact of nematodes on crop productivity, structured interviews were conducted with 150 local farmers, revealing that 80% of respondents cultivated wheat and potato, while 20% primarily grew maize. Farmers reported reliance on chemical pesticides and farmyard manure but highlighted persistent challenges related to pests, diseases, and declining crop yields over the past 10–15 years. The study indicates that plant-parasitic nematodes, particularly *Helicotylenchus* spp., *Pratylenchus* spp., and *Xiphinema* spp., contribute substantially to crop damage and yield losses in the region. These findings underscore the economic significance of nematode infestations and emphasize the need for improved nematode management strategies and farmer awareness programs to enhance sustainable agricultural productivity in Yasin Valley.

***Keywords*:** Agricultural Soils, Gilgit-Baltistan, Hindu Kush, Plant-Parasitic Nematodes

Interactive Effect of Tillage Systems and Biochar Application improved Soil Health and Yield Performance of Wheat under Drought Conditions

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Abstract
Water stress poses a significant threat to crop production under changing climatic conditions. However, its management through various agronomic practices particularly using best tillage practice and biochar application plays an important role in improving soil health and wheat yield under drought stress conditions. Therefore, field experiment was conducted to evaluate the effect of tillage systems and biochar application on soil health and yield performance of wheat under drought stress condition. The experiment comprised of 1) three tillage systems viz. zero-tillage (ZT); minimum tillage (MT); conventional tillage (CT); 2) drought conditions viz. Control (no irrigation); mild drought; well-watered and 3) biochar application viz. no biochar; biochar application @ 3t ha^{-1} and 6t ha^{-1}. Tillage systems and biochar application significantly improved soil porosity and decreased soil bulk density as well as enhanced grain yield and yield related traits in wheat under drought conditions. Conventional tillage with 6 t ha^{-1} biochar application produced highest spike length, grains weight per spike, 1000-grain weight and grain yield (5.22 t ha^{-1}) under well-watered conditions. Regarding rainfed wheat, maximum grain yield (3.92 t ha^{-1}) was obtained with conventional tillage by applying 6 t ha^{-1} biochar application. It is therefore concluded that for improving soil health as well as obtaining highest grain yield under rainfed conditions, wheat should be grown by preparing soil through conventional tillage with 6 t ha^{-1} biochar application.

Keywords: Biochar, Conventional Tillage, Zero-Tillage, Well-Watered, Grain Yield, Wheat Productivity

Inventorying and economic potential of some selected halophytes found in Gilgit, Gilgit-Baltistan, Pakistan

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Abstract
This study focuses on the inventory and economic potential assessment of selected halophytic plant species found in Gilgit-Baltistan, Pakistan. The current inventory documented 20 families comprising 15 genera and 30 halophytic species. Among these, *Capparis spinosa, Pegnum harmala, Sophora mollis*, and *Saccharum filifolium* were identified as having the highest economic potential, playing a significant role in the local economy. These halophytes contribute to the livelihood of the communities through their uses as fodder, fuel, medicinal resources, and industrial raw materials. The findings highlight the importance of halophyte conservation and sustainable utilization for supporting economic development and ecological balance in the saline-affected regions of Gilgit-Baltistan. This research provides a foundational baseline for future halophyte-related ecological and economic studies in the area.

Keywords: *Peganum harmala*, Gilgit-Baltistan, Halophyte Conservation, Economic Potential

Integrated approaches for sustainable and climate-resilient agriculture

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Abstract
This abstract presents the interdisciplinary research efforts in our laboratory aimed at developing sustainable and climate-resilient agricultural systems through the integration of nanotechnology, advanced biochar modifications, biofertilizers, and multi-omics technologies. Our work focuses on nano-enabled fertilizers and pesticides combined with functionalized biochar to achieve precise nutrient delivery, enhanced pest management, and reduced environmental impacts compared to conventional agrochemicals. Controlled-release nanofertilizers improve nutrient use efficiency, minimize leaching and runoff, and support higher crop yields under resource-limited conditions. Targeted nanopesticides reduce off-target effects, promoting biodiversity and soil health. Central to our innovations are biochar-based systems, including magnetic biochar for effective heavy metal immobilization and facilitated soil recovery, and quantum dot-modified biochar that enhances photosynthetic efficiency, chlorophyll content, and antioxidant defenses against abiotic stresses such as drought and salinity. These materials synergize with root microbiomes to improve water retention, soil aggregation, and microbial diversity. We complement these with biofertilizers utilizing plant growth-promoting rhizobacteria (PGPR), which enhance nitrogen fixation, phosphate solubilization, potassium mobilization, and induced systemic resistance, fostering robust microbe-plant interactions essential for climate-resilient cropping. At the molecular scale, multi-omics integration, encompassing metabolomics, transcriptomics and bioinformatics elucidates stress-responsive pathways, revealing key biomarkers like proline, polyamines, flavonoids, and shifts in carbon metabolism that confer tolerance to drought, salinity, and heavy metals. Our advanced facilities enable enzymatic assays (e.g., SOD, POD, CAT, APX), omics profiling, and physiological assessments to decode redox signaling and antioxidant dynamics. Recent advancements, including nano-biochar composites and PGPR consortia, underscore synergistic effects in nutrient efficiency and stress mitigation. By bridging nanotechnology, microbial ecology, and molecular biology, our research translates laboratory insights into scalable field strategies, promoting resilient crops, minimized ecological footprints, carbon sequestration, and sustained food security in the face of escalating climate challenges.

Keywords: Antioxidant Enzymes, Bio-Pesticidesm Magnetic Biochar, Nano-Pesticides, PGPRs

Eco-smart agriculture in arid regions: Biochar, biostimulants, and green nanomaterials to build stress-resilient cropping systems

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Abstract
Arid and hyper-arid agroecosystems face a tightly coupled set of constraints - water scarcity, salinity, heat extremes, and recurrent drought, which reduce soil function and destabilize yields, making food security increasingly sensitive to global disruptions. This presentation outlines an eco-smart, nature-based toolkit for arid agriculture built around three complementary interventions: (i) biochar (and nano-char) produced via pyrolysis from locally available biomass streams (including halophytes and invasive woody species), (ii) biostimulants spanning microbial inoculants (e.g., endophytes and mycorrhizae) and non-microbial plant-derived extracts, and (iii) green-synthesized nanomaterials generated using biological reducing agents (plant/microbial extracts) to minimize environmental burden. Mechanistically, biochar can improve soil structure and porosity, increase water-holding capacity and nutrient retention (via enhanced cation exchange), and support beneficial microbial activity while stabilizing carbon for longer-term sequestration. Biostimulants can strengthen stress physiology through improved root architecture, nutrient use efficiency, osmotic adjustment, and antioxidant capacity, with mycorrhizal networks extending the soil volume explored for water and phosphorus. Green nanomaterials can enable more efficient nutrient delivery and potentially reduce pesticide loads through targeted or slow-release formulations. The talk will integrate these components into a practical pipeline, from feedstock selection and product quality control to crop-specific dosing and field validation, highlighting opportunities and key scaling considerations for sustainable, resilient production in arid and saline environments.

Keywords: Biochar, Biostimulants, Drought Resilience, Green Nanotechnology, Halophytes, Salinity

Integrating ecological vulnerability and economic forestry potential for climate-resilient desert landscapes

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Abstract
Pakistan's arid and semi-arid regions, covering nearly 80% of the country's land area, face accelerating desertification, salinization, and ecosystem degradation due to climate change, unsustainable land practices, and water scarcity. To promote adaptive and productive restoration, this study integrates Ecological Vulnerability Assessment (EVA) with Economic Forestry Potential Index (EFPI) using multi-source remote-sensing data and geospatial modelling. Datasets from MODIS, Landsat, WorldPop, TerraClimate, and national socio-economic surveys were normalized and weighted to assess exposure, sensitivity, and adaptive capacity of dryland ecosystems. The integrated framework identifies zones where ecological fragility overlaps with forestry opportunity, enabling the design of climate-resilient restoration strategies for regions such as Cholistan and Thal Deserts. Results reveal that approximately 29% of Pakistan's arid landscapes exhibit high ecological vulnerability but also moderate to high forestry potential. Recommended species *Haloxylon salicornicum, Tamarix aphylla, Acacia senegal, Prosopis cineraria,* and *Ziziphus mauritiana* offer ecological, climatic, and economic co-benefits through soil stabilization, carbon sequestration, and livelihood generation. The study establishes a geospatial decision-support model for policymakers to prioritize afforestation and livelihood enhancement interventions, bridging scientific evidence with sustainable desert economy planning. This integrated approach demonstrates how eco-smart forestry can transform ecological fragility into economic opportunity, advancing regional resilience under changing climatic conditions.

***Keywords*:** Ecological Vulnerability, Economic Forestry Potential, Remote Sensing, Climate Resilience, Sustainable Dryland Restoration

Biometric responses of maize (*Zea mays* L.) genotypes by the application of green synthesized silver nanoparticles (AgNPs)

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Abstract
The current study was carried out to determine the impact of green-synthesized silver nanoparticles on growth and yield attributes of maize genotypes grown in Azad Jammu and Kashmir. The green synthesis of silver nanoparticles was done through leaf powder of *Justicia adhatoda* L. The transition of silver nitrate solution from yellow to brown color confirmed the presence of nanoparticles in the colloidal solution which was further established through UV-visible spectroscopy. Scanning electron microscopy (SEM) revealed that these silver particles were spherical and nano in size. X-ray diffraction analysis (XRD), confirmed their crystalline nature. Presence of alkaloids and flavonoids which act as biomolecules for capping of silver nanoparticles was monitored through Fourier transmission infrared spectroscopy (FTIR). These green synthesized silver nanoparticles were applied to maize genotypes. Randomized Complete Block design (RCBD) was applied while performing field experiment with three replicates. Morphological characters of maize crop were determined at respective developmental stages through BBCH identification keys of maize. Ten maize genotypes were treated with four concentrations (0ppm, 5ppm, 15ppm and 25ppm) of silver nanoparticles by two modes of application (Seed priming and Foliar spray). Duncan's Multiple Range Test (DMRT) results were found to be significant with respect to growth and yield parameters such as plant height, leaves number, days to tasseling, silking and maturity, grains number in a row, thousand grain weight, grain and biological yield as well as harvest index. It was confirmed by present findings that silver nanoparticles at 5ppm enhanced the growth and yield parameters of maize. Among all genotypes, G5 (Genotype Azam) performance for morphological parameters was well enhanced under the treatment effect at 5 ppm. By applying UPGMA (Unweighted Pair Group Method with Arithmetic mean) cluster examination of maize genotypes was done to generate dendrogram and bivariate data matrix. Dendrogram for SSR revealed two main groups A and B with maximum level of diversity. Group A contained two genotypes whereas major portion of dendrogram was comprised of Group B with four sub clusters. ISSR dendrogram revealed two major groups A and B. Group A contained two genotypes as compared to group B having four genotypes. The PIC values were calculated for each SSR and ISSR locus. As per cluster analysis, dendrogram results interpreted that great genetic variability exists among genotypes of maize and ISSR primers are best suited for its determination. Spanning tree analysis was done both for SSR and ISSR primers respectively and G5 (Genotype Azam) and G7 (Genotype MMRI) came out as most diverse genotypes among all. This study is a pioneer work on local maize genotypes and its results will be helpful in shaping the future research direction of nano-biotechnology in the studied area.

***Keywords*:** Eco-Friendly, Ag-Nanoparticles, Maize, Biometric Parameters, Genetic Diversity

Ecological risks due to leather tanneries with special focus on heavy metal contamination in water, soil and selected crops around the Kasur city of Pakistan

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Abstract
This study aimed at assessing the heavy metal contamination and associated ecological and health risks in Kasur city through water, soil and plant samples collected from industries, wastewater drains, the Sutlej River, and agricultural fields around leather tanneries. Results showed extremely degraded water quality, with Industrial Effluents (IE) and Waste Water (WW) carrying drains showing alarmingly high Water Pollution Index (WPI) values, while river samples also showing high contamination values. The most significant contaminants were chromium (Cr), and cadmium (Cd), with their concentrations exceeding the WHO and NEQS guidelines in IW and WW samples, while river water also showed above threshold WPI. Soil analysis of samples collected from different agricultural fields of Kasur showed Cr and Cd enrichment confirmed through Contamination Factor (CF), Geo-accumulation Index (Igeo), Enrichment Factor (EF), and the Ecological Risk Index (ERI). The high values of these indices indicated severe anthropogenic inputs and ecological hazards. Principal component analysis (PCA) showed strong clusters of metals with separation of highly polluted soils. Spatial interpolation through kriging maps also showed the hotspots of Cr and Cd near wastewater discharge points. Plant samples of edible parts of the five major crops i.e., wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), fenugreek (*Trigonella foenum-graecum* L.), mustard (*Brassica compestris* L.), and green pepper (*Capsicum annuum* L.) confirmed the flow of heavy metals from environment to the food chain with fenugreek and mustard specifically accumulating high amounts of Cd and Pb concentrations in their edible tissues. Mean heavy metal concentrations in all the crops remained above the FAO/WHO recommended safety limits. Bioaccumulation factor (BAF) showed the exceeded value of Cd from one, especially in leafy vegetables. Pb and Ni however, remained comparatively low. Health Risk Index (HRI) showed that Cd and Pb were the major contributors to the human health risk with fenugreek showing the highest hazard index (HI) values in all the intake scenarios. Overall, the results of this study showed a contamination cycle starting from tanneries to water, soils, plants and human body. The findings highlight an urgent need for strict regulations, cleaner production techniques, and safe agricultural practices to tackle the growing ecological degradation and human health risks in Kasur.

***Keywords*:** Heavy Metal Pollution, Ecological Risk Index, Hazard Index, Edible Crops, Water Contamination, Bioaccumulation Factor

Exploring *Arthrocnemum macrostachyum* associated *Bacillus cereus* for Bioemulsifier production and climate-resilient agriculture

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Abstract
Halophytes thrive in saline environment and have evolved various strategies to mitigate various stresses. Microorganisms associated with halophytes interact with their host in various ways. In this context, *Arthrocaulon macrostachyum,* a coastal plant, served as a hub for the habitat of agriculturally important bacteria. Particularly, *Bacillus cereus* E4 isolated from the roots of this plant demonstrated ability to produce an array of industrially-relevant enzymes including cellulase, amylase, xylanase, pectinase and lipase. Owing to its lipolytic abilities the organism was capable to produce exopolysaccharides (EPS) and polyhydroxyalkanoate (PHA) which are considered as a source material for the production of bioplastics. The presence of hydroxyl and carboxyl groups and glycosidic linkage in FTIR validated polysaccharide nature of EPS while its rough surface, and crystalline nature with fibrillar network structure were visualized by AFM and XRD. The oil displaced area and emulsification index of the biosurfactant was noted as 36.95 cm^2 and 50%, respectively. The PHB production by the strain was found 1.98 wt% of the dry cell weight. FTIR of PHB granules showed the presence of carbonyl group of esters and the surface was found slightly rough with uniformly arranged and tightly packed microstructure by SEM. The whole genome sequence of this strain affirmed the potential of E4. The non-pathogenic nature of this strain makes it the promising candidate for agricultural application.

***Keywords*:** *Arthrocaulon macrostachyum*, Bioemulsifier, Bioplastics, Whole Genome Sequence

Synthesis of methylcellulose-polyvinyl alcohol composite, biopolymer film and thermostable enzymes from sugarcane bagasse

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Abstract
Agro-industrial wastes and by-products are the natural and abundant resources of biomaterials to obtain various value-added items such as biopolymer films, bio-composites and enzymes. This study presents a way to fractionate and to convert an agro-industrial residue, sugarcane bagasse (SB), into useful materials with potential applications. Initially cellulose was extracted from SB which was then converted into methylcellulose. The synthesized methylcellulose was characterized by scanning electron microscopy and FTIR. Biopolymer film was prepared by using methylcellulose, polyvinyl alcohol (PVA), glutaraldehyde, starch and glycerol. The biopolymer was characterized to exhibit 16.30 MPa tensile strength, 0.05 g/m2 h of water vapor transmission rate, 366% of water absorption to its original weight after 115 min of immersion, 59.08% water solubility, 99.05% moisture retention capability and 6.01% of moisture absorption after 144 h. Furthermore, in vitro studies on absorption and dissolution of model drug by biopolymer showed 2.04 and 104.59% of swelling ratio and equilibrium water content, respectively. Biocompatibility of the biopolymer was checked by using gelatin media and it was observed that swelling ratio was higher in initial 20 min of contact. The extracted hemicellulose and pectin from SB were fermented by a thermophilic bacterial strain, *Neobacillus sedimentimangrovi* UE25 that yielded 12.52 and 6.4 IU mL^{-1} of xylanase and pectinase, respectively. These industrially important enzymes further augmented the utility of SB in this study. Therefore, this study emphasizes the possibility for industrial application of SB to form various products.

***Keywords*:** Biopolymer, Cellulose, Hemicellulose, Methylcellulose, Pectin, Polyvinyl Alcohol

Green synthesis of ZnO nanoparticles using *Mentha piperita* (Peppermint) extract and evaluation of their antimicrobial potential against *Listeria monocytogenes*

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Abstract
Nanoparticles have emerged as vital units in the realm of food processing and preservation. This study aims at the utilization of *Mentha piperita* for the green synthesis of zinc oxide nanoparticles. The peppermint plant, a hybrid of water mint and spearmint, was selected for its ready availability and widespread recognition for its medicinal properties. Moreover, zinc oxide is known for its antimicrobial attributes. Green synthesis of zinc oxide nanoparticles was done using zinc acetate and peppermint extract. Characterization of nanoparticles was done by UV–Visible Spectrophotometry, SEM, and EDX techniques. Confirmation of nanoparticles was achieved through distinct color change and the peak in UV–Vis at 350 nm. SEM results also confirmed the size of zinc oxide nanoparticles around 85.4 nm and were spherical in shape. The purity of the nanoparticles was confirmed by EDX showing 100% abundance of zinc and oxygen. Subsequently, antimicrobial activity of the nanoparticles was checked against multidrug-resistant L. *monocytogenes* strains, and it was found to be effective with an inhibition zone ranging from 30 to 35 mm. A five-week food testing procedure revealed that ZnO nanoparticles effectively inhibited foodborne pathogens with a delayed visual deterioration of tomatoes. This research signifies a promising stride in the application of zinc oxide nanoparticles in the realm of food safety and antimicrobial intervention.

***Keywords*:** Antimicrobials, Food Safety, *Listeria monocytogenes,* Nanoparticles, Peppermint Extract*,* Zinc Oxide

Anatomical adaptations of halophytes: Background for defining them as stress resilient plants

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Abstract
The nature of many anatomical adaptations of halophytes is xeromorphic, because of the physiological drought occurring in saline environments. Halophytes evolved different anatomical strategies to deal with environmental stresses (salinity, drought, waterlogging), thus defining themselves as stress resilient plants. Within these adaptations, succulence may have a dilution effect on accumulated toxic salts within plant tissues and plays a water storage role during dry periods. Intense lignification linked to successive cambia activity in roots and stems of halophytic chenopods could be also related to salinity and aridity. Salt secretion is an important strategy of recretohalophytes (crynohalophytes); salt glands and salt bladders are involved in the secretion of salt excess from aerial organs toward the exterior of halophytes. Kranz anatomy pattern occurs in C_4 halophytes as a physical support for physiological and biochemical processes typical for C_4 pathway. Bulliform or motor cells act in "amphibious halophytes" for rolling up the leaf during extended drought periods.

Keywords**:** Abiotic Stresses, C_4 Photosynthesis, Chenopods, Halophytes, Xeromorphic Adaptations

Comparative analysis of *Apocynum pictum* and *Apocynum venetum* honey: identify with nutritional and health-promoting metabolites

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Abstract
Apocynum pictum and *Apocynum venetum* are two medicinal important halophytes' plants from Xinjiang, China. However, honey derived from these plants, remains unexplored. This study investigated the physicochemical properties, essential elements, enzymatic activity, and metabolomic profiles of both types of honeys. This study identified *A. pictum* honey significantly higher peroxidase (POD) activity (19.2 ± 1.1 U/g vs. 7.5 ± 0.3 U/g), adenine content (17.5 ± 0.1 mg/g vs. 6.2 ± 0.1 mg/g), and protein levels (13.0 ± 0.5 mg/g vs. 11.2 ± 0.4 mg/g) compared to *A. venetum* honey. Mineral analysis showed potassium (76.5 ± 1.2 mg/L, 2.8 ± 0.1, 46.0 ± 1.5 mg/L), magnesium, and zinc in *A. pictum* honey, aligning with its adaptation to arid conditions. Total 735 differentially accumulated metabolites (DAMs), such as flavonoids (diosmetin, chrysin), phenolic acids (homogentisate), and alkaloids (tryptamine), linked to antioxidant, anti-inflammatory, and anticancer properties. Thus, approved *A. pictum* honey superior nutritional and therapeutic values.

***Keywords*:** Alkaloids, *Apocynum* Sp., Flavonoids, Honey Production, Phenolic Acids

Protecting agriculture with structural biology: Functional insights into conserved type II secretion systems of plant-pathogenic bacteria

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Abstract
Plant-pathogenic bacteria cause around 10% of annual crop losses. Understanding conserved molecular structures required for virulence allows for better strategies to battle plant pathogens and protect crop plants. This talk will combine *in silico* Alphafold structural modelling with *in vitro* molecular biology approaches to provide insights into the architecture of the Type II Secretion System, a widely conserved bacterial virulence factor. *Xanthomonas euvesicatoria* is employed as a model organism.

Keywords: Bacteria, Plant-Pathogens, Structural Modelling, Type II Secretion System, Xanthomonas

Development, evaluation, and molecular dynamics study of ampicillin-loaded chitosan-hyaluronic acid films as a drug delivery system

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Abstract
Periodontitis is an inflammatory periodontal disease defined by the progressive loss of tissues surrounding the tooth. Ampicillin is an antibiotic for managing and treating specific bacterial infections, including periodontitis. Periodontal pockets occur due to periodontal disease progression and act as a natural reservoir that is easily reachable for the insertion of a delivery system, and the amount of drug to be released has a major role in the efficiency of treatment of the disease. Polyelectrolyte complexes (PECs), particularly those based on chitosan and hyaluronic acid combinations, offer a promising avenue to overcome the challenges associated with drug delivery. These complexes are both biodegradable and biocompatible, making them an optimal choice for enabling targeted drug delivery. This study centers on developing and assessing the structure and dynamic attributes of a drug-PEC system encompassing ampicillin and chitosan-hyaluronic acid components, which represents a targeted drug delivery system to better alleviate the periodontitis. To achieve this goal, we conducted experiments including weight and drug content uniformity, swelling ındex, drug release %, FT-IR and SEM analyses, and atomistic molecular dynamics simulations on the drug PECs loaded with ampicillin with varying amounts of hyaluronic acid. All simulations and the experimental analysis suggested that increased HA amount resulted in an increase in drug release % and swelling index. The simulation outcomes provide insights into the nature of the drug and PEC interactions alongside transport properties such as drug diffusion coefficients. These coefficients offer valuable insights into the molecular behavior of ampicillin-PEC drug delivery systems, particularly in the context of their application in periodontitis treatment.

Keywords: Inflammation, In-Silico, Periodontitis, Polyelectrolyte Complexes

Iron nanomaterials enhance nitrogen fixation by modulating root metabolites and rhizosphere microbiome assembly in alfalfa

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Abstract
Iron (Fe) is one of the essential nutrient elements for plant growth and development. However, the potential roles of iron nanomaterials in regulating growth and nitrogen fixation and modulating rhizomicrobiome in legume plants are poorly known. In this study, we reported that 10 mg L^{-1} is the optimal concentration for the application of iron nanoparticles (FeNPs) and seed soaking plus leaf spraying is the optimal application method of FeNPs in alfalfa (*Medicago sativa* L.); FeNPs had more positive effects on the growth and nitrogen fixation capability in alfalfa than $FeCl_2$; FeNPs enhanced the intensity of corporations and competitions among rhizosphere fungal taxa of alfalfa. We also compared the effects of FeNPs, a plant growth-promoting rhizobacterium (PGPR) strain *Pseudomonas rhizovicinus* M30-35, and their co-application (Fe + M) on alfalfa growth, nitrogen fixation, root metabolites, and rhizosphere microbiome. Compared with FeNPs and M30-35, Fe + M increased shoot height, root length, root activity, chlorophyll content, and net photosynthetic rate; the nodule number, nitrogenase activity, ureide content, and leghemoglobin content also rose. Metabolomic analysis showed that Fe + M enhanced the accumulation of benzenoid compounds in roots, while microbial co-occurrence network analysis indicated reduced complexity and connectivity of rhizosphere bacterial and fungal communities. Importantly, core microbes, such as *Hydrogenophaga*, *Nocardioides*, *unidentified_Mitochondria* and *Scedosporium*, were positively associated with benzenoid compounds, which contribute to nutrient cycling in the rhizosphere. Our findings provide insights into the regulation mechanism of FeNPs on growth, nitrogen fixation, and the composition and function of rhizosphere microbial community in legume plants as well as the potential application value of FeNPs in agriculture system, demonstrating that FeNPs and PGPR strain together achieve synergistic effects on the nitrogen fixation in alfalfa.

***Keywords*:** Alfalfa, Fenps, Nodule Formation, Nitrogen Fixation, PGPR, Rhizomicrobiome, Root Metabolites

Living with Saline Lands in Harmony: Efficient Utilization of Saline Resources

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Abstract
It is well know that soil salinization is one of the major constrains for sustainable development of agriculture in the world, especially in arid and semi-arid regions, where soil salinization and water shortage co-exist. Over decades, we have developed effective strategies to manage saline soils, including enhanced salt leaching and groundwater table control via irrigation and drainage; soil structure improvement through amendments to boost infiltration and hydraulic conductivity; evaporation reduction using mulch or cover crops to limit salt accumulation in the root zone; and cultivation of salt-tolerant crops. Among these, irrigation and drainage is most efficient but demands substantial freshwater to flush excess salts from the root zone. However, freshwater resources are becoming scarce as population increases, demanding additional water for domestic and industrial use, even for the use to maintain healthy freshwater environment and ecosystem. Water for irrigation agriculture is actually becoming limited in many arid and semi-arid regions. This approach also requires high investment for infrastructure, often unaffordable for local communities and farmers, while improper drainage may cause environmental pollution from nutrient- or toxin-laden discharge. Therefore, the reclamation of saline soils faces numerous challenges including securing water resources, ensuring economic feasibility, and protecting environment. Despite these challenges, salinized regions have natural saline resources like stress-resistant halophyte plants, abundance of saline water, and land. Can we use these saline resources efficiently for food production and environment rehabilitation, and live with saline land in harmony? In this presentation, I will show some of our innovative approaches on utilization of halophytes, saline water and saline lands. The innovations on the theory, technologies, and industries of efficient utilization of saline resources will be discussed in order to expand agricultural production space, increase farmers' income, improve the ecological environment, and promote high-quality green development of agriculture.

Keywords: Arid regions, Halophytes, Irrigation and drainage, Saline resources, Soil salinity

White Sorghum: A food security crop with commercial potential to replace corn starch in food systems.

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Abstract
White sorghum is a cereal grain having ability to grow in both arid and semi-arid climates. The importance of sorghum has exponentially increased in current era because of diminishing resources and water scarcity. It is considered a food-security crop because of its adaptability to grow in drought hit areas. The largest component of sorghum grain is starch which comprises around (65-70) % of the grain. The starch is a huge international market where main players are tapioca, corn and potatoes. However, sorghum can also be used as a source for starch extraction followed by its modification to improve the functional properties. The present study investigated the application of modified sorghum starch in composite flour for ultimate use in flat bread and also explored modified sorghum starch as a fat and casein replacer in cheese. In both applications, modified sorghum starch was compared to corn starch. The results showed that composite flours prepared using combination of citric acid modified sorghum starch and wheat flour resulted in more reduction in glycemic index of flat breads but did not affect the sensory properties of the bread. In second application hydroxypropylated sorghum starch successfully replaced 15 % casein and 10 % fat in cheese with significantly higher melt and stretch values compared to control mozzarella cheese samples. In cheese application sorghum performed almost similar to corn suggesting that it can successfully replace modified corn starches in future while in flat bread, sorghum showed more efficacy to reduce *in-vitro* glycemic index.

***Keywords*:** Cheese, Corn, Flat Bread, Modified Starches, White Sorghum

Mn_3O_4 Nanoparticles from *Cressa cretica*: A Sustainable Approach to Enhance *Zea mays* L Growth

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Abstract
Green synthesis of metal oxide nanoparticles has emerged as a sustainable alternative to conventional physicochemical methods, offering eco-friendly routes with enhanced biological functionality. In the present study, manganese oxide nanoparticles (Mn_3O_4 NPs) were synthesized using the halophytic shrub *Cressa cretica* L. as a natural reducing and stabilizing agent, and their physicochemical, biological, and agronomic potential was systematically evaluated. Initial phytochemical screening of *Cressa cretica* extracts in different solvents revealed that the aqueous extract was most suitable for nanoparticle synthesis. Optimization of synthesis conditions using UV–Visible spectroscopy indicated that a 1:2 metal salt-to-extract ratio at 80 °C, pH 9, and 30 min reaction time produced stable Mn_3O_4 NPs. Comprehensive characterization using UV–Vis, FTIR, SEM, EDS, and XRD confirmed the successful formation of irregularly shaped, crystalline Mn_3O_4 NPs with sizes ranging from 70-85 nm. Stability analysis was performed through zero-point charge (ZPC). Biological evaluation revealed strong antioxidant activity of Mn_3O_4 nanoparticles. No significant antimicrobial activity was observed, possibly due to phytochemical encapsulation of the nanoparticles. In contrast to their limited antimicrobial efficacy, the agronomic application of Mn_3O_4 nanoparticles showed promising results. When applied to *Zea mays*, Mn_3O_4 NPs significantly enhanced plant growth and photosynthetic efficiency. These findings highlight a functional shift from direct antimicrobial activity toward plant growth promotion, emphasizing the role of Mn_3O_4 nanoparticles as an effective nano-fertilizer rather than a biocide. Overall, this comparative assessment demonstrates that *Cressa cretica*-mediated Mn_3O_4 nanoparticles possess growth-promoting properties. The study underscores their dual significance in advancing green nanotechnology and sustainable agriculture, particularly for improving crop productivity in salt-affected and nutrient-deficient soils.

Keywords: Characterization, *Cressa cretica*, Mn_3O_4 NPs, PSII Efficiency, Salinity

Cell-based phenotyping for breeding crops for future climates

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Abstract
Agriculture is vulnerable to climate change, and sustainable agricultural food production will be not achievable by the current agronomical and breeding practices, due to impact of climate changes and associated abiotic stresses on crop performance. At the same time, tolerance to key abiotic stresses (such as drought; heat; salinity; flooding) is conferred by multiple mechanisms. Each of them operates in a specific tissue/cell type and is regulated by multiple genes. In this context, the (empirical) whole-plant phenotyping (regardless of whether it is hyperspectral imaging, or ionomics, or any other whole-plant based trait) will be always critical for a final validation of genetic material (e.g., in field trails) but is unlikely reveal the role of a specific mechanism/gene, amongst others. To be more effective, breeding targets can be directed towards specific mechanisms. In this talk, I will argue for a need for a paradigm shift from whole-plant to cell-based phenotyping approach and discuss its current prospects and limitations. Using salinity stress as an example I will show the pitfalls of the whole-plant phenotyping approach for crop breeding, and then illustrate how using cell-based phenotyping platforms allow to overcome this problem. I will then demonstrate how combining novel electrophysiological and imaging techniques can be used for discovery of the candidate genes and/or QTLs conferring not only salinity but also tolerance to other abiotic and biotic stresses. I will also argue for a need for a broader use of wild relatives, to regain abiotic stress tolerance that was lost during domestication process.

Keywords: Abiotic Stresses, Agriculture, Cell-Based Phenotyping, Climate Change, Ionomics, Salinity

The Effect of Multiple Abiotic Stresses on Ecophysiological Responses of *Panicum antidotale*

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Abstract
The rapid fluctuations in global climatic patterns generate various abiotic stresses which affect all living organisms throughout the world. Such abiotic stresses include salinity, drought, alkalinity, heat, flooding, and heavy metal stresses etc. Various studies revealed that abiotic factors affect the individual or in combination, collectively called as multiple factor stress combination (MFSC) which alters the growth and yield of plants, especially crops. The global population increases very hastily that creates a pressure on agricultural land, threatening food, fodder, forage, and resource availability. To overcome such problems we designed an experiment based on the ecophysiology of a xero-halophytic grass *Panicum antidotale* by applying multiple abiotic stress combinations. Our study included individual (salinity, drought, alkalinity, and heat) stress, combinations of two, three and four stresses. In this study, we found positive, negative and neutral effects of combined stress treatments as compared to individual stresses on *P. antidotale*. The physiological and biochemical functions were up and/or down regulated under stress conditions applied. However, Panicum showed high adaptability to avoid stress conditions by osmotic adjustment, modification in anatomical features, activated the antioxidant defense system to survive in combination of stresses. This study revealed new combinations and novel responses of *P. antidotale* under multiple combined stresses. Thus, these findings will help to better understand how plants, especially crops, mitigate the harmful effects of multiple combined stress. Climate-resilient crop *P. antidotale* will allow to meet future challenges of food security and will achieve our goals of "No poverty" and "Zero hunger."

Keywords: Climatic Resilient Crops, Ecophysiology, Halophytes, Multiple Abiotic Stresses

Rice for Food Security: Integration of Aroma, Quality and Sustainable Rice Production Addressing Climate Change

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Abstract
Pakistani rice is the best known for its high-quality attributes both in cooking and sensory characteristics. Among all the fine quality characteristics, aroma is regarded as the best quality for rice both in local as well as in international market. It is reported that fragrant rice varieties having low vigor and poor resistance against abiotic stress factors due to functional loss of betaine aldehyde dehydrogenase (BADH2) which decreases the yield and diminishes the aroma at reproductive stage. 2-acetyl-pyrroline (2AP) is the potent volatile compound responsible for fragrance in rice. 2-acetyl-pyrroline biosynthesis pathway is mainly regulated by these genes (pyrroline-5-carboxylate (P5C), betaine aldehyde dehydrogenase (BADH2) and precursors. Proline is an amino acid playing a dual role as a compatible solute (osmoprotectant) to enhance plant tolerance and precursor in the formation of 2AP. Therefore, the study was designed to explore the functional mutations in BADH2 and their relationship with 2-AP in Pakistani rice varieties along with their chemical basis. Genetic analysis revealed that 12 rice varieties have 8bp deletion and 3 SNPs in exon 7 of badh2 gene that establishes the role of these mutations in aroma production by validating the quantification of 2AP and proline. Furthermore, 2-D gel electrophoresis analysis revealed that proline treatment upregulated the aroma related proteins expression under high temperature proving dual role of proline. Proline mediated regulation of BADH2, ProDH and P5CS gene expression in aromatic rice at flowering and grain filling stages was also evaluated along with quantification of intermediates of 2AP metabolism. Results showed that exogenous application of proline significantly enhanced the 2AP biosynthesis intermediates accumulation (proline, nitrogen) with decreased accumulation of GABA. Gene expression analysis showed upregulation of ProDH and P5CS gene while BADH2 is downregulated at flowering and grain filling stages. Another food security issue for rice is arsenic accumulation. The effect of application of silicic acid was evaluated and SEM images of rice leaves showed the anatomical adaptation as cuticle thickenings along with deposition of silica in silicon treated plants. Silicon deposition was also evident by EDX spectra while arsenic was not detected in silicon supplemented rice seedlings under arsenic stress. These findings will be helpful in understanding the factors contributing to rice aroma and developing a shotgun approach (foliar application) for maintaining aroma in harsher climate with reduce arsenic content, that could be implemented in rice breeding programs.

***Keywords*:** Aromatic Rice, FGR Gene, Stress Tolerance, Proline Application, Rice Quality

Restriction of arsenic uptake and translocation: The modulation of OsLsi1 arsenic influx transporter through silicon application in rice seedlings

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Abstract
Arsenic being a toxic metalloid severely affects rice plant growth and development. Due to the rhizospheric coexistence and presence of Lsi1 influx transporter, arsenic enters in rice roots and hinders various metabolic processes. It is reported that silicon exposure enhances plant growth and development under various biotic and abiotic stresses including heavy metal toxicity but its role in mitigation of arsenic stress is not fully understood. The current study examines the role of silicon application in reducing arsenic uptake and translocation in above-ground parts through the regulation of influx transporter (Lsi1) and enhancing iron plaque formation. In this study, rice seedlings of non-aromatic variety (IR-6) and aromatic variety (Super basmati) were grown in hydroponic system for 28 days. For arsenic stress, 25 µM and 50 µM sodium arsenite were applied along with 1 mM silicic acid (Treatment groups: As0, As25, As50, As25 + Si and As50 + Si). The obtained results of qRT-PCR indicated that silicon application significantly reduced relative expression of influx transporter (*Oslsi1*) by 2.29 and 1.58 folds in super Basmati, while 1.61 and 2.02 folds in IR-6 in 25 and 50µM arsenic stressed seedlings, respectively. Furthermore, results of Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) demonstrated the enhanced iron plaque formation by 98.87% and 90.13% at 25 and 50 µM arsenic stress in Super basmati and by 70.28% at 50 µM arsenic stress in IR-6, respectively. Subsequently, arsenic uptake in rice roots was decreased by 57.41% and 61.39% at 25 and 50µM arsenic stress, respectively in Super basmati. Whereas, 24.35% and 4.56% decrease was observed in IR-6 roots at 25 and 50 µM arsenic stress respectively. Consequently, silicon application decreased arsenic translocation from roots to above-ground parts by 15.43% and 12.58% at 25µM arsenic stress while 25.59% and 18.30% at 50µM arsenic stress in Super basmati and IR-6 respectively. Hence, these findings suggested that silicon application restricts the arsenic uptake and translocation and ultimately reduce its phytotoxicity. This study would serve as a step towards developing the approach for the rice grains with reduces arsenic content. This mitigation strategy will be helpful in environmental sustainability along with ensuring food security.

Keywords: Arsenic Influx Transporter, Heavy Metal Stress, ICP-MS, Iron Plaque Formation, Silicon Supplementation

Genetic Analysis of Starch Composition, Eating Quality and Glycemic Index in Pakistani Rice for Climate-Resilient Breeding

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Abstract
Climate change is a threat to future rice production as most of world's rice is grown in Asia. To develop environment resilient and globally adaptable rice varieties, genetic diversity of rice regional germplasm like Pakistan is crucial to identify superior germplasm with better eating and cooking qualities (ECQs). Starch composition is not only an important determinant of rice ECQs but also determines the health effects particularly glycemic index (GI). Thirty-two varieties from Pakistan and Nipponbare (japonica control) were tested for the polymorphisms of starch synthases genes with respect to amylose content (AC), gelatinization temperature (GT) and glycemic index. AC ranged from 16-30 % and Alkaline spreading value (ASV) ranged from 2 to 7 and there was no correlation between these two traits. Kompetitive allele specific-PCR (KASP) genotyping assays targeted SNPs for twenty-one loci in six starch synthesizing genes and an InDel for aroma. The 23 non-aromatic rice had higher AC (mean 25.4 %) than the 10 aromatic rice that had a AC of 21.9%. All Pakistani rice tested had Wxa (G) alleles, previously reported as responsible for high AC while low AC Wxb (T) allele was present in Nipponbare only. Three other alleles of this gene (wx, Wxmq and Wxop) were absent in rice from Pakistan. Three functional exonic Wx loci were significantly correlated with AC and ASV. Polymorphism patterns were similar between these three functional loci and four non-functional loci of Wx, indicating that both intronic and exonic positions can be useful for the selection of Waxy phenotypes. The locus for OsSSII_b or alk was also significantly associated with AC: non-aromatic rice had alkj (GC) alleles whereas, all aromatic varieties had alki (TT) alleles. The population was structured into four main subgroups mainly corresponding with four haplotypes of Wx. None of the functional loci for alk, BADH2, PPR and OsSSI were significantly associated with AC. All loci of these except OsSSI were highly associated with the rice GT. Most of these rice varieties have a genetic combination that is desirable for superior eating and cooking quality (ECQ) rice. The GI was intermediate except Lateefy variety that had high GI. GT was more influential on rice GI than AC. The combination of fgr deletion, intermediate Wxin and stronger alki had lower eGI and can be used for marker assisted selection of aromatic, intermediate AC and high GT rice varieties which are desirable traits in national and international markets.

Keywords: Amylose, Aroma, Gelatinization, Starch Syntheses, Temperature

Eco-physiological and Biochemical Responses Illustrating Seed Tolerance to Various Abiotic Stresses in the Co-occurring *Suaeda* Species from the Salt Deserts of Qatar

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Abstract
Climate change poses a serious threat to plant survival, particularly during the sensitive seed germination stage. This study compared germination responses and stress tolerance in two co-occurring halophytes, *Suaeda aegyptiaca* and *S. vermiculata*. Seeds of both species were non-dormant and showed high germination at low to moderate temperatures, but germination reduced sharply at high temperatures, especially in *S. aegyptiaca*. Increasing salinity and alkalinity reduced germination in both species; however, ungerminated seeds showed substantial recovery upon stress removal, even under severe conditions. Overall, *S. vermiculata* showed better germination and recovery under prolonged salinity, flooding, and drought stresses. Biochemical assays indicated greater salinity-induced damage as assessed via lipid peroxidation in *S. aegyptiaca* seeds than drought. Seeds of both halophytes activated antioxidant defenses but employed different strategies. Seeds of *S. aegyptiaca* mainly relied on enzymatic antioxidants (APX, SOD) to cope with salt stress, while *S. vermiculata* showed greater drought tolerance through increased levels of the non-enzymatic antioxidant GSH. These results indicate metabolic diversity in two co-occurring *Suaeda* species in response to abiotic stresses, and greater tolerance responses of *S. vermiculata* also coincide well with its broader distribution in diverse habitats compared to *S. aegyptiaca*.

Keywords: Biochemical Responses, Climate Change, Germination Eco-Physiology, Seed Germination, Stress Tolerance

Exploring the functionality of starch from climate resilient Pearl millet: A comparative study with corn starch for food security

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Abstract
Pearl millet (*Pennisetum glaucum*), locally known as 'bajra', is recognized as a climate resilient nutri-cereal owing to its rich nutritional profile and adaptability to grow in harsh conditions. These traits make this crop a significant contender for addressing food insecurity challenges in Pakistan. Commercially available starches are primarily isolated from corn, wheat and potato, all of which possess significant food value. Therefore, this research aimed to isolate starch from less exploited starch resource i.e. pearl millet grains, chemically modify it and compare the technofunctional and in vitro digestibility characteristics with corn starch. Briefly, both starches were modified via citric acid (CA) at 10, 20 and 40% (w/w) and designated as CR_{10}, CR_{20}, CR_{40} for corn starches whereas, PM_{10}, PM_{20}, PM_{40} for pearl millet starches, respectively. Additionally, CR_c and PM_c denoted native corn and pearl millet starches. Scanning electron micrographs revealed that CA modification up to 20% level had no significant impact on the granule morphology, while CR_{40} and PM_{40} depicted slight rough surfaces. Swelling power increased and solubility increased due to CA modification but more pronounced impact was observed in CR starches. Interestingly, CA modification significantly increased the resistant starch content at all levels with the greatest increment observed for CR_{40}. The CR_c and PM_c starches showed A-type X-ray diffraction patterns with a decline in percent crystallinity with concomitant increase in CA levels. The outcomes of this study suggested that native and modified pearl millet starches could be efficiently utilized to replace commercially available corn starch ensuring food security in Pakistan.

***Keywords*:** Citric Acid Modification, Corn Starch, Pearl Millet Starch, Resistant Starch

Impact of Climate Change on Water Resources in Pakistan and the Role of Smart Agriculture

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Abstract
Climate change is increasingly reshaping water resources in Pakistan, posing serious threats to water security, agriculture, ecosystems, and human livelihoods. From the glaciers of the Hindu Kush–Karakoram–Himalaya (HKH) region to the plains of the Indus Basin, rising temperatures, altered precipitation patterns, and accelerated glacier melt are transforming the country's hydrological systems. Pakistan is experiencing more frequent floods, prolonged droughts, groundwater depletion, and declining water quality, making water scarcity a present and growing reality. The HKH region, often referred to as the "water tower of Asia," feeds major river systems that support millions of people, yet its glaciers are rapidly retreating, increasing the risk of glacial lake outburst floods (GLOFs), landslides, and seasonal water variability. These changes directly affect the Indus River system, which is the backbone of Pakistan's agriculture and food security. Agriculture consumes the largest share of Pakistan's water resources and is highly vulnerable to climate-induced water stress. Traditional irrigation practices are inefficient and increasingly unsustainable under changing climatic conditions. In this context, smart agriculture emerges as a critical adaptation strategy. Smart agriculture integrates precision irrigation, climate-resilient crop varieties, soil moisture monitoring, weather-based advisories, remote sensing, GIS, and digital decision-support tools to enhance water-use efficiency and crop productivity. By optimizing water application, reducing losses, and improving climate responsiveness, smart agriculture can significantly reduce vulnerability to droughts, floods, and heat stress. However, the adoption of smart agriculture in Pakistan faces several challenges, including high initial costs, limited technical capacity, inadequate digital infrastructure, small landholdings, weak extension services, and policy and institutional gaps. Addressing these barriers through targeted investments, capacity building, institutional strengthening, and supportive policies is essential. Integrating smart agriculture into national climate and water strategies can play a transformative role in building climate-resilient, water-efficient, and sustainable agricultural systems in Pakistan.

***Keywords*:** Climate Change, Glacier Melt, Indus River System, Smart Agriculture, Water Security, Water Resources

The Impact of Plant Growth-Promoting Microbes on Biocide Action and the Nutritional Profile of Okra (*Abelmoschus esculentus*)

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Abstract
Global consumer demand for sustainable and organic produce is rapidly increasing, driven by heightened awareness of health, environmental impact, and the nutritional value of pesticide-free food. Consequently, the agricultural use of microbial plant biostimulants is an increasing market. While extensive research focuses on their role in mitigating plant stress, there is a distinct gap in literature regarding their specific impacts on post-harvest fruit quality, including appearance, chemical composition, and physical longevity. This study investigates the efficacy of novel microbial biostimulant consortia—comprising wild plant-isolated fungi strains integrated with organic soil amendments—on the nutritional content and overall quality of *Abelmoschus esculentus* (Okra) under field condition. The assessment included comprehensive evaluations of fruit quality, biomass production, and stress resistance indicators. The results confirm that these inoculants possess multifaceted benefits, exhibiting robust plant growth-promoting traits alongside significant in vitro and in vivo disease resistance and pathogenicity suppression. Final observations revealed enhanced defense system induction, reduced infection rates, and superior fruit quality. These findings suggest that the tested microbial biostimulants offer efficient direct and indirect protection against a variety of major crop diseases, positioning them as valuable bio-control inoculants for future sustainable agriculture.

Keywords: Biostimulants, Nutritional Content, Okra, Soil Amendment

Eco-Smart Poultry Agriculture: Opportunities and Challenges in Pakistan

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Abstract
The poultry sector plays a critical role in Pakistan's agricultural economy by contributing significantly to food security, employment generation, and affordable animal protein supply. However, conventional poultry production systems increasingly face challenges related to environmental degradation, rising input costs, climate variability, and public health concerns. Eco-smart poultry agriculture has emerged as a sustainable approach that integrates resource efficiency, environmental protection, and technological innovation to enhance productivity while minimizing ecological impact. This paper examines the opportunities and challenges associated with adopting eco-smart poultry practices in Pakistan. Key opportunities include growing market demand for poultry products, utilization of renewable energy sources, waste-to-value systems such as biogas and organic fertilizers, and the adoption of smart technologies for improved feed efficiency and disease management. At the same time, the sector faces major constraints, including high feed costs, limited access to finance, inadequate infrastructure, weak biosecurity systems, and insufficient policy support for sustainable practices. Climate change and disease outbreaks further exacerbate production risks. The study highlights the need for coordinated policy frameworks, capacity building, and public-private collaboration to facilitate the transition toward eco-smart poultry systems. Promoting sustainable poultry production can enhance environmental resilience, improve farmer livelihoods, and contribute to long-term agricultural sustainability in Pakistan.

Keywords: Eco-Smart Poultry Farming, Environmental Sustainability, Resource-Efficient Livestock Farming, Feed Efficiency Management, Poultry Disease Management

Trichome Development Genes as Key Regulators of Plant Stress Resistance: Mechanisms and Applications

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Abstract
Trichomes, the epidermal structures on most terrestrial plants, constitute a primary interface with the environment and are crucial for defense against biotic and abiotic stressors such as herbivory, high radiation, and drought. Over 100 genes regulating their initiation, differentiation, and branching have been identified, predominantly encoding transcriptional regulators. This review systematically classifies these developmental genes and explores an emerging paradigm: their potential multifunctionality in broader stress response pathways. We discuss the crosstalk between developmental and stress signaling networks, proposing that trichome genes are integral nodes in plant resilience. Deciphering these mechanisms in model species illuminates the evolution of adaptive structures and unlocks key genetic targets. Ultimately, this knowledge paves the way for genetic engineering strategies to enhance stress tolerance in crops, contributing to the development of climate-resilient agricultural systems for future food security.

Keywords: Genes, Regulators, Stress, Tolerance, Trichomes

Exploring the Effects of Zeolite/Zinc Oxide Nanocomposites on *Zea mays* Under Drought Stress

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Abstract
Drought stress is an environmental constraint, limiting the productivity of key cereal crops such as *Zea mays*. Conventional soil treatments for drought resilience, such as Zinc Sulphate and Zeolite offer some relief, but newer methods based in nanotechnology offer potential for a higher efficacy for such growing challenges. This study investigated the potential of zeolite/zinc oxide nanocomposites (NC) to enhance drought resilience in maize (variety NK 7530). Nanocomposites were synthesized at a 1:1 weight ratio, characterized via SEM, EDX, and FTIR, Nanocomposites were found to have an average particle size of 85 nm, with EDX and FTIR confirming purity and presence. Maize plants were subjected to two watering regimes: well-watered (W) and drought-stressed (D). Treatments included varying concentrations of nanocomposites (20–640 ppm), alongside positive controls (zinc sulfate, zeolite) and negative controls. Results from one-way ANOVA indicated that nanocomposite treatments significantly improved several physiological and growth parameters under drought stress. Notably, NC 320 D and NC 40 D treatments yielded the highest levels of chlorophyll a (F = 4.614, p < 0.001) and total chlorophyll (F = 6.466, p < 0.001), significantly outperforming drought controls. Significant improvements were also observed in shoot length (p = 0.046), fresh root and shoot biomass (p < 0.001 and p = 0.037, respectively), and relative water content (RWC) (p = 0.037). While morphological traits like leaf and flower count remained largely unchanged, the nanocomposites aided in osmotic adjustment and protected against pigment degradation. These findings suggest that zeolite/ZnO nanocomposites surpass conventional zinc supplements in maintaining the water status, and photosynthetic machinery of maize during drought, implying that a strategy based in nano-agronomy is key for sustainable agriculture in water-limited environments.

***Keywords*:** Chlorophyll, Drought, Maize, Nanocomposite, Plant, Zinc

Green Synthesis of Manganese Nanoparticles and Its Effect on Plant Growth Under Stress Condition

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Abstract
This study reports the green synthesis of manganese nanoparticles using *Cassia fistula* leaf extract as a reducing and stabilizing agent. An aqueous extract of *C. fistula* leaves was employed to synthesize manganese nanoparticles from potassium permanganate ($KMnO_4$). The synthesized nanoparticles were subsequently incorporated into fertilizer formulations to enhance drought resistance in plants. This eco-friendly approach integrates the bioactive potential of *C. fistula* with the functional properties of manganese nanoparticles to develop a sustainable agricultural solution. Manganese nanoparticles exhibit unique optical, magnetic, and catalytic properties that can improve nutrient uptake efficiency and strengthen antioxidant defense mechanisms in plants under stress conditions. Their application in fertilizers aims to mitigate the adverse effects of drought stress and improve overall crop productivity. The results demonstrate that nanoparticle-enriched fertilizers can significantly enhance plant tolerance to water scarcity. This integrated strategy highlights the potential of nanotechnology as an innovative tool to address critical agricultural challenges associated with climate change and water limitations. Furthermore, the study emphasizes the importance of bio-inspired nanoparticle synthesis in promoting environmentally sustainable practices and ensuring long-term food security.

***Keywords*:** *Cassia fistula*, Drought Resistance, Nanotechnology, Manganese Nanoparticles, Sustainable Agriculture

Climate Change Mitigation Toolkit For Sustainable Agriculture: Half Decade of Strategic Research

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Abstract
The world is facing a serious problem of climate change. Natural disasters and abrupt changes in climate including heat, drought, waterlogging and salinity, bring lot of challenges to sustainable agricultural production. The uncontrolled urbanization is engulfing lot of productive agricultural land. While the food demand is continuously increasing due to rapidly growing population. To overcome these challenges there is dire need of strategic research to develop effective strategies for the enhanced production of crop plants. In this regard, the Institute of Botany, Bahauddin Zakariya University Multan along with some national and international collaborators, is significantly contributing in developing some strategic tools for the mitigation of drastic effects of various environmental constraints for the sustainable agricultural production. This toolkit includes the use of osmoprotectants and osmoregulators; biofertilizers; biochar; plant growth promoting microbes such as endophytic bacteria, rhizospheric bacteria and mycorrhizae; biofortification; nanoparticles, classical breeding and genetic engineering. Some of the bacterial strains isolated from the rhizosphere of Cholistani grasses have been screened as effective in growth promotion and drought and salinity stress amelioration in Maize, Pearl millet, Mung beans and Guar plants. The foliar application of ascorbic acid, salicylic acid and alpha tocopherol have strengthened the growth and have helped in drought and salinity stress management in Wheat, Maize, Pearl millet, Sunflower, Barley, Canola and Quinoa plants. The cross breeding of various wheat varieties resulted in some new promising lines with enhanced production and stress tolerance. Some of these lines are under field trials. Transgenic approaches are being utilized in heterologous expression of the genes of some WRKY transcription factors, defensin-like peptides, thionin-like peptides, AVP1, HKT1 and Cry2A to induce tolerance against heat, salinity, drought, bacterial blight, nematodes and insects in Arabidopsis, Tobacco and Cotton plants. The comparative studies of morphology, anatomy, biochemical profile, antioxidants profile, reactive oxygen species (ROS) analysis, physiological mechanisms, molecular signaling pathways insights and differential genes/proteins expression analysis, provide better understanding of the stress management strategies by tolerant plants. These investigations and applied contributions will be helpful in enhancing productivity of the crops plants for sustainable agriculture in changing climate.

Keywords: Biochar, Biofertilizers, Climate change, Osmoprotectants, Salinity stress, Transgenic approaches

Importance of Microbial diversity in Health, diseases and stability of Ecosystem

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Abstract
Microbial diversity in nature is very important in health and diseases. It consists of a range of different kinds of unicellular organisms, bacteria, archaea, protists, and fungi in different habitats. It is one of dynamic and crucial for ecosystem stability, and nutrient cycling. Unfortunately, most of the organisms are uncultivable in labs. The diverse groups of microbes thrive throughout the biosphere, defining the limits of life and creating conditions conducive for the survival and evolution of other living beings. Humans have around 100 trillion gut microbes that produce a wide range of enzymes, chemicals, hormones, and vitamins and potentially interact with their bodies. Studies have shown that disruption of this intricate system (dysbiosis) and low diversity are associated with many metabolic diseases including obesity, diabetes, etc. Similarly, Medicinal plants harbour endophytic microorganisms. Many of the pharmaceutical compounds produced by medicinal plants are reportedly produced by their endophytic organisms. Only a few plants have been studied for their endophyte biodiversity and their potential to produce bioactive secondary metabolites. There is a need to understand the biodiversity of endophytic fungi and their potential of producing novel compounds of medicinal importance. Hence, it is important to study medicinal plants for their endophytic organisms for biodiversity and then to determine their medicinal properties. *Withania somnifera* (L.) Dunal is known to possess medicinal properties. Thirty-three fungal strains of 24 species have been reported, The highest species richness as well as frequency of colonization was in stem; with the exception of Aspergillus niger, A. terreus and A. alternata, all the other fungi were found to be organ-specific.

Keywords: Aspergillus, Biosphere, Diseases, Endophytes, Fungi, Microbes

Efficacy of medicinal plants Increases with Intermittent Fasting and Calorie Restriction in a diabetic mouse model.

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Abstract
Pakistan is the top country with a prevalence rate of more than 31% among the adult population. Its prevalence is also rising in all countries. Many patients living with diabetes has difficulties in getting appropriate treatment due to the cost and availability of suitable drugs. Nevertheless, complications of diabetes may result in serious consequences to vital organs and overall health. Food with a high glycemic index not only gives high sugar peaks but also enhances insulin levels. Continuous high insulin levels or peaks may induce chronic inflammation, eventually affect β-cell function, and sometimes lead to insulin resistance, leading to Type 2 Diabetes. Intermittent fasting is becoming a popular method with a calorie-restricted diet to manage type 2 diabetes. The role of antioxidants and anti-inflammatory agents in controlling diseases is well recognised. A low-calorie diet with intermittent fasting reduces inflammation. In the current study, diabetic mice were produced and then treated with regular feed containing flaxseed, chia seed, and moringa leaves powder separately or a mixture of all, for eight weeks, and their blood glucose levels were tested. Interestingly, all treatments showed a significant drop in blood glucose levels. However, flaxseed was found to be the most effective in lowering blood glucose levels from (125-150mg/dl) to (82-87mg/dl) within three months under intermittent fasting and a calorie-restricted diet. Diabetes is a reversible disease; it can be achieved by reducing calorie intake, following intermittent fasting, and increasing the uptake of more antioxidants.

Keywords: Antioxidants, Diabetes, Drugs, Flaxseed, Glycemic, Inflammation

A Review of the Halophytic Vegetation and Flora of Saudi Arabia

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Abstract
A preliminary study of the halophytic vegetation of Saudi Arabia was carried out. Ten major halophytic communities were recognized based on field observations. The halophytic flora of Saudi Arabia indicated high species diversity with 189 species from 118 genera and 45 families of flowering plants. Members of Amaranthaceae (26%), and Poaceae (14%) dominated the vegetation and hosted 43 C_4 plant species, including two single cell C_4 (*Bienertia sinuspersici* and *B. cycloptera*) and one CAM species with reported photosynthetic type in this study. Phanerophytes (34%), followed by Chaemophytes (22%) and Hemicryptophytes (19%) were the major life forms. High propensity of adaptations for salt and drought tolerance was found in halophytes reported in this study. Leaf recreting (62), root recreting (46) species made up about 57% of the halophytic flora followed by leaf succulent (54), and stem succulent (15) plants. Most of the species (>100) were eu-halophytes with xero-halophytic character typical of the Saharo-Sindian (SS) phytogeographic elements. The monregional species (SS, 103) were followed by plurigerional (48) species with much low representation in bi-regonal (20), tri-regional (1), cosmopolitan (7) and pantropical (5) chorotypes. North and South Hijaz were the diversity hotspot areas possibly due to high habitat diversity. Ten communities were identified based on dominant halophyte species: 1) *Halocnemum strobilaceum* and 2) *Halopeplis perfoliata* from muddy salt flats, 3) *Arthrocaulon macrostachyum* and 4) *Salicornia europea* in salt marshes, 5) the hydro-halophytes, 6) Mangrove, 7) Halophytic shrubs, 8) *Tamarix* communities, 9) Hydrophillous types and 10) annual halophytic communities. The diverse halophytic vegetation represents a valuable resource of stress tolerant species with considerable economic and ecological potential. The need for more work on the photosynthetic pathways and conservation status is stressed.

Keywords: Biodiversity, Conservation, Ecology, Halophytes, Plant Type, Xerophytes

Challenges of Mangrove Habitat Loss: A potential security threat to seafoods crises

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Abstract
Mangrove forests are vital ecosystems at the intersection of land and sea that provide food resources, supporting the food security and livelihoods of coastal communities in tropical and subtropical areas. This systematic review investigated the food and medicinal potential of mangrove species in Indonesia, with relevant global insights incorporated to enrich the context. The review also examines how environmental degradation affects the productivity of these resources and identifies the key knowledge gaps related to sustainable use and management practices. A comprehensive search revealed 31 articles that met the screening criteria. The findings highlight *Nypa fruticans* and *Bruguiera gymnorrhiza* as the most frequently utilized mangrove species for food, with their leaves, fruits, and plant sap being consumed directly or processed into products such as syrup, flour, and fermented beverages. These mangrove-derived foods hold not only nutritional importance but also cultural and traditional value for local communities. In addition to their role as food sources, several mangrove species possess notable medicinal properties, including antioxidant, anticancer, antidiabetic, and antimicrobial activities, indicating their dual potential in nutrition and healthcare. Despite their ecological and socioeconomic value, mangrove resources face productivity threats from environmental degradation and unsustainable practices. This review identifies key knowledge gaps, particularly the limited research on underutilized mangrove species with food or medicinal value. This review underscores the role of mangrove-derived foods and medicines in advancing sustainable development by supporting coastal food security, promoting health, and contributing to the achievement of global sustainability goals, particularly SDG 2 (Zero Hunger) and SDG 15 (Life on Land). Future research and policy interventions that integrate food security objectives into mangrove conservation and rehabilitation efforts are needed. Strengthening sustainable mangrove management and increasing awareness of their benefits will be key to guaranteeing the long-term resilience of coastal communities in the face of climate and environmental change.

Keywords: *Bruguiera*, Food security, Coast, communities, Mangroves

Comprehensive Functional Characterization of CCCH Tandem Zinc Finger Protein Genes in Rice

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Abstract

A number of zinc finger proteins are known to function in biotic and abiotic stress responses. In rice there are nine CCCH tandem zinc finger protein genes. The expression profiles of tandem zinc proteins genes were analyzed. The expressions of OsC_3H_{10} and OsC_3H_{50} were induced by drought and NaCl. The expressions of other 07 genes were also regulated by different biotic and abiotic stresses. For sub-cellular localization, the coding regions were cloned in frame with Green Fluorescent Protein (GFP). OsC_3H_{10}-GFP was localized in cytoplasmic foci and at times in nucleus. Similarly, OsC_3H_{50}-GFP protein localization was observed in the cytoplasm and nucleus. The coding region of these genes were cloned adjacent to maize (*Zea mays*) ubiquitin promoter in pBI binary vector and transformed into *Agrobacterium tumefaciens* (EHA105). The regenerated putative transgenic plantlets were confirmed by Northern blot analysis. Transgenic rice plants overexpressing these genes driven by ubiquitin promoter displayed different phenotypes upon maturity. *Ubi*:OsC_3H_{10}-OX plants showed improved tolerance to drought stress while *Ubi*:OsC_3H_{50}-OX were tolerant to both drought and NaCl stress. Microarray analysis revealed that compared to control, 695 genes revealed 2.0-fold or greater changes in *Ubi*:OsC_3H_{10}-OX. Out of 695 genes, 189 genes were up-regulated and 506 genes were down-regulated in microarray analysis of *Ubi*:OsC_3H_{10}-OX rice. Microarray analysis showed that genes related to stomata, chlorophyll, reactive oxygen species, and abiotic stresses were regulated in *Ubi*:OsC_3H_{10}-OX rice. Our comprehensive analysis of CCCH tandem genes shed light on their functions. The results reveal that these genes are involved in conferring abiotic stress tolerance in rice and they should be analyzed further for specific functions in abiotic stress tolerance.

Key words: Rice, Zinc finger protein, *Agrobacterium*, Ubiquitin promoter

***ABSTRACTS*:**

Poster Presentations

Eco-Smart Grafting Strategies to Enhance Salinity and Stress Resilience in *Ziziphus jujuba* for Saline/Arid areas

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Abstract
Eco-smart agriculture demands sustainable strategies that enhance crop resilience and productivity under increasing salinity, water scarcity, and climate variability. Grafting is an effective biological approach for improving stress tolerance by exploiting rootstock–scion interactions, particularly in perennial fruit crops cultivated on marginal lands. In *Ziziphus jujuba* Mill. (Chinese jujube), long-term field observations have revealed the emergence of distinct phenotypes originating from genetically similar rootstocks, suggesting complex regulation of stress responses beyond genetic uniformity. This study aims to elucidate rootstock-mediated phenotypic plasticity in jujube with a specific focus on salinity and abiotic stress resilience. Phenotypically divergent rootstocks of comparable age and origin will be grafted with a uniform scion and evaluated under controlled conditions. Morphological traits, growth performance, photosynthetic efficiency, water relations, and ion homeostasis will be assessed alongside key biochemical markers associated with oxidative stress and osmotic adjustment. To uncover regulatory mechanisms, transcriptomic, metabolomic, and epigenetic analyses will be integrated to identify stress-responsive pathways linked to phenotypic divergence. Multivariate statistical tools, including principal component analysis, will be used to relate physiological and molecular responses. The outcomes are expected to provide mechanistic insights into rootstock-driven stress adaptation and resource-use efficiency. This research supports the development of climate-smart and salinity-resilient horticultural systems and contributes to sustainable food production in arid and salt-affected environments.

Keywords: Crop Resilience, Rootstock–Scion Interaction, Salinity Stress, Phenotypic Plasticity, Stress Resilience, *Ziziphus jujuba*

Tissue specific ion flux and salt secretion in *Urochondra setulosa*: Insights into Climate-Smart Agriculture on saline lands

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Abstract
This work is focused on the growth attributes, ion-flux and salt secretion rates of *Urochondra setulosa* (high salt resistant grass) under **1)** different concentrations of NaCl (0, to 600 mmol L-1), **2)** different duration with salinity exposure (0 to 30 days), **3)** different light intensities (low – 500 µmol and high - 1500 µmol m-2 s-1), and **4)** different seasons (winter and summer) in natural field condition. Optimal plant growth was fond at 50 mmol L-1 while plant resists high salinity by utilizing $Na^+$and Cl^- as a cheap osmotica to maintain tissue water content and keep nutrient ($NO3^-$ and $NH4^+$) homeostasis. Ion secretion mechanism excluded >50% absorb Na^+ and Cl^- to protect plant from ion toxicity. The accumulation of Na^+ and Cl^- was high in root than shoot during early period (within a week) of salinity treatment. The higher accumulation of Na^+ and Cl^- in shoot than root during long term salinity exposure is directly linked with high salt secretion rate. High light enhanced the ion uptake and ion secretion rate in comparison of plant growing in low light condition. In winter, soil of *U. setulosa* habitat had high EC (due to increase in Na^+, Cl^-, $NO3^-$ and $NH4^+$ content) than summer season. Moreover, the high Na^+ and Cl^- secretion in winter is linked with their soil salt content. Knowledge of tissue related ion flux and salt secretion can help us in understanding the ability of the plants to survive in a saline habitat and improve the salt-tolerance of crops like low salt secretor-*Zea mays*.

Keywords**:** Ion Flux, Nutrient Homeostasis, Osmotica, Recretohalophyte, Salt Gland, Salt Secretion Rate

Eco-friendly Compost Production from Banknote Currency Waste and Manure for Sustainable Waste Management and Biomass Yield

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Abstract
Rapid urbanization and population expansion have intensified solid waste management challenges across urban and rural areas. Waste is one of the major challenges in ensuring environmental safety and human health. In the present study, discarded banknotes were valorized as a bio-compost to synthesize a green bio-fertilizer along with cattle manure on maize plants under greenhouse conditions. Fully characterized bio-compost was prepared with increasing concentrations of 2, 4 and 6% w/w compost (1:1 w/w cow manure and discarded bank notes). Maize plants were grown in a netted greenhouse under ambient environmental conditions. Plant growth was optimal in the 4% and 6% compost treatments compared to the other treatments, including the control and 4% treatment. Soil electrical conductivity (ECe), water holding capacity (WHC), organic matter (OM), increased with increasing compost concentrations (2, 4 and 6%). In general, compost-treated plants had higher biomass than the controls. Higher biomass production in 4% compost treatment may be associated with upregulated photosystem II as a consequence of improved soil (WHC) and plant water relations (leaf turgor). The results in this experiment suggest that discarded banknotes could be recycled as bio-compost for obtaining higher crop yields. However, further experiments are needed for safe use on a larger scale.

***Keywords*:** Composting, Discarded Bank Notes, Photosystem II, Waste Management, *Zea mays*

The eco-physiological responses of *Atriplex griffithii* under salinity, heat, and combination of both stresses

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Abstract
Salinity and elevated temperature are major abiotic stressors that severely limit plant growth and productivity. The present study investigated individual and combined effects of salinity and heat stress on a natural inhabitant halophytic plant, *Atriplex griffthii*. Plants were grown in greenhouse and exposed to salinity (100 and 400 mM NaCl), heat (H) (48°C-50°C) and combination of both (100+H and 400+H). Growth parameters declined under single and combined stress; however, severity of stress was not found after combining salinity and heat stress. Enhancing the area of epidermal cells to prevent water loss may help plants to mitigate combined stress severity. This reduction may also align with harmful effect of ionic imbalance caused by higher Na^+ and reduced K^+ contents under salinity and combined stress. However, ion secretion of leaf suggested that *A. griffithii* avoid Na^+ toxicity by removing them from the leaf. In contrast, photosynthesis efficiency compromised. Interestingly, the quantum yield of PSII and electron transport reactions in heat with contemporary 400 mM NaCl treatments. The quenching of reactive oxygen species uttermost need to avoid oxidative stress thus antioxidant enzymes activated as a defense mechanism of *A. griffithii*. This study demonstrated that combination of salt and heat stress could not cause severity of multiple stress factors and provide insights into the adaptive strategies of *A. griffithii*. Therefore, these findings advocate the utilization of *A. griffithii* in extreme environments.

***Keywords*:** Antioxidant Enzymes, Chlorophyll Fluorescence, Ion Secretion, Ion Toxicity, Multiple Stresses

Eco-Friendly Innovation: Fortifying Wheat Cookies with Salt and Drought-Tolerant *Panicum antidotale* Retz flour

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Abstract
Rapid climatic changes are hazardous for conventional agriculture. It is, globally, a need of time to utilize unexplored plants into account but resistant to harsh habitats. *Panicum antidotale* is a salt and drought tolerant halophytic species valued for its nutritional richness, making it a potential ingredient for value-added functional foods. This study aimed to evaluate the effects of incorporating Panicum seeds flour into wheat flour on the nutritional, physicochemical, sensory, and rheological properties of cookies. Wheat flour was fortified with Panicum at different concentrations of 5%, 10% and 15%, while 100% wheat flour served as the control sample. The dough characteristics, including gluten content, water absorption, dough stability, were assessed using rheological analysis. Results revealed a significant reduction in the cookies made of 15% Panicum seeds flour, such as reduction in its gluten formation, also this sample exhibited the lowest wet and dry gluten content and a gluten index showing no measurable gluten network. Overall Panicum seeds flour demonstrated potential as a functional ingredient in bakery products while maintaining desirable product quality. Thus, addition of non-conventional crops shares the burden of market and will help the former and industry to utilize marginal land for growing stress resistant plants as per market need.

Keywords: Dough Stability, Dough Rheology, Functional Cookies, Gluten, Nutritional Properties, *Panicum antidotale* Seeds Flour

Mangroves as Bio-shields against Heavy Metal Pollution along the Arabian Sea Coast of Pakistan

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Abstract
Mangroves are vital coastal guardians, protecting shorelines, fostering marine life, supporting rich biodiversity, and filtering pollutants. This research investigated heavy metal pollution, a significant environmental threat, in the water and sediments samples of three major mangrove zones along Pakistan's Arabian Sea coast inducing the Indus Delta, Sandspit, and Miani Hor. These sites experience different pressures from nearby cities, industrial, and agricultural activities. Water and sediment samples were collected during the rainy season (monsoon), the after-rain period, and the pre-rain period. Results showed that pollution levels depended strongly on the location, time of year, and whether samples came from water or mud. Water generally contained more heavy metals during the rainy season, likely due to increased river runoff and tidal movement. In contrast, sediments accumulated higher concentrations during the pre-rain season. Among the three sites, Sandspit was the most polluted, reflecting substantial industrial and domestic discharge from Karachi. The Indus Delta showed moderate contamination linked to river and agricultural inputs, while Miani Hor remained the least affected. This research highlights how mangroves serve as natural indicators of pollution, revealing clear differences between regions and seasons. Consistent monitoring of these ecosystems is essential for coastal health and for guiding sustainable management. Understanding where and when metals accumulate helps us protect these vital habitats and the communities that rely on them.

***Keywords*:** Arabian Sea, Coastal Monitoring, Coastal Water, Environmental Pollution, Mangrove Ecosystems, Seasonal Variations, Sediments

Application of Green Nanotechnology to Mitigate Drought Stress in a Medicinal Plant

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Abstract
Drought is a major challenge for crop production in arid and semi-arid regions, were water scarcity limits plant growth and productivity. Medicinal leguminous plants are valuable for eco-smart agriculture, but their performance declines sharply under water deficit. This study examined whether plant-based zinc nanomaterials could help improve drought tolerance in a medicinal legume. Water deficit significantly reduced plant growth, biomass, leaf water content, and photosynthetic pigments, and increased cellular damage caused by oxidative stress. Although drought triggered some natural protective responses in plants, these were not sufficient to maintain normal growth. Foliar application of green-synthesized zinc oxide nanoparticles noticeably improved plant performance under drought conditions. Treated plants showed better growth, improved water retention, and more stable photosynthetic pigments. Accumulation of osmoprotective compounds increased, helping plants cope with limited water availability. At the cellular level, nanoparticle application reduced membrane damage and strengthened antioxidant activity, allowing plants to better control stress-induced damage. In addition, compounds related to plant defense and medicinal value increased following treatment. Overall, the results suggest that plant-derived zinc nanomaterials can support plant growth and stress resilience under drought conditions. This eco-friendly nanotechnological approach offers a practical option for improving crop performance in water-limited environments affected by climate change.

***Keywords*:** Drought Stress Tolerance, Eco-Smart Agriculture, Plant-Based Nanomaterials, Medicinal Properties, Oxidative Stress, Water Relations

Eco-smart Solutions for Sustainable Crop Production: Combining Microbial Inoculants and Carbon-Based Nanomaterials for enhancing Salt Tolerance in a Multipurpose Crop

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Abstract
Soil salinity poses a critical challenge to sustainable food production, demanding innovative and ecologically sound approaches to enhance crop resilience. This study explores a novel eco smart strategy that combines beneficial soil bacteria (plant growth-promoting rhizobacteria, PGPR) with carbon-based nanomaterials to improve plant performance under saline conditions. We examined the effects of two selected PGPR strains and carbon nanotubes, applied individually and in combination, on a model crop exposed to salt stress. Our findings demonstrate that the integrated treatment significantly improved plant growth and biomass under salinity, with root length increasing by up to 45% and shoot length by 31% supporting the development of stress-resilient crops. Photosynthetic efficiency was maintained through elevated pigment levels, including chlorophylls (109%) and carotenoids (44%), while ion toxicity was mitigated via reduced sodium accumulation (up to 44%) and enhanced potassium uptake (up to 157%). The combined approach also strengthened the plant's antioxidant defense system, lowering oxidative damage and boosting the production of osmo-protectants (proline increased by up to 80%) and stress-responsive metabolites such as total phenolics (up to 71%). This work illustrates how the synergy between microbial partners and advanced nanomaterials can activate multiple adaptive pathways, offering a sustainable, multi-mechanistic solution to salinity stress. By enhancing crop resilience through ecologically compatible inputs, our approach aligns with the principles of eco-smart agriculture, promoting food security and environmental sustainability in salt-affected regions.

***Keywords*:** Carbon Nanotubes, Medicinal Plant, Nanotechnology, Plant Growth-Promoting Rhizobacteria, Salt Stress Resilience

Plant-Derived Nanomaterials Improve Salinity Stress Management in a Medicinal Leguminous Crop

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Abstract
Soil salinity poses a growing threat to crop productivity on marginal lands, where stress-resilient medicinal legumes offer potential for eco-smart agriculture. Salinity limits plant performance by disrupting water relations, ion balance, photosynthesis, and redox homeostasis. This study examines the effectiveness of foliar-applied, plant-derived zinc-based nanomaterials in enhancing salinity tolerance through coordinated physiological and biochemical regulation. Salinity stress markedly reduced growth, biomass, tissue hydration, and pigment stability, accompanied by sodium accumulation, potassium depletion, and elevated membrane damage and oxidative stress. Although endogenous osmotic and antioxidant responses were activated, they were insufficient to maintain normal growth. Application of plant-based zinc oxide nanoparticles significantly alleviated salinity-induced damage by improving biomass production, water status, and photosynthetic pigment retention. Nanomaterial treatment enhanced ionic homeostasis by restricting sodium accumulation and promoting potassium retention, while stimulating osmolyte and carbohydrate accumulation for improved osmotic adjustment. In addition, reduced lipid peroxidation and membrane leakage coincided with strengthened enzymatic and non-enzymatic antioxidant systems, indicating improved redox regulation. Stress-responsive secondary metabolites also showed consistent enhancement by nanoparticle application. Overall, plant-derived zinc oxide nanomaterials offer an eco-friendly strategy to improve salinity resilience by integrating agronomic benefits with mechanistic regulation of ionic balance and antioxidant defense, supporting sustainable crop production.

Keywords**:** Antioxidant Regulation, Eco-Smart Agriculture, Green Nanoparticles, Ionic Homeostasis, Salt Tolerance; Sustainable Crop Production

Redox priming as a sustainable strategy to improve early establishment of *Panicum antidotale* under saline conditions

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Abstract
Early lifecycle stages, notably seed germination and seedling establishment, are most sensitive to abiotic stresses, particularly salinity, which poses a major obstacle to sustainable agricultural productivity. Seed priming, particularly with redox-active compounds, has proven effective in enhancing germination and stress tolerance in various crops, yet its efficacy on non-conventional fodder species such as wild halophyte grasses remains underexplored. Moreover, information about the effects of seed redox priming on early or nascent seedlings remains scant. This study investigated the role of redox seed priming in enhancing seed germination, seedling growth, and salinity tolerance in the halophyte fodder candidate *Panicum antidotale*. All priming treatments enhanced germination percentage and rate under non-saline conditions, while ascorbic acid and sodium nitroprusside (SNP) specifically improved germination under saline stress. Seedling fresh weight increased under both saline and non-saline conditions across all priming treatments, whereas dry weight showed a marked increase with priming under saline conditions. Furthermore, primed seedlings exhibited enhanced water content and succulence under both stressed and unstressed conditions. However, little to no enhancement in chlorophyll fluorescence parameters was observed in early seedlings following priming treatments under both non-saline and saline conditions. Hence, redox priming appears to primarily improve water-related physiological traits without significantly affecting the photosynthetic efficiency of *P. antidotale*, and could be used as an effective strategy to enhance early establishment of halophyte fodder candidate *P. antidotale* for mass-scale cultivation under saline conditions.

Keywords: Halophyte Fodder, Redox Compounds, Salinity Tolerance, Seed Germination, Seed Priming, Seedling Growth

Salt and Lead Co-Tolerance: Unraveling Antioxidant and Polyphenol Dynamics in *Arthrocaulon macrostachyum*

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Abstract
The twin menace of soil salinity and heavy metal pollution are threatening for most of the plants that results in hyper-osmotic and ionic stresses. The industrial pollution, leading to the accumulation of heavy metals such as lead (Pb) may cause soil degradation, which ultimately reduces plant growth besides being toxic to other biotic components of the ecosystem. The combined effect of both lead and salinity may be toxic for metabolic processes in plants that induce oxidative stress. Salt resistant plants, such as halophytes, protect themselves by triggering the accumulation of bioactive metabolites to scavenge excessive ROS. However, information regarding quantity and general properties of such compounds is scant. Current study investigated the effect of NaCl and Pb $(NO_3)_2$ on growth and antioxidant responses of a salt marsh halophyte *Arthrocaulon macrostachyum*. This plant is an obligate halophyte that is known to accumulate trace metals, predominantly Pb from saline polluted lands. In this experiment, plants were grown in quartz sand with half strength Hoagland solution under varying Pb $(NO_3)_2$ concentrations (0, 0.75, 3, 6 and 12 mM) with and without NaCl (300 mM). The plant optimized its growth under NaCl treatment alone, while maintained its growth in combined NaCl and Pb $(NO_3)_2$ up to 300 mM NaCl. Under non-saline conditions, growth was either improved or remained unaffected under increasing Pb $(NO_3)_2$ treatments. The shoot biomass was substantially reduced in treatments higher than 3 mM Pb $(NO_3)_2$ (i.e., 6 & 12), while root biomass was decreased to 3 mM Pb $(NO_3)_2$ and remained unchanged with further increases. Total phenols, flavonoid, tannin, and proanthocyanidin showed variations under different NaCl and Pb $(NO_3)_2$ concentrations. Results indicated that *A. macrostachyum* had high capacity for scavenging radicals (DPPH and ABTS) and reducing oxidants (FRAP and TAC) both with and without NaCl, with an increasing trend of free radical scavenging in shoots under higher Pb $(NO_3)_2$ concentrations. It may be concluded that *A. macrostachyum* could be used as a tool for phytoremediation and reclamation of salt affected as well as Pb-contaminated soils. The higher activity of antioxidant compounds makes this halophyte an important resource for medicines and pharmaceutical industry.

***Keywords*:** Bioactive Compounds, Heavy Metal Pollution, Medicinal Properties, Salt Stress, Secondary Metabolites

Exploring the Effects of Zeolite/Zinc Oxide Nanocomposites on *Zea mays* Under Drought Stress

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Abstract
Drought stress is an environmental constraint, limiting the productivity of key cereal crops such as *Zea mays.* Conventional soil treatments for drought resilience, such as Zinc Sulphate and Zeolite offer some relief, but newer methods based in nanotechnology offer potential for a higher efficacy for such growing challenges. This study investigated the potential of zeolite/zinc oxide nanocomposites (NC) to enhance drought resilience in maize (variety NK 7530). Nanocomposites were synthesized at a 1:1 weight ratio, characterized via SEM, EDX, and FTIR, Nanocomposites were found to have an average particle size of 85 nm, with EDX and FTIR confirming purity and presence. Maize plants were subjected to two watering regimes: well-watered (W) and drought-stressed (D). Treatments included varying concentrations of nanocomposites (20-640 ppm), alongside positive controls (zinc sulfate, zeolite) and negative controls. Results from one-way ANOVA indicated that nanocomposite treatments significantly improved several physiological and growth parameters under drought stress. Notably, NC 320 D and NC 40 D treatments yielded the highest levels of chlorophyll a (F = 4.614, p < 0.001) and total chlorophyll (F = 6.466, p < 0.001), significantly outperforming drought controls. Significant improvements were also observed in shoot length (p = 0.046), fresh root and shoot biomass (p < 0.001 and p = 0.037, respectively), and relative water content (RWC) (p = 0.037). While morphological traits like leaf and flower count remained largely unchanged, the nanocomposites aided in osmotic adjustment and protected against pigment degradation. These findings suggest that zeolite/ZnO nanocomposites surpass conventional zinc supplements in maintaining the water status, and photosynthetic machinery of maize during drought, implying that a strategy based in nano-agronomy is key for sustainable agriculture in water-limited environments.

Keywords: Chlorophyll, Drought, Ecophysiology, Nano-Composite, *Zea mays*, Zno

Light and salinity responses of a biofuel candidate – *Sporobolus tremulus*

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Abstract
Salt tolerant C_4 grasses of warm, subtropical maritime deserts have unique adaptations for growth under abiotic stresses such as high light, drought and salinity. However, little information is available on the interactive effects of these factors on salt tolerant grasses. In this experiment, *Sporobolus tremulus* was grown under variable salinity (0, 200 and 400 mM NaCl) and light intensities (high: ~1800 PPFR, and low: ~200 PPFR). Plant length, biomass and succulence decreased progressively with increasing salinity but were higher in low light exposed plants. The relative water content significantly increased in high light plants grown under saline treatments indicating better osmotic regulation. High light exposed plants appeared to be better adapted in protecting their photosystem by increasing the activity of superoxide dismutase to counter oxidative stress. Low light exposed leaves exhibited higher total chlorophyll with increase in salinity. Moderate salinity (200 mM NaCl) showed least signs of photo-inhibition indicating optimal condition for the growth of *S. tremulus*. Increase in electron transport, ΦPSII and qL in highest salinity (400 mM NaCl) in plants grown under low light indicated better performance while, plants exposed to high light and moderate salinity (200 mM NaCl) showed better photosynthetic performance. Decreased non-photochemical quenching indicated improved health of the plant. Highest salinity and low light showed a decrease in connectivity between the antenna complexes of PSII leading to an impaired energetic flux. The quinone pool showed depletion coupled with a severe damage at the donor side of PSII (OEC). As a result the equilibrium constants of redox reactions were affected leading to significant reduction in performance index of the plant. Plants exposed to moderate salinity (200 mM NaCl) and high light showed lower signs of stress, better redox reaction equilibrium constant and increase in total performance index. *S. tremulus* grown under moderate salinity (200 mM NaCl) and high light (~1800 PPFR) showed overall better photosynthetic performance and water status in comparison to rest of the treatments.

***Keywords**:* Photosynthesis, Light Reaction, OJIP, *Sporobolus Tremulus*, Salinity, Coastal Halophyte

Green Synthesis of Manganese Nanoparticles and its effects on plant growth under drought stress

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Abstract
The present study reports the green synthesis of manganese nanoparticles using *Cassia fistula* leaf extract as a reducing and stabilizing agent. An aqueous extract of *C. fistula* leaves was employed to synthesize manganese nanoparticles from potassium permanganate ($KMnO_4$). The synthesized nanoparticles were subsequently incorporated into fertilizer formulations to enhance drought resistance in plants. This eco-friendly approach integrates the bioactive potential of *C. fistula* with the functional properties of manganese nanoparticles to develop a sustainable agricultural solution. Manganese nanoparticles exhibit unique optical, magnetic, and catalytic properties that can improve nutrient uptake efficiency and strengthen antioxidant defense mechanisms in plants under stress conditions. Their application in fertilizers aims to mitigate the adverse effects of drought stress and improve overall crop productivity. The results demonstrate that nanoparticle-enriched fertilizers can significantly enhance plant tolerance to water scarcity. This integrated strategy highlights the potential of nanotechnology as an innovative tool to address critical agricultural challenges associated with climate change and water limitations. Furthermore, the study emphasizes the importance of bio-inspired nanoparticle synthesis in promoting environmentally sustainable practices and ensuring long-term food security.

***Keywords*:** Nanotechnology, Manganese Nanoparticles, *Cassia fistula*, Drought Resistance, Sustainable Agriculture

Increasing levels of LDPE microplastics reduce growth and disrupt water balance in *Rhizophora mucronata*

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Abstract
The exponential rise in plastic disposal leads to plastic waste accumulation in coastal waters. Plastic pollution harms biotic components of the coastal ecosystems including mangroves. Several factors such as solar heat, microbial activity, mechanical stress, and chemical exposure can lead to the formation of persistent microplastics such as low density polyethylene (LDPE) which remain in coastal waters for long. The interaction of LDPE can negatively alter soil properties besides chelating heavy metals. This study was designed to evaluate on how different concentrations (0, 0.5, and 1% w/v) of LDPE microplastics affect the growth and water balance of *Rhizophora mucronata* with and without seawater. Growth parameters (relative growth rate, plant fresh and dry weights) were gradually reduced with the increasing concentration of LDPE microplastics which was more pronounced in 1% LDPE without seawater salinity. Leaf growth parameters (leaf area, fresh and dry weights) also showed a similar response both with and without seawater. Plant pigments (SPAD values as well as chlorophyll:CAR ratio) were also decreased with visible symptoms of necrosis in 1% LDPE. Leaf water and osmotic potentials were also reduced with increasing LDPE concentrations along with decreased chlorophyll fluorescence parameters (i.e., Fv/Fm and ϕPS-II). Results suggest that microplastic pollution in coastal waters could have negative impact on the growth parameters of *Rhizophora mucronata* which may cause the extinction of precious mangrove species due to the accumulation of microplastics in coastal environment.

Keywords: Chlorophyll Fluorescence, LDPE, Leaf Water Relations, Microplastics, *Rhizophora mucronata*

Medicinal Halophytes as Sources of Neuroprotective Agents: Exploring Health Benefits Beyond Food Security

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Abstract
Stress-resilient plants growing in saline environments represent an underexplored biological resource with potential benefits extending beyond food security. Halophytes, traditionally used in coastal and arid regions for medicinal purposes, are particularly rich in stress-adaptive metabolites that may offer therapeutic value. This study explores the neuroprotective potential of selected medicinal halophytes, with a focus on their anticonvulsant and antioxidant properties. Extracts from multiple halophytic species commonly used in folk medicine were evaluated using an experimental seizure model to assess their ability to modulate seizure onset, severity, and recovery. The plant extracts were well tolerated, with no observable signs of toxicity, highlighting their safety profile at the tested levels. Several halophytes markedly delayed seizure initiation and reduced the intensity and duration of convulsive episodes compared to untreated controls, indicating notable anticonvulsant activity. To explore possible mechanisms underlying these effects, antioxidant capacity and phytochemical composition were also assessed. The tested halophytes exhibited strong free-radical scavenging ability and reducing power across multiple antioxidant systems. These activities were closely associated with high levels of phenolic compounds, flavonoids, tannins, and related secondary metabolites. Species with stronger antioxidant profiles consistently showed greater neuroprotective effects, suggesting a functional link between oxidative stress regulation and seizure mitigation. A subset of the most promising species was further examined for dose-responsive effects and behavioral outcomes, confirming their sustained protective potential. Overall, the findings highlight medicinal halophytes as valuable stress-resilient bioresources with applications extending into complementary health strategies. Beyond their ecological and agricultural relevance, these plants offer promising leads for the development of nature-based therapeutic agents, supporting the broader vision of eco-smart systems for sustainable health and resilience under climate stress.

***Keywords*:** Antioxidant Defense, Complementary Therapeutics, Halophyte Bioresources, Secondary Metabolites, Stress-Tolerant Plants

Halophyte-Derived Nanomaterials for Salinity Stress Management: An Eco-Smart Strategy toward Sustainable Ashwagandha Production

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Abstract
Soil salinity is an increasing constraint to agricultural productivity and medicinal plant cultivation in arid and semi-arid regions. *Withania somnifera* (Ashwagandha) is a globally important medicinal plant widely used in traditional and modern healthcare systems for its adaptogenic, anti-inflammatory, neuroprotective, and immunomodulatory properties. Owing to its expanding pharmaceutical, nutraceutical, and herbal market demand, sustainable cultivation of Ashwagandha under marginal soil conditions is of growing economic and agricultural interest. This study examined the impact of sodium chloride–induced salinity on the growth and ecophysiological performance of *W. somnifera*, and evaluated the potential of foliar-applied, halophyte-derived zinc oxide nanoparticles (ZnO NPs) as an eco-smart stress-mitigation strategy. Salinity stress caused marked reductions in plant growth, biomass accumulation, water status, and photosynthetic pigment stability, accompanied by ionic imbalance and enhanced oxidative damage. Foliar application of halophyte-based ZnO nanoparticles significantly improved plant performance under saline conditions. Treated plants exhibited enhanced growth and tissue hydration, stabilization of chlorophyll and accessory pigments, and improved ionic regulation through reduced sodium accumulation and better potassium retention. Increased accumulation of compatible solutes further supported osmotic adjustment under salt stress. At the cellular level, nanoparticle treatment reduced membrane damage and oxidative stress, coinciding with coordinated activation of enzymatic and non-enzymatic antioxidant systems. Overall, the findings highlight the potential of halophyte-derived nanomaterials as eco-friendly inputs for improving salinity resilience in high-value medicinal crops. This approach supports sustainable Ashwagandha production on salt-affected soils and contributes to eco-smart agricultural systems addressing food, health, and economic security under climate change.

***Keywords*:** Antioxidant Defense, Climate-Smart Strategy, Halophyte-Derived Nanomaterials, Ionic Regulation, Medicinal Plant Cultivation

Exploring the salicylic acid signaling for tissue specific ion transport and salt secretion in *Urochondra satulosa*

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Abstract
Soil salinity is a major environmental stress that severely limits agricultural productivity, especially in arid and semi-arid regions. About 831 million hectares across 75 countries are currently affected, and the problem is expected to worsen. Salinity causes osmotic stress and ion toxicity, disrupting nutrient uptake and photosynthesis. Therefore, understanding salt-tolerance mechanisms in halophytes is crucial for future food security. This study aimed to investigate time-dependent, tissue-specific changes in ion accumulation and leaf ion secretion in *Urochondra setulosa* under salinity stress, and to examine the role of salicylic acid signaling in regulating these processes under saline conditions. Seeds collected from coastal saline areas of Sindh, Pakistan, were grown hydroponically under non-saline (0 mM NaCl) and saline (300 mM NaCl) conditions, with SA applied at 0, 0.75, and 1.5 mM. Ion dynamics were assessed over eight time points up to 168 h. Under 300 mM NaCl, *Urochondra setulosa* showed rapid Na^+ and Cl^- accumulation within 6–24 h, with restricted Na^+ transport to shoots but continued Cl^- buildup in shoots, while K^+, Ca^{2+}, and N balance were progressively disturbed, especially at 72–168 h. Na^+ and Cl^- secretion increased early (6–24 h) but later stabilized. Application of salicylic acid (0.75–1.5 mM) improved ionic homeostasis by reducing Na^+ and Cl^- in shoots, enhancing root Na^+ retention and Cl^- secretion, and restoring K^+ and Ca^{2+} levels. SA also stimulated NO_3^- and NH_4^+ accumulation, with effects appearing early (3–24 h) and strengthening at later stages (72–168 h).

Keywords: Halophytes, Ion Flux, Salicylic Acid, Salinity, Signaling, Salt Secretion

Scrutinizing the role of Calcium Signaling in Whole plant Ion Transport and Salt Secretion in *Urochondra setulosa*

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Abstract
Soil salinity severely reduces crop productivity by disturbing plant water balance, nutrient uptake, and ion regulation. This problem is worsening with climate change, highlighting the need to study salt-tolerant crops and grasses. Calcium (Ca^{2+}) acts as a crucial secondary messenger during salt stress by generating specific cytosolic signals that activate stress-responsive pathways. Through these signals, Ca^{2+} regulates ion transporters and channels, stabilizes cell membranes, maintains Na^+/K^+ balance, and helps plants reduce sodium toxicity while preserving essential nutrients. The findings of our research have indicated the role of Ca^{2+} signaling in ion flux and salt secretion in the halophytic grass *Urochondra setulosa*. Seedlings were grown and exposed to 300 mM NaCl with varying Ca^{2+} concentrations (0, 1, and 10 mM) over multiple time intervals (3, 6, 12, 24, 48, 72,168 hrs). Growth traits, water relations, ion accumulation (Na^+, K^+, Ca^{2+}, Cl^-, NO_3^-, NH_4^+), were analyzed. Initial salinity exposure 300mM NaCl caused a noticeable reduction in plant biomass and water content. However, calcium supplementation 1 and 10 mM significantly mitigated this salt-induced inhibition, resulting in a 50% increase in biomass (FW and DW) and improved water retention by 168h, although the succulence index decreased due to rapid dry matter accumulation. Exposure to salinity triggered a sharp rise in internal Na+ and Cl- levels and a transient K+ increase before declining. Notably, NO- /NH+ levels remained stable under salt stress. Exogenous Ca2+ accelerated the reduction of internal Na+ as early as 3h and significantly enhanced Na+ and Cl- secretion between 48 and 168h. Furthermore, 10mM Ca2+ induced a transient rise in NO3 (6 –12h) and NH4 (3-6h) levels, suggesting calcium temporarily boosts nutrient uptake and stabilizes membrane transporters to facilitate long-term ionic balance. Overall, the findings demonstrate that Ca^{2+} plays a critical role in coordinating ion regulation and salt secretion in *U. setulosa*, highlighting the potential of halophytic grasses for managing saline soils and improving sustainable agriculture.

***Keywords*:** Calcium, Halophytes, Ion Flux, Salinity, Signaling, Salt Secretion

Evaluation of Antioxidant and Anti-inflammatory Potential of Endangered Medicinal *Berberis lycium* royale in vitro

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Abstract
Berberis lycium royale is an endangered plant with strong therapeutic potential. It belongs to family Berberidaceae, native to the Himalayan region of Pakistan. *B. lycium* has numerous pharmacological effects, including anticancer, antioxidant, anti-inflammatory, antibacterial, antiviral, antihyperlipidemic, antidiabetic, anticolic, hepatoprotective, and immune-enhancing capabilities. This plant is categorized as a threatened species under the IUCN list due to overharvesting and poor natural regeneration. Limited literature exists on the conservational strategies of *Berberis lycium* royale. This study aims to develop a potent in vitro propagation protocol through somatic embryogenesis for large scale multiplication and evaluate their therapeutic effects by performing antioxidant and anti-inflammatory assays. Different explants have been cultured on MS medium with varying concentrations of auxin, cytokinin and carbohydrate to induce somatic embryos via direct and indirect embryogenesis. After the successful propagation of somatic embryos, perform bioassays. This integrated approach focuses on both the conservation and investigating the medicinal value of *Berberis lycium* royale, making it a promising candidate for sustainable pharmaceutical applications.

Keywords: *Berberis lycium* royale, Somatic Embryogenesis, Antioxidant, Anti-Inflammatory Assays

Investigating the Therapeutic Potential of Saffron (*Crocus sativus* L.) via *in vitro* Propagation

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Abstract
Crocus sativus, commonly known as Saffron is a highly valuable medicinal plant, globally called "Red gold". Saffron has a diverse range of applications in food, dye, fragrance and therapeutic activities. It is renowned for its bioactive constituents mainly Crocin, Picrocrocin and Safranal, which are accountable for its colour, aroma, and taste. Mainly due to these compounds saffron possess diverse therapeutic activities such as antioxidant, anti-depressant, neuroprotective, cardiovascular health, anticancer and anti-inflammatory. However, its traditional propagation through corms is slow, seasonal, and yields a very limited number of daughter corms which restricts its large-scale production. Furthermore, saffron grows once a year, for a short time period. Plant tissue culture is an effective strategy for saffron propagation. This study aims to develop a scalable *in vitro* propagation system using MS media, along with various plant growth regulators (BAP, NAA, TDZ) to induce somatic embryos. Histological analysis is performed to confirm the development of somatic embryos, while biological assays such as antioxidant, anti-inflammatory, and antiglycation activities are also performed. This study will demonstrate the potential of plant tissue culture and elicitor-based strategies for sustainable saffron production with improved pharmacological value.

***Keywords*:** *Crocus sativus*, In Vitro Propagation, Somatic Embryogenesis, Secondary Metabolite Enhancement, Elicitation

In Vitro Regeneration and Therapeutic Assessment of *Cannabis sativa* L. Phytocannabinoids via Somatic Embryogenesis

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Cannabis sativa L., commonly known as industrial hemp, is an herbaceous flowering plant that belongs to the family Cannabaceae. It has gained significant attention for its diverse medicinal and industrial applications. Among the Cannabis species, C. sativa is particularly valuable for its high cannabidiol (CBD) and low tetrahydrocannabinol (THC <0.3%) content, minimizing psychoactive effects while maintaining strong therapeutic potential. This study focuses on the somatic embryogenesis of C. sativa through tissue culture techniques to develop a sustainable disease- free system for the production of genetically uniform plants rich in bioactive compounds. Floral and leaf explants were cultured on Murashige and Skoog (MS) medium supplemented with various concentrations of plant growth regulators (2,4-D, NAA, and GA_3) to induce both direct and indirect somatic embryogenesis. This regeneration pathway represents a key step in achieving large-scale plantlet formation and uniform cannabinoid accumulation under controlled conditions. The biological potential of tissue-cultured C. sativa has been evaluated through antioxidant, anti-inflammatory, and antiglycation assays to assess the therapeutic potential of its phytocannabinoids. Further quantification of cannabinoids in Cannabis cultures, mainly cannabidiol (CBD), was also analyzed by using spectrophotometric analysis.

Keywords: Bioactive Compounds, Cannabidiol (CBD), *Cannabis sativa*, Phytocannabinoids, Somatic Embryogenesis, Tissue Culture

Experimental Assessment of Germination Loss and Oxidative Stress in Stored Seeds of the Multipurpose Halophyte *Suaeda fruticosa*

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Abstract
Information about in stress tolerance, reactive oxygen species (ROS) production and antioxidant responses during long-term storage of halophyte seeds is scant. This study examined germination, stress tolerance, oxidative damage and antioxidant responses of the seeds of a multipurpose euhalophyte *Suaeda fruticosa* stored under various conditions. Briefly, seeds collected from the Hawke's Bay were stored in seven small batches (5 × 10 cm muslin-cloth bags). These seed batches were allocated to following storage treatments: 1) Fresh seeds (FS; which were used immediately after collection), 2) Moderate temperature (MT) storage at 20/30 °C, 3) Low temperature (LT) storage at 10/20 °C, 4) High temperature (HT) storage at 25/35 °C, 5) Dark storage (D) by covering in dark photographic envelop at 20/30 °C, 6) Frozen (F) storage at -20 °C and 7) *In situ* or Field storage (FC) by burying seed bags in the natural field. Germination, stress tolerance and biochemical attributes of the stored seeds were assessed after every 4 months for a period of one year. Our research indicates that the seeds could maintain viability for up to 12-months of storage under various conditions. However, a decline in seed germination and salinity tolerance were observed after 4 months of storage, especially under field and high temperature. Hydrogen peroxide (H_2O_2; a common ROS) levels peaked in field-, high-temperature-, and dark-stored seeds, while malondialdehyde (MDA; indicator of lipid peroxidation) levels increased across all stored seeds compared to fresh seeds, despite increased antioxidant activity. These findings indicate incidence of oxidative damage, coinciding reduced germination and salinity tolerance, upon long term dry storage of the *S. fruticosa* seeds, particularly in field and high temperature conditions.
Keywords: Antioxidant, Germination, Halophyte, Oxidative damage, Salinity tolerance, Seed storage

***BIOGRAPHIES*:**

Keynote and Invited Speakers



Prof. Dr. Sergey Shabala is a UWA Chair in Plant Physiology at University of Western Australia and a Head of the Stress Physiology laboratory. His area of expertise is plant stress physiology and mechanisms of plants adaptation to harsh environmental conditions such as drought, salinity, waterlogging, oxidative stress, and nutritional disorders. Over his research career Sergey has published over 500 peer-reviewed papers and successfully supervised to completion 59 PhD students. He is an ISI Highly Cited researcher for the last nine consecutive years. His current H-index is 122, and his work has been cited more than 53,000 times.



Prof. Dr. Hans-Werner Koyro is a German biologist and plant ecologist who has specialized in the ecophysiology of salt-tolerant plants (halophytes). He is serving as a Senior Academic Advisor and researcher at the Institute of Plant Ecology, Justus Liebig University Giessen (JLU). His research work is focused on sustainable bio-saline agriculture and its role in combating global food insecurity. His focal point of research is Ecophysiology of Halophytes with special emphasis on plant adaptation to extreme environmental stressors, particularly salinity, drought, and light. He has worked on profitable and ecologically sound cultivation of saltwater-resistant crops, such as *Chenopodium quinoa* (Quinoa). Moreover, his work addresses land degradation caused by climate change, industrial pollution, and excessive fertilizer use. His technological development includes specialized "**Quick-check-systems**" in greenhouses to monitor plant growth under controlled saline conditions. Dr. Hans has also served as a Guest Editor for journals like **Plants** and **Environmental and Experimental Botany**. He has mentored several PhD students and their projects across both JLU and THM, facilitating international scientific exchanges. He is also oe of the main collaborators with the team of scientists at the Dr. M. Ajmal Khan Institute of Sustainable Halophyte Utilization (ISHU) through International Linkage program.



Dr. Xiaojing Liu serves as a Professional and one of the leading researchers at the Center for Agricultural Resources Research (CARR), part of the Institute of Genetics and Developmental Biology under the Chinese Academy of Sciences (Shijiazhuang, Hebei, China). His research deals with the reclamation and efficient utilization of saline-alkali land to strengthen food security and sustainable agriculture. He leads a number of high level projects in China, transforming low-yield saline-alkali lands into high-productivity grain areas. Dr. Liu pioneered freezing saline water irrigation, an innovative technique where saline water forms an ice layer in winter; it thaws in spring, allowing high-salinity meltwater to infiltrate first, followed by low-salinity water that leaches the soil and desalinizes the root zone. His work extends to halophyte research, exploring salt tolerance mechanisms in species such as *Suaeda salsa*, *Tamarix chinensis*, and *Atriplex centralasiatica* to enable phytoremediation of saline soils. Dr. Liu also optimizes agricultural management practices, including field ridging, plastic mulching, and straw incorporation, to control soil salinity for

crops like winter wheat and maize. He received a number of awards such as: The First Grade of Award for Science and Technology Progress of Hebei Province, Zhu-Li Yuehua Excellent Teacher's Award of Chinese Academy of Sciences; and National Excellent Worker of Science and Technology. Dr. Liu has a long collaboration history with the Dr. Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization, University of Karachi (Pakistan) spanning over two and half decades.



Prof. Dr. Wang Yongdong is a researcher affiliated with the National Engineering Technology Research Center for Desert-Oasis Ecological Construction (NETRCDOEC) at the Xinjiang Institute of Ecology and Geography (XIEG), part of the Chinese Academy of Sciences (CAS). His work centers on arid region ecology, desertification control, and sustainable oasis development, with key themes including desert and oasis ecosystem stability, water and soil resource management, vegetation restoration, ecological processes, the water-energy-food nexus for agriculture in water-stressed areas, and the role of desert microbes in soil carbon sinks. Notable contributions encompass developing technologies for vegetation restoration, such as the Tarim Desert highway shelterbelt, and investigating microbial life-history strategies that influence soil carbon accumulation, positioning him as a specialist in arid zone ecological engineering within China's leading desert and oasis research institution.



Prof. Dr. Jinlin Zhang is a distinguished professor at the State Key Laboratory of Herbage Improvement and Grassland Agro-ecosystems at Lanzhou University, China. A key focus of his work is halophyte physiology, where he studies adaptations in salt-tolerant species like *Haloxylon ammodendron* and *Zygophyllum xanthoxylum* to reclaim saline soils. Zhang also investigates plant growth-promoting rhizobacteria (PGPR) from desert plants, demonstrating their role in enhancing salt tolerance in grasses such as perennial ryegrass (*Lolium perenne*) and *Puccinellia tenuiflora*. At the molecular level, his studies elucidate mechanisms including ion homeostasis (Na^+ and K^+ balance), osmotic adjustment, and H_2O_2 signaling that delays leaf senescence in plants like seashore paspalum. He is also currently focusing on improving stress tolerance and nitrogen fixation in plants via application nano-materials. Zhang earned his PhD in Plant Physiology from Lanzhou University in 2008 and has gained international experience through visiting positions at the University of Sussex (UK), Texas Tech University (USA), and Purdue University (USA). He serves as a Guest Editor for journals like Agronomy (MDPI), including special issues on "Abiotic Stress Tolerance in Grasses," and has authored a large number of peer-reviewed publications, advancing knowledge of salt and stress tolerance in plants.

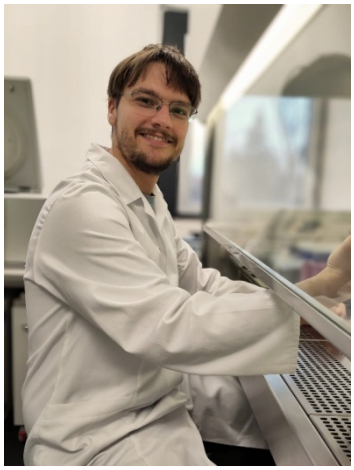


Dr. A. Aldrie Amir is a prominent Malaysian mangrove ecologist and conservationist. As of 2026, he leads critical efforts to protect Malaysia's coastal wetlands through integrated research, advocacy, and policy engagement. He holds the position of Associate Professor and Senior Research Fellow at the Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia (UKM). Dr Amir also coordinates the Malaysian Mangrove Research Alliance and

Network (MyMangrove), fostering nationwide collaboration on mangrove research and conservation. On the international stage, he serves as a Commission Member of the IUCN SSC Mangrove Specialist Group, shaping global strategies for mangrove preservation.



Prof. Dr. Ali El-Keblawy is a distinguished plant ecologist renowned for his extensive research on desert plant populations, communities, reproductive ecology, and seed germination, with applications in biodiversity conservation, desertification control, habitat restoration, urban greening, and weed management using indigenous species. His work examines grazing effects on rangelands, life history traits of invasive exotics for better control, artificial forest conservation, wildlife-livestock dynamics in deserts, nurse plants and nebkhas for degraded habitat recovery, and global change impacts on high-mountain flora. Leading a $1 million Qatar Foundation project, he mapped the full life cycles of 120 Arabian Peninsula native species, ranging from herbs and shrubs to trees, optimizing seed collection, dormancy breaking, germination, storage, propagation, and growth needs. Over 80 of these species are now flourishing in Doha experimental plots, and led to 40+ peer-reviewed publications and consultancies for Expo City Dubai, Al Nakheel, Masdar City, and others. He also directs Sharjah-funded restoration efforts with Spanish partners, applying "Ecological Engineer" techniques via native shrubs to enhance biodiversity and stability in degraded sites. In reproductive ecology, he investigates breeding systems, resource allocation, maternal effects like salinity on progeny tolerance, and warming-driven phenology shifts endangering mountain species. Additionally, El-Keblawy is also focusing on sustainable energy by converting biomass of invasive *Prosopis juliflora* in to biochar and biogas, while assessing local oil-seed plants such as *Citrullus colocynthis*, *Moringa peregrina*, and *Cyperus conglomeratus*, plus resilient introductions like neem and safflower, for biodiesel feedstock.



Dr. Samuel Goll is a molecular genetics researcher at the Department of Genetics, Institute for Biology, Martin-Luther University Halle-Wittenberg in Germany, where he specializes in the protein secretion systems of Xanthomonas bacteria, particularly Xanthomonas euvesicatoria, the pathogen causing bacterial spot disease in pepper and tomato. His work centers on the Type II Secretion (T2S) Xps system, vital for secreting plant cell wall-degrading enzymes that drive virulence. Key contributions include his 2025 discovery of the structurally conserved XpsCLM trimeric complex—comprising XpsC, XpsL, and XpsM—which acts as a dynamic assembly platform linking the cytoplasmic ATPase XpsE to the outer membrane secretin XpsD, with subcomplexes forming independently. Leveraging Golden Gate assembly, he developed modular, plasmid-borne xps gene clusters to enable precise deletions, replacements, or modifications of system components, advancing functional studies. Dr. Goll frequently collaborates with Professor Daniela Büttner, an expert in bacterial secretion systems, with his research ongoing as of early 2026.



Prof. Dr. Rehana Kausar is a renowned academician, researcher, and administrator at The University of Azad Jammu & Kashmir (UAJK) in Muzaffarabad, Pakistan, where she is serving as Associate Professor in the Department of Botany. Currently, she is the President of Botanical Society of Pakistan (2024-26). In May 2025, she was elected as the President of Academic Staff Association (ASA) at UAJK. She has also proven her leadership as Director Students' Affairs (2015-2017; 2025 till date) and Chairperson of the Department of Botany (2017–2022). Under her guidance, the department advanced its research output and fostered collaborative initiatives across disciplines. Dr. Kausar holds a Ph.D. in Plant Molecular Biology (2015) from PMAS-Arid Agriculture University Rawalpindi and completed a prestigious postdoctoral fellowship funded by the Islamic Development Bank, conducting cutting-edge research in Japan on proteomic responses to environmental stresses (2022-23). Her research expertise spans plant biotechnology, proteomics, and molecular biology, with a particular emphasis on engineering salt stress tolerance in staple crops like wheat, rice, soybean as well as drought stress in barley, which are critical for food security in Pakistan's arid and saline regions. She has authored a large number of peer-reviewed publications in high-impact journals such as *Plant Physiology* and *Journal of Proteomics*, and secured grants from national bodies like the Higher Education Commission (HEC) and international partners. Recognized as an HEC-approved Ph.D. supervisor, Dr. Kausar has mentored 02 doctoral and 22 master's students, many of whom now lead in academia and agribusiness. She is a passionate advocate for climate change education, developing curricula on sustainable agriculture and leading workshops for farmers and policymakers in Azad Jammu & Kashmir. Through her multifaceted work, Dr. Kausar continues to drive innovation in plant sciences, promote equitable academic environments, and address pressing environmental challenges in South Asia.



Prof. Dr. Shujaul Mulk Khan Tenured Professor of Plant Sciences, Director Career Counselling and Job Placement QAU, Member of the Pakistan Academy of Sciences, Visiting Professor/Scientist in Italy, and Universities of Margulan, Turaighyrov & Kozybayev Kazakhstan, President International Society of Ethnobiology (ISE) & Vice President Global Traditional Medicines, South Asia Chapter. He has supervised 13 PhDs, 71 MPhil & 21 BS Theses. He has published 200+ research articles with 500+ impact factor 7000+ citations, 2 books, 46 book chapters, and 100+ Conference abstracts/talks. He is winner of the HEC & OIC-COMSTECH best paper awards, 2017 and 2024 respectively. He also won Pakistan Academy of Science Gold Medal under the age of Fifty. He achieved and completed 6 research projects from PARC, PSF, NSFC, PSF and PAS. Recently one of his project been approved from KBF-GBF worth one Million US Dollars. His work as green solutions for pollution and climate change mitigation is considered a commendable job, globally.



Prof. Dr. Asad Jan is a renowned expert in biotechnology and genetic engineering, with a primary focus on rice molecular biology, abiotic stress tolerance mechanisms, and functional genomics. He completed his Ph.D. in Plant Biotechnology at the University of Tsukuba, Japan (2006), where he conducted pioneering research on the functional analysis of gibberellin-regulated genes in rice using advanced microarray systems, alongside student supervision. Earlier, he earned an M.Phil. in Molecular Biology from the University of Punjab, Lahore (2000), investigating the expression of the Cry1Ab gene in rice under three different promoters. He further advanced his expertise through a prestigious JSPS Postdoctoral Fellowship at the Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan (2008), emphasizing rice abiotic stress tolerance, project write-ups, hands-on research, and mentoring. He has successfully completed high-impact research projects, including a collaborative Joint Research Agreement with JIRCAS titled "Search for Novel Genes Conferring Abiotic Stress Tolerance in Plants" (2014-2021); the PSF-funded "Development of Abiotic Stress Tolerance in Rice" (2013-2017, Rs. 1,676,064); and the HEC-supported project on "Entomopathogenic Fungi used as Biologics" (2013-2017, Rs. 490,000). His outstanding contributions have earned him prestigious awards such as the Japan International Award for Young Agricultural Researcher (2014), JSPS Postdoctoral Fellowship, MEXT PhD Scholarship, and the 5th HEC Outstanding Research Award.



Dr. Muhammad Sohail is a Professor of Microbiology at the University of Karachi, Pakistan, with over two decades of experience in teaching, research, and academic administration. He holds a PhD from the University of Karachi and completed postdoctoral research at University College London, UK, with a strong focus on microbial genomics, microbial biotechnology, enzyme technology, and antimicrobial resistance. Dr. Sohail has supervised more than 30 MPhil and PhD scholars, secured and led numerous nationally funded research projects. He has published over 130 research articles in high-impact international journals and holds multiple patents. His work is widely cited, reflecting his sustained contributions to microbiological research, capacity building, and scientific collaboration at national and international levels.



Ms. Neha Farid is a dedicated Senior Lecturer and Final Year Project (FYP) Co-ordinator in the Department of Biosciences at SZABIST University. She holds a Bachelor's and Master's degree in Biosciences (specializing in Microbiology and Plant Tissue Culture) from SZABIST University, and currently enrolled as PhD scholar as well. With over five years of teaching and research experience, Ms. Farid has mentored undergraduate students in various life sciences courses, and has 15+ publications. She has actively participated in numerous conferences, oral presentations, and poster competitions. Notably, she was awarded the ICGEB grant to present her research in CESAR 2025 in Croatia. In addition, her project on

an Antibiotic Surveillance System was recognized as one of the top seven projects in the Health Innovation Challenge organized by Bosch Pharmaceuticals, and also in the National Antimicrobial Stewardship initiative by Getz Pharma. Ms. Farid continues to inspire and contribute to the academic and research community, driven by her unwavering commitment to advancing biosciences.



Dr. Uroosa Ejaz is a microbiologist and biotechnologist with a PhD in Microbiology from the University of Karachi (2023). She currently serves as Program Manager of the BS Biotechnology Program and Assistant Professor in the Department of Biosciences at SZABIST University. Her 10 years research and academic career focuses on microbial biotechnology, enzyme production, biomass valorization, and sustainable bioprocessing. She has led numerous projects, including HEC-funded NRPU initiatives, resulting in over 50 publications, 05 book chapters, and 02 patents. She has >1000 citations on Google scholar. She serves as Guest Editor for Discover Environment (Springer Nature) and peer reviewer for multiple international journals. Dr. Ejaz has supervised many undergraduate and postgraduate research students. She has presented her work in many platforms and also received award for innovation, including recognition at UNESCO Future Designer International Innovation Awards. Her work integrates fundamental microbiology with industrial and environmental applications, emphasizing sustainable solutions for global challenges.



Dr. Tahira Mohsin Ali is currently working as an Associate Professor in Dept. of Food Science & Technology in University of Karachi. She has been associated with Academia since 15 years and has around 100 publications including Research papers, Review Papers, Book chapters and Patent. Since last 5 years she is serving as editorial board member of Impact factor Journal "Legume Science" published by Wiley Interscience. She is also recepient of several competetive research grants funded by PSF, Sindh HEC, Federal HEC and food industries. She also presented her work in different National and International Conferences including Malaysia, Turkey and Thailand. Her key research areas are Food Product Development, Food rheology, Modified Starches from non-conventional sources, biodegradable films and Functional products.



Dr. Muhammad Ajmal Shah is a registered pharmacist and an academic researcher. He obtained his PharmD and MPhil in Pharmacognosy degrees from Federal Urdu University, Karachi, Pakistan. He obtained his PhD in Pharmaceutical Sciences from Prince of Songkla University, Hat-Yai, Thailand by securing Thailand Education Hub for ASEAN Countries PhD Scholarship Award (TEH-AC 2014-17). He has published more than 100 scientific articles in well reputed international journals, edited one book with Elsevier and has authored over 60 chapters in different books published by Elsevier, Springer and other well recognized publishers. He has also been listed in Top 2% global research scientist's category for the year 2024 and 2025 as analysed and published by Stanford University, UK. He is a reviewer and an editorial board member of various reputed international journals. Dr. Shah is an active member of the American Society

of Pharmacognosy, Phytochemical Society of Europe, American Society of Microbiology, and GA Society for Medicinal Plant and Natural Product Research Germany. Previously, he has worked as an assistant professor and head of department at the Department of Pharmacognosy, Faculty of Pharmaceutical Sciences, Government College University Faisalabad, Pakistan and currently he is working as an Assistant Professor at Department of Pharmacy, Hazara University, Mansehra, Pakistan. He is also an adjunct professor at Department of Pharmacy, Diponegoro University, Indonesia, Faculty of Pharmacy, Universitas Muhammadiyah Surakarta, Indonesia and Faculty of Pharmacy, Pancasila University Jakarta, Indonesia. He is also a visiting professor at Tashkent Institute of Pharmaceutical Sciences, Ministry of Health, Uzbekistan. His primary research interests include green extraction and enrichment of bioactive compounds, their isolation, and pharmacological evaluation in metabolic and aging-associated diseases.



Dr. Fahad Shafiq is currently serving as an Assistant Professor in the Department of Botany, Government College University, Lahore He completed Postdoctoral Fellowship at the Department of Plant Sciences, University of Cambridge, UK. His research primarily focuses on plant physiology, mineral nutrition, and plant-nanomaterial interactions. His work explores the effects of engineered nanomaterials on edible plant species, including cereals and vegetables, with particular emphasis on iron and zinc biofortification. Dr. Shafiq has published 65 research articles in reputable international journals, with a cumulative impact factor exceeding 250 and more than 2,600 citations to his credit.



Dr. Qamar Abbas is an Associate Professor in the Department of Plant Sciences at Karakoram International University (KIU), Gilgit Pakistan, and additionally serving as the University Provost. He is a distinguished plant scientist with expertise in plant taxonomy, ethnobotany, Phytochemistry, biodiversity and conservation. Dr. Abbas has received advanced international trainings in specialized areas of plant sciences and higher education. He completed professional training in Botanical Garden Management at the Chenshan Botanical Garden, Shanghai, China; acquired advanced expertise in Phytochemistry and Protein Profiling from the University of Hamburg, Germany; and completed a certified course in Teaching and Learning from the University of Alabama, USA. These experiences have significantly strengthened his interdisciplinary and applied research approach. His research broadly addresses the impacts of climate change on natural flora, cultivated fruits and vegetables, insect and pests' management and their biological control mechanisms. His scholarly interests also encompass biodiversity conservation, non-timber forest products (NTFPs), cultivation of medicinal and aromatic plants, phytochemical analysis, the sustainable utilization of natural resources, and assessing anthropogenic threats such as overgrazing and deforestation across the Karakoram and greater Hindu Kush–Himalayan (HKH) regions. Dr. Abbas has made notable contributions to floristic research through comprehensive studies conducted in ecologically important valleys of Gilgit- Baltistan, where he identified rare, endemic, and endangered plant species. He serves as the focal person for WWF Pakistan at KIU and played a pivotal role as team lead in establishing the Center for Biodiversity,

Conservation, and Natural Resource Management at the university. Through his research leadership, Dr. Abbas has published 41 research articles in national and international peer-reviewed journals, completed 10 projects, contributed three book chapters, authored two scientific booklets, and successfully supervised 23 MS research theses.



Dr. Haibat Ali is an Associate Professor in the Department of Environmental Sciences at Karakoram International University (KIU) in Gilgit, Pakistan. He earned his PhD in 2013 from the Institute of Sustainable Halophyte Utilization, University of Karachi, under the supervision late Prof. Dr. M. Ajmal Khan *S.I.* His research centers on plant diversity, ethnobotany, and ecological responses to environmental stressors in the Gilgit-Baltistan region's mountainous valleys, including Hunza, Haramosh, and Jutal, where he conducts floristic surveys to quantify species abundance, evaluate conservation status, and document traditional knowledge of medicinal and non-medicinal plants for community healthcare and livelihoods. Dr. Ali also specializes on the Blue Panic Grass (*Panicum antidotale*), and has investigated its potential as a fodder alternate to maize for cattle, and has also examined reactive oxygen species (ROS) homeostasis and antioxidant enzyme responses of this grass during early life-cycle stages under salt stress. Through these contributions, he promotes research on sustainability, botanical conservation and plant stress physiology in Pakistan's challenging ecosystems.



Dr. Sujjad Hyder is currently serving as an Assistant Professor in the Department of Environmental Science at Karakoram International University. He holds a PhD in Botany with a specialization in plant taxonomy and plant ecology from the University of Karachi, where his doctoral research focused on inventorying and monitoring the flowering plant biodiversity of Hunza and Nagar valleys in Gilgit-Baltistan. His academic qualifications also include M.Phil/PhD coursework in plant taxonomy and ecology, an MSc in Botany (Plant Ecology), and a B.Ed in education. Recently, he was nominated as the focal person for the KIU-IMPLAD (China) exchange program and received a fellowship from INTI International University, Malaysia. Dr. Hyder has a strong record in teaching and research, with 45 research articles published in reputable national and international journals. He has taught in the Departments of Environmental Sciences and Biological Sciences, offering courses on biodiversity and conservation, restoration ecology, vegetation ecology, medicinal and aromatic plants, and natural resource management, and has supervised numerous BS and MS research projects. His current research interests include floral biodiversity assessment, climate change impacts on vegetation, ethnobotany, conservation of medicinal and aromatic plants, phytosociology, and biomass estimation. Here's a refined and grammatically correct version of your sentence with smoother flow and professional tone: He has worked as a research consultant with WWF Pakistan, GLOF, NCPC, the Forest Department G.B, FAO, and SLF Pakistan, and has recently led and participated in FAO- and UNDP-funded projects on medicinal plants and forest biomass as Principal Investigator (PI) and Co-Principal Investigator (Co-PI).



Dr. Saddia Galani is a plant scientist, has been serving as

Professor and Sectional Head at Agriculture Biotechnology Wing, Karachi Institute of Biotechnology and Genetic Engineering (KIBGE), University of Karachi, Karachi Pakistan and involved in research, teaching and various administrative activites. Since two decades, she is involved in sustainable crop production by investigating biotic and abiotic stress tolerance mechanisms in crop plants . She also focussed on food security and safety issues such as antimicrobial resistance, pesticides and arsenic contaminations in food chain. Her professional goals include human resource development in the field of agriculture biotechnology with special emphasis on the molecular mechanisms of crops conferring stress tolerance using proteomics and genomics approaches. During her PhD research she has explored the tissue-specific accumulation of dehydrins in the leaves of sugarcane under heat stress and immuno-histolocalized the presence of dehydrins in various cell/tissue types for physiological elucidation. As an internationally recognized young scientist, with an impact factor of ~60.06 and 7040 citation index, she has 55 scientific publications and genbank depositions on her credit, including book chapters, review articles and research papers. She is also very keen to receive and impart professional trainings and active member of many professional societies. She has attended ~48.0 national and international training workshops/conferences by seeking foreign assistance from COMSTECH, Wellcome Trust, UK and Higher Education Commission. She has received research grants from HEC Under NRPU and SRG Programs in 2015 and 2016. She is HEC Approved Supervisor and involved in teaching, supervising Ph.D. and M.Phil. students (in academia) and training and supervising other members of staff. Up till now, she produced 10 Ph.D. and 13 M. Phil. students. Besides enjoying a close collaboration with renowned national and international scientists, she has accumulated all the requisite skills and abilities for being a productive scientist. Consequent to her professional achievements, the Ministry of Science and Technology, Islamabad, Pakistan enlisted her as the '*Productive Scientist of Pakistan 2011 and 2012*. Dr. Galani is member of many prestigious societies including Asian Federation of Biotechnology (AFOB), Pakistan Botanical Society (PBS), Pakistan Biological Safety Association (PBSA), International Plant Proteomics Organization (IPPO) and International Council for Life Sciences (ICLS) etc. As a *work-a-holic* person, she believes in symbiotic professional growth and she reckons work as the only dignity.



Prof. Dr. Habib-ur-Rehman Athar is a renowned Pakistani plant physiologist currently serving as the Director of the Institute of Botany at Bahauddin Zakariya University (BZU), Multan, a position he has held since July 28, 2025. Dr. Athar earned his PhD in Botany from the University of Agriculture, Faisalabad (UAF) and completed his post-doctoral research on photosynthesis at the University of Manchester, UK. His research primarily focuses on uncovering the physiological mechanisms of stress tolerance in plants. He has extensively explored the physiological and molecular foundations of induced stress tolerance in crops through the exogenous application of antioxidants and osmoprotectants, such as proline, glycine betaine, and ascorbic acid. His current work emphasizes the use of rapid, non-invasive, and cost-effective phenotyping tools to select stress-tolerant crop cultivars, specifically utilizing OJIP analysis to assess PSII structural stability alongside PAM techniques to evaluate the functional activity of both PSII and PSI. In recognition of his significant contributions to the university, Dr. Athar was awarded BZU's Appreciation Shield in October 2025. His leadership extends to the international stage, where he played a pivotal role in organizing numerous events, most notably the 9th International and

18th National Conference of Plant Scientists (INCPS-2024) held at BZU under the auspices of the Pakistan Botanical Society. Furthermore, as a prolific researcher, he has published an extensive body of work in high-impact, peer-reviewed journals that continue to be frequently cited by the global scientific community.



Dr. Kausar Hussain Shah is working as Associate Professor (Tenured at the Institute of Botany, Bahauddin Zakariya (BZ) University Multan Pakistan. He did PhD with distinction in Plant Biotechnology under the supervision of Prof. (Assoc.) Dr. Holger Bohlmann at the Institute of Plant Protection, Department of Crop Science, University of Natural Resources and Life Sciences Vienna, Austria; MPhil in Molecular Biology at the National Center of Excellence in Molecular Biology (NCEMB), University of the Punjab Lahore and MSc in Botany at the Botany Department, IP&AB, BZ University Multan His **research interests** include Molecular Plant Stress Physiology (abiotic stresses); Molecular Plant Microbe-Interaction (biotic stresses); Molecular Genetics; Functional Genomics; Heterologous expression of recombinant peptides/proteins in Plants; Plant Antimicrobial Agents (Peptides, Proteins and Metabolites) and Plant Growth Promoting / Stress ameliorating Agents (PGPR, Endophytic bacteria, Biochar, Osmoprotectants, etc). He is founding incharge of Plant Molecular Biology Laboratory and Plant Microbe-Interaction Laboratory at the Institute of Botany, BZ University Multan. He supervised 100+ research students. He has **50+ publications** with **80+** impact factor and **1000+** citations. He presented his research work in several international and national seminars, symposia, conferences, congresses and workshops. Additionally he is serving the institute as member of scientific purchase committee; Secretary General of the Zakariyan Association of Botanists (ZAB) and moderator of the Institute Journal Club. He served the Pakistan Botanical Society as Joint secretary in 2023.



Prof. Taseer Ahmed Khan is a senior Professor at the Department of Physiology, University of Karachi. He has also served as a Chairman of the Physiology Department till 2025. Currently, he is the Director of the Biological Research Center (BRC) besides serving as the “Incharge Semester cell” and as a coordinator for the BS Poultry Science program at the University of Karachi. His academic work spans human and animal physiology, with specific interests in Poultry Science, their feed formulation, animal nutrition, and the impact of poultry on human health. Dr. Khan has investigated vitamin D receptor (VDR) gene polymorphisms and their association with breast cancer risk. His most cited works include studies on Haematological responses in broiler chickens, Newcastle disease virus sub-genotypes and Hepatoprotective activities of natural substances like *Nigella sativa*.



Dr. Allah Wasaya is currently working as Associate Professor of Agronomy, Institute of Agronomy, Bahauddin Zakariya University Multan, Pakistan. He did his PhD from University of Agriculture, Faisalabad, Pakistan during 2011 while, Post-Doctorate from Centre for Agricultural Resources Research,

Institute of Genetics and Developmental Biology, Chinese Academy of Sciences, China during 2016-2017. He has a research experience of 16 years and has H-index of 35 and 4200 citations according to Google Scholar. His research interests includes Tillage systems, Intercropping, Stress physiology and nutrient management in cereals. He has published about 95 research articles in National and International journals and 20 book chapters in peer reviewed books. About 23 M.Sc. (Hons.)/M.Phil students have completed their thesis research under his supervision. He has also presented his research work in various International conferences. He won various research projects form National organization and also won a research project under National Research Program for Universities from Higher Education Commission of Pakistan.



Dr. Muhammad Kazim Ali is an Associate Professor of Biotechnology in the Department of Applied Sciences (DAS), Faculty of Engineering Sciences and Technology (FEST), Hamdard University Karachi, where he also serves as Incharge of Biotechnology program. He holds a MSc and Ph.D. in Biotechnology from the University of Karachi in 2010 and 2015, respectively. His research focuses on addressing biotic and abiotic stresses in crops, particularly rice and sugarcane through biotechnological approaches. His work explores thermotolerance mechanisms, antioxidant enzyme activity, molecular chaperones (e.g., HSP70), and the development of climate-resilient crop varieties. He has collaborated internationally with institutions such as the Yunnan Academy of Agricultural Sciences in China. Dr. Ali has authored multiple peer-reviewed articles, book chapters, and presented at numerous national and international conferences. He has been awarded several research grants from the Higher Education Commission of Pakistan and received the Talented Young Scientist Fellowship from the Ministry of Science and Technology, China (2018–2019). He is an active member of several professional societies, including the Pakistan Society of Biotechnology (PSB) and Pakistan Biological Safety Association (PBSA). His career is dedicated to advancing sustainable agriculture in Pakistan through innovative research, academia-industry linkages, and international collaboration.



Dr. Kamran Yaqoob obtained his PhD in Biotechnology from the KIBGE, University of Karachi in joit collaboration with School of Environmental and Natural Sciences, Bangor University, UK through the commonwealth scholarship. His areas of interest are, plant genomics, tissue culture, and genetic engineering. Currently he is serving as Scientific Officer at the Multidisciplinary Research Lab (MDRL), Bahria University Health Sciences, Karachi.



Dr. Marium Shaikh is an Assistant Professor in the Department of Food Science and Technology, University of Karachi, Pakistan. She has expertise in starch modification, sustainable food packaging, and functional cereal-based foods. Her research focuses on the valorization of underutilized crops and agro-waste for developing eco-friendly packaging materials and functional food applications.

Dr. Shaikh has published research articles and review papers in leading international peer reviewed journals, authored multiple book chapters, and has received the Hameed & Azra Award (2023) for outstanding research. She has secured competitive research grants as Principal and Co-Investigator and also actively supervises PhD, MPhil, and undergraduate research students. In addition to her research and teaching roles, she contributes to academic quality assurance as a departmental focal person for the Quality Enhancement Cell (QEC).



Dr. Musarrat Ramzan is an Assistant Professor in the Department of Botany at The Islamia University of Bahawalpur (IUB), a public sector university in Bahawalpur, Pakistan, originally established in 1925 as Jamia Abbasia by His Highness Nawab Sir Sadiq Muhammad Khan Abbasi-V. Her research centers on plant responses to salinity stress in agriculture, aiming to mitigate its detrimental effects on crops such as maize, wheat, and brinjal. She investigates innovative, sustainable interventions, including nanoparticles, biochar, and plant-derived compounds like kaempferol, caffeic acid, salicylic acid, GSH, and GABA, to enhance growth, nutrient uptake (e.g., Na^+/K^+ balance), and yield under saline conditions common in arid regions. She has published a large number of research articles and completed numerous projects on aforementioned aspects.



Dr. Aysha Rasheed is a dedicated young researcher and academician specializing in the eco-physiology of halophytes (i.e. salt-tolerant plants) naturally found in extreme saline environments. Currently serving as a lecturer in the Education and Literacy Department for the Government of Sindh in Karachi, Pakistan, she previously held positions as a Research Associate at the Dr. Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization (MAK-ISHU) at University of Karachi, Assistant Professor and Postdoctoral Researcher at the Centre of Excellence in Marine Biology (CEMB) at University of Karachi (Pakistan). Her research revolves around halophyte adaptations essential for saline agriculture, food security, and climate resilience. Key areas of her research include seed germination ecology under salt and drought stress, antioxidant systems and compatible solutes for abiotic stress tolerance, soil amendments (like manure and compost) with saline irrigation for arid-region yields, and halophytes as non-conventional crops amid climate change. She also examined eco-physiological population dynamics of the xero-halophyte *Salsola drummondii* in her PhD at MAK-ISHU (University of Karachi). She has published numerous articles on aforementioned aspects, which are widely cited by the peers.



Mr. Zaki Ul Rahman is a research-focused environmental ecologist with expertise in water and soil pollution assessment, particularly heavy metal contamination from leather tanneries. His work integrates field sampling, GIS-based spatial analysis, and advanced statistical and machine learning techniques. He has experience conducting high-impact environmental and health risk assessments across polluted agricultural landscapes. His academic goal is to

contribute rigorous, data-driven research to support sustainable environmental management and policy.



Mr. Arslan Akhtar is a Master's research student at the Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (CAS), where he works under the supervision of Prof. Wang Yongdong. His research focuses on desert ecosystem restoration, remote sensing–based ecological assessment, and sustainable forestry planning for arid and semi-arid environments. Before joining CAS, he completed his Bachelor's degree in Botany from The Islamia University of Bahawalpur, Pakistan, where he conducted research on the ecological dynamics and vegetation patterns of the Cholistan Desert. His current work integrates ecological vulnerability assessment and economic forestry potential modeling to design climate-resilient restoration and livelihood strategies for Pakistan's drylands. His research contributes to advancing eco-smart agriculture and sustainable desert economy initiatives under the Belt and Road framework.