BOOK OF ABSTRACTS

2nd International Conference on Climate Change Impacts on Agriculture and Food Security (IC3AF-2025)

April 22-24, 2025

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Pakistan Science Foundation

Message from the Vice Chancellor &Chief Patron of IC^{3}AF-2025

As Vice Chancellor and Chief Patron, I extend my heartfelt congratulations to the organizing team of the Department of Agriculture, University of Swabi, for successfully hosting the 2nd International Conference on Climate Change Impacts on Agriculture and Food Security (IC^{3}AF-2025). This conference marks a significant milestone in the University's journey toward academic and research excellence.

Since its establishment in 2012, the University of Swabi has earned a respectable reputation among the renowned institutions of higher learning in the province and across the country. This is attributed not only to its deep-rooted cultural heritage but also to its commitment to delivering quality education to a diverse student body at an affordable cost.

It brings me great joy to witness the rapid progress the University has made in a relatively short span of time. Notable advancements have been achieved in higher education, research, and collaborative initiatives with various stakeholders. In particular, the Department of Agriculture has introduced innovative research initiatives and launched advanced scientific courses at the postgraduate level.

Climate change and food security stand as critical and interconnected areas of research, capturing the attention of faculty, researchers, students, and industries alike. I am confident that IC^{3}AF-2025 will serve as a valuable platform to foster academic excellence and knowledge exchange, benefitting from the insights of distinguished national and international speakers. The deliberations and outcomes of this conference are expected to offer practical guidance to policymakers, enabling them to address the challenges of climate change and devise strategic solutions.

I also commend the Department of Agriculture for developing a modern infrastructure that includes not only architecturally impressive buildings but also state-of-the-art laboratories and doctorate faculty members. IC^{3}AF-2025 will undoubtedly enrich students' understanding of climate change and food security, paving the way for progress, prosperity, and a sustainable future.

It is particularly encouraging to note that the Department has previously organized the 1st International Conference (IC^{3}AF) in 2018, as well as several national workshops and seminars on pressing issues—successfully blending traditional values with contemporary academic trends.

In conclusion, I once again congratulate the Patron, Co-Patron, Chief Organizer, Focal Person, and all members of the organizing committees for their remarkable achievement. Their dedication and teamwork have turned this vision into reality. I wish the Department of Agriculture, University of Swabi, continued success and a future filled with growth and excellence.

Prof. Mian Sayed Khan (Ph.D)
Vice Chancellor University of Swabi
Chief Patron of IC^{3}AF-2025

Message from the Dean,Faculty of Sciences, University of Swabi

It is my great pleasure to extend a warm invitation to all research enthusiasts and professionals to the land of hospitality and knowledge for the 2nd International Conference on Climate Change Impacts on Agriculture and Food Security (IC^3AF-2025), scheduled to take place from April 22nd to 24th, 2025.

Climate change has emerged as one of the most significant global challenges, with far-reaching consequences across environmental, social, and economic spheres. Its effects on agriculture are particularly profound—altering rainfall patterns, increasing the frequency of extreme weather events, degrading soil health, and threatening crop productivity. These disruptions pose a direct risk to global food security, especially in vulnerable regions already facing resource constraints.

In this context, IC^3AF-2025 aims to serve as a collaborative platform to bring together renowned researchers, academicians, policymakers, industry experts, and students from around the world. Our goal is to share scientific insights, innovative technologies, and evidence-based strategies that can help mitigate the adverse impacts of climate change on agriculture and strengthen food systems.

The conference will feature keynote speeches, panel discussions, technical sessions, and poster presentations, providing participants the opportunity to exchange knowledge, foster interdisciplinary collaborations, and contribute to shaping sustainable agricultural policies and practices for the future.

We strongly believe that your presence and contributions will greatly enrich the discussions and outcomes of the event.On behalf of the University of Swabi, I thank you and look forward to welcoming you all to this meaningful gathering.

Stay happy, inspired, and blessed.

Prof. Syed Muhammad Mukarram Shah (Ph.D)
Dean, Faculty of Sciences University of Swabi
Patron-IC^3AF-2025

Message from the Chairperson, Department of Agriculture, and Chief Organizer of the (IC^{3}AF-2025)

It is my honor, as the Chairperson of the Department of Agriculture, University of Swabi, and the Chief Organizer of IC^{3}AF-2025, to welcome the national and international eminent scientists, researchers, policy makers, and professionals to this prestigious event. The Department of Agriculture is the pioneer department of the University of Swabi, offering BS, MS, and PhD programs in key disciplines such as Agronomy, Horticulture, Plant Breeding and Genetics, Entomology, Food Science and Technology, Soil Sciences, and Plant Pathology. Since the establishment of the university, our highly qualified faculty members holding PhDshave successfully organized national and international seminars, webinars, conferences, workshops, talent hunt tests, and training programs. Many of our faculty have also completed postdoctoral fellowships in the USA, Australia, and China, and are actively engaged in cutting-edge research while collaborating with national and international institutions.

The 2nd IC^{3}AF-2025builds upon the success of our 1stIC^{3}AF-2018, which featured distinguished speakers from China, USA, and Turkey in hybrid mode. This year, we are proud to host an even larger gathering, with confirmed participation from renowned researchers from across the Pakistan, AJK and abroad including Germany, USA, UAE, KSA, Turkey, Egypt, China, Qatar, Canada, South Korea, Morocco, and Sri Lanka—both in-person and through video link.

On behalf of the organizing committee and the Faculty of Agriculture, I extend my best wishes to all speakers, both from Pakistan and abroad, for their valuable contributions. I am also delighted by the overwhelming response, with over 100 abstracts submitted for oral presentationsby students and professionals.

I would like to express my deepest gratitude to our sponsoring organizations, including the Higher Education Commission (HEC) of Pakistan, the Directorate of Science and Technology (Govt. of Khyber Pakhtunkhwa), and the Pakistan Science Foundation, for their invaluable financial support. Special thanks to the administration of the University of Swabi, his dedicated team and the Women University Swabi for their collaborative partnership.

Finally, we warmly welcome all our esteemed guests to the land of hospitality “Khyber Pakhtunkhwa”. Your presence enriches this conference, and we look forward to productive discussions on addressing the critical challenges of climate change impacts on agriculture and food security.

Assoc. Prof. Hidayat Ullah (Ph.D)
Chairperson, Department of Agriculture, University of Swabi
Chief Organizer, IC^{3}AF-2025

Massage from the Focal Person IC^{3}AF-2025

It is with immense pleasure and a deep sense of responsibility that I extend a warm welcome to all our National and International participants attending the 2nd International Conference on Climate Change Impacts on Agriculture and Food Security (IC^{3}AF-2025), to be held from April 22 to 24, 2025, at the University of Swabi, Pakistan.

As the Focal Person of IC^{3}AF-2025, I take great pride in the University of Swabi's role in fostering global dialogue on the urgent and far-reaching impacts of climate change, particularly on agriculture and food security in Pakistan and other vulnerable regions. With agriculture contributing nearly 20% to Pakistan's GDP and employing over 38% of the workforce, the sector remains critically exposed to climate-related risks. In just the past two decades, the country has suffered economic losses exceeding $30 billion due to climate-induced disasters. The 2022 floods alone displaced over 33 million people, devastated agricultural land, and triggered a national food crisis. This conference provides a vital platform for researchers, policymakers, practitioners, and students to exchange knowledge, showcase innovative research, and explore practical strategies for building climate-resilient agricultural systems.

In light of these challenges, IC^{3}AF-2025 is not merely an academic conference; it is a strategic call to collective action. It underscores our shared responsibility to advance sustainable practices, promote evidence-based policies, and safeguard food systems for future generations. We look forward to stimulating discussions, meaningful partnerships, and impactful outcomes that will shape future research and policy in the face of climate challenges.

On behalf of the organizing committee and the University of Swabi, I express my heartfelt appreciation to our esteemed keynote speakers, panelists, sponsors, and participants. We are honored to host you on our campus and are confident that your engagement will make this conference both intellectually enriching and practically significant

Dr. Muhammad Adnan
Lecturer Department of Agriculture
Focal Person of IC^{3}AF-2025

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IC³AF-2025-01

Funneliformis Mosseae Improves Wheat Growth/Nutrient Accumulation by Facilitating Soil Nutrient Uptake under Daytime-Eco₂, Not Nighttime

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Almost all reports of plant responses to elevated CO_2 (eCO_2) concentrations have been executed under equal CO_2 concentrations over daytime and nighttime, while ambient CO_2 (ACO_2) can be 10-20 % greater during nighttime than during daytime. A simulation of currently atmosphere daytime or nighttime CO2 concentrations would provide a closer observation on how plants could respond to forthcoming CO2 rising. Arbuscular mycorrhizal fungus (AMF) always improves plant nutrient absorption and growth. However, interactive effects of eCO_2 and AMF on accumulations of carbon (C), nitrogen (N), phosphorus (P) and potassium (K) in plant and soil, and thus plant growth are rarely elucidated. To understand mechanisms of eCO_2 plus AMF on crop growth and soil fertility, wheat (Triticum aestivum cv. Yunmai) were grown over 12-weeks under plus or minus AMF (Funneliformis mosseae) inoculation and four CO_2 concentrations, i.e. (1) daytime/nighttime ACO_2 (410/460 ppm), (2) sole daytime eCO_2 ($DeCO_2$, 550/460 ppm), (3) sole nighttime eCO_2 ($NeCO_2$, 410/610 ppm), and (4) dual daytime+nighttime eCO_2 ((D+N)eCO2, 550/610 ppm). Biomass of shoot and root, accumulations of plant C, N, P and K, activities of soil invertase and urease generally significantly enhanced, while concentrations of shoot and root N, P and K, and soil available N, P and K decreased under $DeCO_2$, $NeCO_2$ and $(D+N)eCO_2$. Compared with non-AMF control, effects of F. mosseae on above-mentioned characteristics were significantly positive under ACO_2, $DeCO_2$ and $(D+N)eCO_2$, while on accumulations of plant biomass, C, N, P and K were negative under NeCO2. F. mosseae association generally mitigated soil nutrient restraints on wheat's response to $DeCO_2$, while $NeCO_2$ reduced AMF's positive effects on wheat. These results demonstrated that integrations of AMF's benefits to crops growing under natural habitats of $DeCO_2$ and/or $NeCO_2$ are vital in managing potential long-term consequences of forthcoming CO_2 rising on worldwide farming systems.

Keywords: Arbuscular mycorrhiza; biomass production; enzyme activity; nitrogen; phosphorus; potassium

IC³AF-2025-02

Building Climate Change Resilience in Agriculture Production Systems

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Agricultural sustainability faces serious challenges due to climate change, traditional agronomic practices, extensive agrochemical use, tillage practices, and soil degradation, lead to nutrient losses and elevated greenhouse gas (GHG) emissions. To enhance food production, synthetic nitrogen (N) fertilizer application is inevitable though one of the major sources of nitrous oxide (N2O) emission. Consequently, synthetic N fertilizers consumption has doubled in last 35 years, which caused substantial GHG emission, global warming and soil deterioration in different cropping systems across the globe. Approximately, 21% of total global GHG emissions is contributed by Agriculture industry. The elevated levels of GHG emissions and deterioration in soil health emphasize the need to develop beneficial management practices (BMPs) to enhance sustainable agriculture crop production and to turn these challenges into opportunities. To promote sustainable agriculture, BMPs can be developed using 4R-based N management strategies considering soil quality and health, climate, tillage, and fertilizer application. The Farming communities need technologies that can improve soil health, increase fertilizer use efficiency, crop yield, and lower GHG emissions in addition to other environmental risks. Biochar amendment, crop rotation, cover crops/intercropping and N stabilizers have shown potential to improve soil quality and health, increase nutrient use efficiency, mitigate GHG emissions, reduce nutrient runoff and leaching, and optimize crop yield. This presentation will shed light on GHG mitigation, improving soil health in different cropping systems in response to different BMPs.

Keywords: Beneficial management practices, greenhouse gas, global warming, nitrogen management strategies, soil degradation,

IC³AF-2025-03

Invasive *Mimosa pigra* Seed Bank Assessment in Flood Plains around Nilwala River Basin and a Literature Survey.

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Floods are considered one of the most common natural disasters causing disastrous effects on living beings worldwide. This study aimed to assess the emergence patterns of vegetation types in seed bank samples collected from the Nilwala flood plain. Seed bank samples were observed for eight weeks. According to a seed bank analysis around *Mimosa pigra* infested areas in the Nilwala flood plain in southern Sri Lanka, *M. pigra* seeds were viable up to 30 cm depth in the soil and most prominent in 0-10 cm seed bank soil depth. Forbs, grasses, and sedges illustrated the same pattern, with a high number of viable seeds available in the uppermost layer (0-10 cm) and generally decreasing with the depth up to 30 cm. Mosses have an emergence in both shallow layers and deeper soil layers. Nilwala River Basin is considered a flood-prone river typically experiencing annual floods. The majority of the *M. pigra* spread is observed near the Nilwala River bank, and it is likely to have spread during the flood events. The sedimentation process due to the flood causes the introduction of *M. pigra* seeds into deep layers. The buoyant seedpods were carried downstream by flood currents, allowing the seeds to colonize new areas along riverbanks and floodplains. The floods by 2014 facilitated the dispersal of *M. pigra* seeds in the Kelantan River Basin. Sand scarification due to strong flowing water causes the

removal of the hard seed coat of *M. pigra* ultimately breaking the dormancy. The controlling efforts are more difficult due to prolific seed production and flood-aided dispersal of *M. pigra*. Therefore, the contribution of the flood scenario appeared significant for the spread of invasive *M. pigra.*

Key words: Colonize, dormancy, emergence, floods, seed bank

IC^{3}AF-2025-04

Recent Developments in Omics Techniques for Improving Plant Abiotic Stress Using Microbes

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Farmers could not obtain substantial crop yields due to varying biotic and abiotic stress factors. Microorganisms can effectively cope with abiotic stressors, such as heavy metals, heat, and cold, and biotic stressors, such as pests and diseases. However, before utilizing microbes to alleviate these stresses, conducting a comprehensive investigation of indigenous microbial communities' ecology, evolution, and operation through omics methodologies is crucial. Powerful tools for understanding the complex interactions between microbes and plants are provided by omics approaches, opening the door to creative ways to increase plant resistance to abiotic stress. This review is to investigate how omics technologies are revolutionizing knowledge of plant–microbe interactions, which are essential advancing sustainable agriculture, and to collectively provide information on different microbial omic approaches such as genomic, transcriptomic, proteomic, metabolomic, genome editing, and bioinformatic information about microbes to manage biotic and abiotic stress in plants. Additionally, the review will explore integrating multiple forms of omics techniques within a unified framework. The goals of the current review of omics techniques to enhance plant resilience to abiotic stress through the use of microbes are to further knowledge of the interactions between plants and microbes, make it easier to create successful microbial-based interventions, and eventually help to improve global food security in the face of environmental challenges and climate change. Through the application of various omics techniques, researchers can improve plant resilience to abiotic stress in agricultural systems, identify potential microbial candidates for enhancing stress tolerance, and obtain insights into the molecular mechanisms underlying plant–microbe interactions.

Key words: Abiotic stress, global food security, microbial-based interventions, omics approaches, stress tolerance

IC^{3}AF-2025-05

Agro-Biological Diversity for Food, health and Energy Security along Belt and Road in China -Pakistan under Fast Climatic changes

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Sino-Pak bilateral Eco-partnership in Asia with diverse ecology and rich Agro- Biological resources along belt and road initiative may provide food, health and energy security to associated communities for livelihood development. Pakistanhosted diverse ecological ranges of biological diversity in Himalaya, Karakoram and Kohindukush with long chain of mountain supporting with cultural communities. In this region, currently a project by China Pakistan Economic Corridor (CPEC) is underway to bring revolutionary socio-economic development. China and Pakistan are diverse bio-geographical countries with unique plant and Agro- Biological diversity and experts from both countries have started number of joint international projects on animal and plant resources using modern technologies including digitization of biological diversity, smart

agriculture, GIS based data center, ecological conservation of plant resources, conservation of trans-border indigenous knowledge and exchange of ideas by institutions through smart technology to cope SDGs in order to use Agro- biological resources for socio-economic development under fast climatic changes. This study contributes to a deeper understanding of the interplay between the built environment, biodiversity, and the SDGs, allowing key industry actors and policymakers to prioritize Agro- Biological diversity in SDG-related policies and programs. In order to do this, we have compiled all of the empirical data that is currently available on the connections between biodiversity and economic growth, concentrating on changes in climate, invasive alien species, and land use. Finally, we demonstrate how scenario planning for significant policy instruments such as the Convention on Agro-biological resources towards sustainability. This belt and road initiative will leads to establish Sino-Pak Biodiversity and ecological conservation research Centre by joint venture of Northwest Agriculture and forestry university Yangling, China and Quaid-i-Azam University Islamabad, Pakistan to initiate exchange program, for experts, students, researchers and farmers in line with global efforts for sustainable development. This initiative may further lead to trained post graduate students, scientists, ecologists, zoologists, Biodiversity Experts, eco-physiologists, Plant botanists and layman regarding the equal sharing benefits of ecological Plant diversity with sustainable way through which China and Pakistan further strengthen the ties in both brotherhood countries.

Key words: Agro- Biological diversity, China Pakistan Economic Corridor, economic growth SDGs, socio-economic development

IC^{3}AF-2025-06

Forecasting the impact of climate change on key crops of Khyber Pakhtunkhwa

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The world is facing climate challenges in the form of flash floods or harsh droughts, intense thunder storms or occasional rains, swamped plains or barren land, water assimilation or water scarcity. The aim of this research is to study the impact of climate changing events on Pakistan in general and its agriculture sector in particular. It will help in better copping against the future climate changing incidents. The intense rains of 2010, which resulted in a sever flood, is one of the climate change event in Pakistan. Khyber Pakhtunkhwa was among the provinces affected by the flood event of 2010. Khyber Pakhtunkhwa by ecological landscape can be divided into three zones or regions i.e. the Northern, the Central and the Southern regions. This study is an attempt to measure the climate variations in the three climate zones of the province, over the thirty-year period (1980-2010). The environmental trend analysis results of the study shows that Khyber Pakhtunkhwa as a whole has experienced the climate change impacts in terms of rise in mean temperature from 0.3°C to 1.2°C and average rainfall from11mm to 15mm over the thirty years span. The climate intense event of 2010 impact was observed in terms of decreased agricultural production of Kharif and rabi crop. Khyber Pakhtunkhwa agricultural statistics showed a decline of Kharif (maize) crop from 1880 kg/hector in 2008-09 to 1783 kg/hector in 2009- 10 and Rabi (wheat) production of 1565 Kg/hector in 2008-09 was reduced to 1520 Kg/hector in 2009-10. The climate changing impacts on agricultural sector is accessed by analyzing the two seasoned crops i.e. Rabi and Kharif of the province. The economic regression analysis is performed in this respect. The findings of the study show that climate factors doe's effects crop production. Climate impacts on Rabi crop of the province are more distinct than the Kharif crop. The regional regression results depicts a positive impact of climate change on the northern part of the province whereas a negative impact on crop production is seen due to the elevated temperatures and untimely rainfalls.

Key words: Climate challenges, ecological landscape, flash floods, harsh droughts, water scarcity

IC³AF-2025-07

Strategies for Water Savings and Agricultural Enhancements in UAE through Management Practices

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Arid and semiarid regions account for almost 40-45% of the Earth's total land surface, and these areas are highly prone to salinization due to low rainfall and improper water management practices. Salinity and drought, two very closely associated abiotic stressors, negatively affect crop productivity (Gamalero et al., 2020). Almost 20% of the total irrigated land has been degraded due to excess soil salinity (FAO, 2020).To meet the fodder requirements ,it is critical to developing sustainable agricultural systems under constricted conditions in these marginal lands. Innovative agriculture techniques involves the cultivation of fodders, using ground and low-quality water for irrigation, thus reducing the reliance on the depleting freshwater resources.Date farming, food security and UAE Water Security Strategy 2036 states that water as one of the essential aspect, mainly to save water. We have tested a subsurface irrigation tube system to reduce water use and irrigation requirements for the cultivation of date palms and to increase productivity. Al Nakhli has a long-term vision and achieved a modern subsurface irrigation system to make a big step further in using the precious source, water for irrigation purposes. Innovative subsurface irrigation tube is technically a woven polyester and nano-tech impregnated porous hose that can penetrate the root zone to an unlimited depth. With direct root irrigation, we have observed that deeper roots were developed and creating a larger rhizosphere. The extensive rhizosphere is responsible for a efficient uptake of water by the date palm trees. Tests resulted in a 40% irrigation water reduction and have achieved a 5-7% higher yield in terms of overall productivity. Since the application of water through this system is the first step and tested recently to cater to the date palm growth, shortly the date palm trees subsurface water application will create even bigger and better root growth mediated water uptake. Therefore, it will become more efficient and will lead to further reduction of water losses due to evaporation. Such innovative technology use in date palm production is significant towards the profitability of the date sector but even as crucial for the government to achieve its Water Security Strategy 2036 goals. A timid calculation of 35 cbm per year per date palm for 12 million date palms means a total of almost 420,000,000 million cubic meter of water. The application of new technology for date palm irrigation implies that a water-saving of 100 liter per day per capita, only by implementing a modern subsurface irrigation system. Keeping in view the importance of restoration of marginal environments, the present review focus on alternative water application and production systems and their management.to identify and develop strategies for sustainable agricultural production systems under saline and arid conditions for field applications.

Key words: Date palm, farming, agriculture, water security, sub surface irrigation, direct rootzone irrigation, water conservation.

IC³AF-2025-08

Hybrid Wheat: Preparation of Dealing with New Challenges Facing Food Security

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Hybrid wheat is a global challenges but also the preferred pathway to substantially improving comprehensive yield of wheat. Chinese scientists firstly found the photo-thermo sensitive male sterile germplasms (PTMS) in wheat. After more than 20 years of research, Chinese scientists had firstly created the technology system for two-line hybrid wheat in China. At the same time, it was entered into rapid application stage. The

technology system for two-line hybrid wheat in China is widely hoped to lead the direction of international hybrid wheat development and prepare to deal with New Challenges Facing Food Security.

Key words: hybrid wheat, two-line system, PTMS, restorer lines, seed production technology

IC^{3}AF-2025-09

Impact of climate change on soil microbial dynamics and its subsequent influence on crop productivity and food security

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Climate change is now a reality and has caused visible influence on every spere of life. Climate change also caused considerable influence on soil microbial communities which play crucial role in crop productivity and food security. The impact of climate change on microbial dynamics in soil is multifaceted. For example, rising temperatures can accelerate microbial metabolism and growth rates. This can lead to increased decomposition of organic matter, potentially releasing more carbon dioxide (CO2) into the atmosphere. Changes in precipitation patterns, such as increased droughts or flooding, can alter soil moisture levels. Microbial communities vary in their tolerance to moisture extremes, which can shift community composition and function. For instance, some bacteria thrive in wetter conditions, while others prefer drier soils. Climate change can influence the availability of nutrients in the soil. For example, increased microbial activity driven by higher temperatures may enhance nutrient cycling but could also lead to nutrient leaching during heavy rainfall events. Climate change can cause shifts in microbial community composition and diversity. Some species may thrive under new climatic conditions, while others may decline, potentially disrupting established ecological balances. Elevated temperatures may stimulate microbial respiration rates, increasing CO2 emissions. This can impact the soil's ability to sequester carbon, further contributing to climate change. Changes in microbial dynamics can affect plant health and growth. Plant-microbe interactions may be altered, which can influence crop yields and ecosystem resilience. Overall, climate change poses significant challenges to microbial dynamics in soil, affecting their roles in nutrient cycling, carbon sequestration, and overall soil health, with cumulative effects on agricultural productivity and ecosystem stability.

Key words: Climate change, carbon dioxide, ecosystem stability, food security, soil microbial dynamics,

IC^{3}AF-2025-10

Climate Change and Crop Productivity in Pakistan: Challenges and Way Forwards

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The increase in global temperatures since the mid-20th century is attributed to the observed increase in anthropogenic greenhouse gas (GHG) concentrations. Water and agriculture sectors are likely to be most sensitive to climate change-induced impacts in Asia. Agricultural productivity in Asia is likely to suffer severe losses because of high temperature, severe drought, flood conditions, deforestation and soil degradation. Although, Pakistan is not contributing much to GHG emissions (ranked 135) as compared to other industrialized nations, however, it is listed on number 7 among the nations that are most vulnerable to the global warming. Considering the countries' high dependence on agricultural products, to support their economies and growing populations, it is vital to gauge factors impacting crop productivity. This study quantifies the change in temperature and precipitation. Coupled with their respective effects, on productivity of three major crops; wheat, rice and cotton, within two of Pakistan's largest provinces: Punjab and Sindh. Based on the primary and secondary data, multivariate regression analysis is

conducted. Moreover, highly vulnerable areas to climate change have been identified under RCP scenarios 4.5 and 8.5, for 21st century. Results show that there is a substantial increasing trend in temperature, whereas precipitation has large inter–annual variability, in addition to some tele-connections to large scale ENSO circulation. Efforts are made to explore the temperature tipping points for selected crops in Pakistan. Regression results, based on fixed/random effects models, indicate that temperature above threshold values: 24.3°C, 33.0°C, 32.1°C for wheat, rice and cotton, respectively, negatively impacts productivity (statistically significant). Precipitation is statistically insignificant in explaining productivity. The biggest constraint in developing world towards environmental monitoring/assessment is the lack of an adequate environmental monitoring network. As conventional methods for environmental assessment requires substantial resources and maintenance cost. Therefore, Low-cost wireless sensor network could be equally efficient in devising and monitoring the effective policy actions for the abatement of environmental degradation in Pakistan. There has been significant development in the field of low-cost sensors for various applications (air Quality, Forest monitoring and management, smart agriculture) in environmental monitoring but still they face severe challenges such as accuracy and handling of huge data, acceptability, and technical capacity of regulatory authorities. Further, this study will present the glimpses of research activities going on at IESE-NUST Pakistan and how we can benefit our agriculture sector.

Key words: Climate change, crop productivity, deforestation, GHG emissions, soil degradation

IC^{3}AF-2025-11

Soil Degradation, Climate-Resilient Agriculture and Food Security: Insights from Pakistan

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Climate change poses significant threats to agriculture and food security, particularly in climate-vulnerable countries like Pakistan. Farmers have already started to feel the pinch of erratic rain patterns and departure of average temperature from normal temperatures. Considering the evolving environmental conditions, all over the world, especially in Pakistan where climate risk index is high, climate smart technologies are so essential to address these challenges and explore opportunities for developing climate-resilient production systems to ensure food security. In Pakistan, food production growth is slower than population growth; therefore, there will definitely be increasing food security challenges in the coming years. Soil sustainability is of great importance to feed a growing population, however, productive land in Pakistan is shrinking due to soil degradation, rapid urbanization and industrial expansion. Many of the environmental problems are directly affecting soil and these issues are also linked to the land and soil management. Land degradation both causes and is affected by climate change, as 35% of the elevated carbon dioxide in the atmosphere is a result of land destruction since 1850. In Pakistan, soil degradation such as loss of organic matter, decline in soil fertility, erosion, salinity and the effects of toxic chemicals and pollutants is a serious global environmental problem. Healthy soils are essential to ensure the production of sufficient food and fiber in the long term. Therefore, effective and careful soil management is necessary to prevent soil degradation and maintain long-term sustainability, especially in the context of climate change, which will ultimately ensure food security.

Key words: Climate Change, food security, soil degradation, soil fertility rain pattern

IC^{3}AF-2025-12

Industry 6.0 Technologies in Agriculture and Food Industries and Their Impact on Climate Change

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The integration of Industry 6.0 technologies in agriculture and food industries is transforming traditional practices into hyper-connected, AI-driven, and climate-resilient systems. With the global food demand projected to increase by 56% by 2050, advanced cyber-physical systems, artificial intelligence (AI), Internet of Things (IoT), quantum computing, and blockchain are enabling precision agriculture, smart food processing, and sustainable supply chains while minimizing environmental impact. AI-powered precision farming utilizes hyperspectral imaging, autonomous drones, and sensor-based irrigation systems, reducing water usage by 50% and optimizing fertilizer application, thereby lowering nitrous oxide (N_2O) emissions. Automated vertical farming, powered by AI-driven nutrient management and LED-optimized photosynthesis, increases crop yield per square meter by 350× while using 90% less water compared to traditional farming. In food processing, Industry 6.0 innovations such as AI-controlled enzymatic food preservation, quantum-enhanced fermentation modeling, and robotics-assisted smart sorting enhance efficiency, reduce waste, and improve food security. Smart blockchain-enabled supply chains ensure 100% traceability, reducing food fraud and optimizing transportation logistics to cut CO_2 emissions by 40%. Lab-grown meat and cellular agriculture, powered by CRISPR gene editing and bioreactors, reduce methane (CH_4) emissions by 92% compared to conventional livestock farming. We need to explore the transformative potential of Industry 6.0 in the agriculture and food sectors to highlight its impact on climate change mitigation and the transition towards carbon-neutral, resource-efficient food production systems. The role of AI, quantum computing, nanotechnology, and bioengineering in creating a resilient, high-yield, and sustainable global food ecosystem, aligning with SDG 2, 9, and 13.

Key words: Industry 6.0,precision agriculture, AI in food processing, climate-resilient farming, blockchain in supply chains, sustainable food technologies

IC^{3}AF-2025-13

Utilization of Genomics, Gene Editing, and Phenomics in Plant Breeding to Develop Climate-smart Cultivars

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Enhancing the resilience of food systems in the face of climate change requires innovative approaches to develop climate-smart cultivars with improved adaptability, productivity, and stability. Genomics, gene editing, and phenomics are transforming plant breeding by enabling precise and accelerated crop improvement. The integration of pangenomics has unraveled the genetic diversity within and across species, providing a comprehensive framework for identifying adaptive traits crucial for resilience. Single-cell technologies offer unparalleled resolution to study cellular responses to environmental stresses, while CRISPR/Cas-based gene editing facilitates targeted manipulation of key genes to enhance stress tolerance, nutrient efficiency, and yield stability. Phenomics, including high-throughput and field-based approaches, bridges the gap between genotype and phenotype, enabling the identification and validation of climate resilient traits. These advanced tools are being utilized to improve pulses, grains, and other staple crops critical for global food security. This multidisciplinary approach allows breeders to develop cultivars tailored to diverse climatic challenges, ensuring sustainable food production under changing conditions. By leveraging these technologies, the plant breeding community is poised to create cultivars that meet the dual challenge of feeding a growing population and

mitigating the impacts of climate change. This presentation highlights key examples from soybean, wheat, and other commodities, illustrating the transformative potential of genomics, gene editing, and phenomics in advancing climate-smart agriculture.

Key words: pangenome, single-cell, CRISPR/Cas, climate-smart, resilience, pulses, grains

IC^{3}AF-2025-14

Potential Impact of Climate Change on the Agricultural Sector in Egypt

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The complex interrelationship between climate change and agricultural production will become one of the most significant policy debates in developed and developing countries. Global and regional climate changes will modify the agricultural production capacity. Climate change can have several impacts on the agricultural sector and the stability of food security in Egypt. Crop production will be affected negatively due to the expected increases in temperature, extreme weather events, drought, plant diseases, and pests. Also, land use will change due to flooding from sea level raising, seawater intrusion, and secondary salinization. The temperature increases will reduce wheat yields from 8.1% to 24.5%, maize from 9.7% to 29.1%, and rice from 2.1% to 6.1% by 2070. Food prices are expected to rise from 13.5% to 18.9% by 2070. In terms of food stability, the food security level in Egypt will decrease from 76.1% to 73.9%. Water resources may be affected due to global warming and decreases in precipitation. Moreover, crop water requirements are expected to increase. The confounding effect of all these components represents the main challenge for researchers.

Keywords: Environmental changes, natural resources, soil, yield production.

IC^{3}AF-2025-15

Strengthening National Biosafety Frameworks to Safeguard Agriculture and Food Security: The Role of Pakistan's Biosafety Guidelines

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The sustainable integration of biotechnology into agriculture is contingent upon the establishment of robust biosafety frameworks. In compliance with the Cartagena Protocol on Biosafety under the Convention on Biological Diversity, the Government of Pakistan, through the Pakistan Environmental Protection Agency (Pak-EPA) and the Ministry of Climate Change & Environmental Coordination, has developed and revised the National Biosafety Guidelines (2005, amended 2024). These guidelines establish a comprehensive regulatory and procedural framework for the safe use, transfer, and handling of Living Modified Organisms (LMOs) and Genetically Modified Organisms (GMOs), ensuring environmental protection and long-term food security. This study underscores the critical role of Pakistan's updated biosafety guidelines in addressing climate change-induced agricultural vulnerabilities. The 2024 amendments introduce enhanced risk assessment methodologies, monitoring protocols, and institutional mandates to mitigate emerging biosafety challenges. By adopting a precautionary approach, the guidelines promote responsible biotechnological innovation while minimizing ecological risks. As Pakistan contends with escalating climate stressors threatening food systems, the national biosafety framework serves as a critical safeguard against unintended consequences of modern biotechnology, fostering sustainable agricultural development.

Key words: Biosafety, Pakistan EPA, cartagena protocol, GMOs, climate resilience, agricultural sustainability, food security

IC³AF-2025-16

Abiotic Stress Adaptation in Field Crop Plants

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Agriculture production must be substantially increased in order to support the urgent requirement for food for the rapidly growing population. The depletion of natural resources combined with a hiking tendency in climatic variability has already harmed the worldwide agricultural production system. Numerous factors have a major role in determining how well crops are produced (climatic, agronomic, and soil nutrient status), and stress is defined as any unfavourable climatic situation that impairs plant development. Under today's changed scenarios of climate, abiotic stresses, such as drought, salinity, rising temperatures, submergence, and nutritional deficits, are becoming more common for crops. These stresses impede crop output by wreaking havoc on plant morphological processes, biochemical pathways, and physiological characteristics that are all intimately related to diverse plant development and yield phenomena. Abiotic stress is viewed as a multi factorial event involving various processes in field crops. Numerous field crops, including cereals, legumes, oilseeds, tuber crops, and other important cash crops, have seen drastic yield reduction due to abiotic stresses. Several abiotic stresses that plants experience, including temperature extremes, drought, salt, and heavy metals, will be discussed in this chapter. All of these are significant constraints on agricultural yield and sustainability. To address the challenges associated with elucidating the stress tolerance mechanism, this chapter also discusses several mitigating strategies involving improved breeding techniques, modern technology for field crop production, and the use of various nanotechnologies in conjunction with ICT interventions.

Key words: Abiotic stresses, cash crop, legumes, natural resources, soil health

IC³AF-2025-17

Ensuring Food Security: The Response of Chinese Hybrid Lines to Varied NPK Fertilization Levels

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Pakistan's average wheat production is significantly lower than that of the rest of the world, including adjoining countries like India and China. NPK are the major primary nutrients needed by the plants in large amount. Optimum amount of these nutrients has to be maintained in soil for achieving the yield potential. High yielding varieties of wheat have high nutritional requirements and generally give prominent response to the applied levels of NPK. A field research entitled "Response of Chinese wheat lines to different levels of NPK" was conducted at Agronomy Research Farm, The University of Agriculture Peshawar during Rabi season 2020-2021. The research was carried out in randomized complete block design (RCBD) having three replications. Treatments were consisted of Chinese wheat lines (18A1, JM-1215, JM-1683, H-1 and WS-1) with two local check (Wadan-17 and Pirsabak-15) and two NPK levels (F1: 120-90-60 and F2: 150-112-75 kg ha^{-1}). The results of the experiment indicated that wheat line WS-1 produced higher tillers (444 m^{-2}), leaf area (32.7 cm^2), leaf area index (5.0), plant height (105.4 cm), spike length (22.0 cm), spikes (336 m^{-2}), grains $spike^{-1}$ (59), thousand grain weight (62.2 g), biological yield (9769 kg ha^{-1}). Grain yield was recorded higher for wheat lines WS-1 (4236 kg ha^{-1}), JM 1683 (4204 kg ha^{-1}), H-1 (3923 kg ha^{-1}) and 18A1 (3812 kg ha^{-1}) while higher harvest index (55%) was noted in JM-1683. Application of NPK at the rate of (150-112-75 kg ha^{-1}) took less days to emergence (13) and increased emergence (87 m^{-2}), number of tillers (432 m^{-2}), leaf area (22.7 cm^2), leaf area index (3.4), plant height (98.3 cm), spike length (16.0 cm), spikes

(319 m^{-2}), grains $spike^{-1}$ (43), thousand grain weight (56.6 g), biological yield (9057 kg ha^{-1}) and grain yield (3702 kg ha^{-1}) followed by lower level of NPK (120-90-60 kg ha^{-1}). It is concluded that wheat lines WS-1, JM-1683, H-1 and 18A1 produced higher grain yield with the application of NPK at the rate of 150-112-75 kg ha^{-1} is therefore recommended.

Key words: Chinese Hybrid, food Security, NPK, soil health, wheat production

IC^{3}AF-2025-18

Future of our Crops in the Scenario of Climate Change

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Climatic changes are affecting every sector of life including our crops and ecosystem. It's changing the weather pattern, increasing drought, creating floods, and bringing wildfires. Acceleration in soil erosion, habitat fragmentation, and deterioration of aquifers are some of the negative impacts of these changes that in turn threaten the plants life, food security as well as food safety. Mechanized agricultural practices, genetic engineering, and invasive species are some other reasons of the loss of native biodiversity. The situation is further worsened by rapid urbanization, increasing poverty, overhunting, overfishing, and inadequate water resources. There is always a solution to a problem. Apart from long-term solutions, some short-term remedies include, supporting small-scale food production, minimizing the agro-fuel expansion, and enhancing the plantation drives through ecologically sound methods within the umbrella of sustainable agriculture. There is also a dire need of combating the climate crises by achieving sustainable development goals. It's also the right time to have negotiation on Carbon, stocks, Carbon currency and Carbon Tax at national, regional and global levels among all the stakeholders especially academicians and researchers.

Keywords: Climate change, global warming, deforestation, urbanization, industrialization.

IC^{3}AF-2025-19

Climate Change and Food Insecurity

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Climate change is defined as the change in the statistical distribution of weather patterns for an extended period of time (i.e., decades to millions of years). Climate change is happening now and impacting peoples and countries across the globe. The poorest segments of the societies/ countries are at a greater risk of being affected by these changes. Climate change and Food insecurity are interconnected issues. Climate change has deep impacts on crop production. This has brought changes to the land utilization and agronomic practices across the globe. Still, climate change threats to food and cash crop production in years to come due to adverse effect in the form of temperature changes. Many studies have clearly mentioned that the climate change and the global warming is a result of anthropogenic activities. Ever increasing demands of growing population give rise to the culture of 'consumerism' which puts pressure on the supply side to meet their demands that results in unrestricted exploitation of natural resources. Pakistan is not an exception; in fact, Pakistan is facing the repercussions of climate change and global warming in the form of devastating floods. According to the latest reports, temperature is increasing constantly which may lower production of wheat by

1.5-2.5 percent and rice by two to four percent. Cotton would be hit severely. It is expected that temperature might rise by another 0.6 to one °C by 2030. It has been noted by many studies that a rise in temperature in the range of 1-5 °C (Celsius) could bring down the wheat yield in sub-mountains, arid and semi-arid regions. On the other hand, higher temperature may improve wheat yield in the mountainous region. The national wheat and rice production would lower than the potential. Rice is more responsive to climate change. Vegetables and livestock are also vulnerable to the impact of climate change. In order to address this, the country needs a strategy (Policy framework) that would require expansion in water storage capacity, improvement in the efficiency of water usage, and introduction of high yielding crop varieties that are suitable for the changing climate conditions.

Key words: Climate change, food insecurity, rise in temperature, crops production, coping strategy

IC^{3}AF-2025-20

Effects of Soil and Crop Management Practices on Soil Quality and Health Indicators in the Rice-Wheat Cropping System under Semi-Arid Climate: Current Status and Challenges

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Assessment and monitoring of soil health and its links with sustainability and food security has gained paramount significance on global scale. The rice-wheat cropping system (RWCS) is backbone of agriculture and food security in South Asia including Pakistan. We analyzed 95 soil samples from the rice-wheat belt in Pakistan for physico-chemical and biochemical properties and tested the effects of soil and crop management practices on these soil quality indicators. Crop management practices included rice (direct-seeded vs puddled conditions sowing) and wheat (zero tillage vs seed-bed sowing) whereas soil management practices were organic amendments (no amendment vs animal manure), irrigation sources (tube well vs canal plus tube well mixed), rice residue management (burning, removal, incorporation and zero tillage), and wheat residue management (removal vs incorporated). Soil pH, bulk density (BD; g cm^{-3}), soil basal respiration (mg CO_2-C g^{-1} 24 h^{-1}) and total organic carbon (TOC; g kg^{-1}) ranged from 7.31-8.84, 0.79-1.65 g cm^{-3}, 0.21-3.10 mg CO_2-C g^{-1} 24 h^{-1} and 0.66-11.5 g kg^{-1}, respectively. Application of manure and mixing tube well and canal water reduced soil pH. Crop residue retention and zero tillage resulted in lower soil pH than removing or burning the residues. Application of mixed irrigation significantly reduced soil BD compared to tube well irrigation. Incorporation of both rice and wheat residues and zero tillage practices reduced soil BD than burning and removing the crop residues. Soil basal respiration was nearly two-fold higher under mixed water irrigation compared to the tube well irrigation. We also found that incorporation of rice and wheat residues significantly enhanced soil basal respiration and values were two-times higher compared to burning, removing and retaining crop residues under zero tillage practices. Soil basal respiration was significantly higher under puddled nursery sowing than the direct-seeded rice. Addition of animal manure and mixed irrigation practices increased TOC contents. Moreover, rice and wheat residue incorporation enhanced TOC contents when compared with residue removal and burning. Our study demonstrated that BD, soil basal respiration and TOC were influenced more by the crop and soil management practices than soil pH and, hence, were more sensitive indicators of soil quality. Data also suggested that these soil quality indicators strongly reflect the long-term changes in productivity and soil health of RWCS. Application of animal manure, retaining crop residue, mixing tube well and canal water, adopting zero tillage practices and continuity of these practices on long-term basis could enhance the sustainability of the RWCS under semi-arid climate and ensure local and regional food security.

Key words: Animal manure, crop management,soil health, soil basal respiration, zero tillage

IC³AF-2025-21

Role of AI in Climate-Smart Agriculture

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As the global agricultural landscape faces significant challenges from climate change, the need for innovative, adaptive, and resilient farming practices has never been more urgent. Climate-smart agriculture (CSA) aims to sustainably increase productivity, enhance resilience, and reduce greenhouse gas emissions. Artificial Intelligence (AI) has emerged as a transformative force capable of accelerating the realization of CSA goals. This talk explores the multifaceted role of AI in shaping the future of climate-smart agriculture. AI technologies are revolutionizing how farmers adapt to climatic variability, from predictive analytics for weather and crop modeling to intelligent decision-support systems for resource optimization. The presentation will highlight real-world case studies and emerging AI tools that enable precision farming, early warning systems for pests and diseases, soil health monitoring, and agricultural sustainability. AI in agriculture has now become Agricultural Intelligence. Emphasizing both opportunities and ethical considerations, the session will also address challenges related to data accessibility, smallholder inclusion, and the need for interdisciplinary collaboration. This talk aims to inspire a new era of innovation for food security and environmental sustainability by bridging cutting-edge AI research with practical agricultural applications.

Key words: Agricultural landscape, Artificial Intelligence, Climate-smart agriculture, climatic variability

IC³AF-2025-22

Exogenously Applied Plant Growth Regulators Affect Heat-stressed Rice Pollens

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Increasing temperature due to global warming has emerged one of the gravest threats to rice production. The present study examined the influence of high temperature and exogenously applied plant growth regulators on pollen fertility, anther dehiscence, pollen germination and metabolites synthesis in pollens of two rice cultivars (IR-64 and Huanghuazhan). Plants were subjected to high day temperature (HDT), high night temperature (HNT), and control temperature (CT) in controlled growth chambers. Four different combinations of ascorbic acid (Vc), alpha-tocopherol (Ve), brassinosteroids (Br), methyl jasmonates (MeJA), and triazoles (Tr) were used along with a nothing-applied control. Our results depicted that high temperature severely reduced the pollen fertility, anther dehiscence, pollen retention, germination and metabolites synthesis in pollens of both rice cultivars. Nonetheless, exogenous application of various plant growth regulators assuaged the adverse effects of high temperature and Vc+Ve+MeJA+Br was found the best combination than the other treatments for every studied characteristic. The HNT posed more negative effects than the HDT. Variations were also apparent between cultivars and Huanghuazhan performed better than IR-64 under high-temperature stress, with higher pollen fertility, better anther dehiscence, and greater pollen retention and germination rates. The greater tolerance of Huanghuazhan to high temperature was related with the higher synthesis of metabolites in this cultivar.

Key words: Anther dehiscence, fertility, high temperature, metabolites, plant growth regulators, pollen germination.

IC³AF-2025-23

The Impact of Climate Change on Major Agricultural Crops: Evidence from Punjab, Pakistan

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This study focuses on the impact of on changes in climate change indicators on production of four major crops in Punjab, Pakistan. The results show that in the short run the increase in temperature is expected to affect the wheat productivity but in long term the increase in temperature has positive affect on wheat productivity. Similarly, the increase in precipitation has negative impact in both short and long term. A rise in temperature is beneficial for rice production initially. However, beyond a certain optimal temperature, further increase in temperature becomes harmful for rice production. Interestingly, the increase in precipitation does not harm the rice productivity. It has been evident that the change in climate variables (temperature, precipitation) has a significant negative impact on production of cotton. Finally, the increase in temperature also harms the sugarcane productivity in long term. Mainly, the impact of changes in temperature and precipitation varies significantly with the timing, crop type, production stages of the crops and location.

Key words: Climate Change, climate variables, precipitation, rising temperature, wheat productivity.

IC^{3}AF-2025-24

The Future of Food: Climate-Resilient Agriculture for a Warming World

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Climate change presents an existential challenge to global food security, affecting agricultural productivity through rising temperatures, erratic precipitation, and extreme weather events. This paper explores climate-resilient agricultural strategies such as regenerative agriculture, precision farming, and advanced genetic engineering to enhance food security in the face of climate change. Integrating artificial intelligence, IoT-driven smart irrigation, and CRISPR-based crop enhancements, the study highlights technological innovations that mitigate climate risks. Case studies from India, the Netherlands, and China demonstrate successful climate-smart agricultural practices. This paper advocates for policy interventions, investment in sustainable agricultural research, and global cooperation to build a resilient food system capable of withstanding climate-induced disruptions.

Key words: Climate change, food security, climate-resilient agriculture, precision farming, sustainability, smart irrigation, CRISPR.

IC^{3}AF-2025-25

Sustainable Nitrogen Management for Ensuring Food Security, Climate Action and Environment Sustainability

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Nitrogen is essential for the very existence of life on planet Earth. Ever-increasing population and urbanization has increased the reactive nitrogen (Nr) use and its release in the environment, disturbing the nitrogen cycle. This has resulted in deterioration of soil, water and air quality, biodiversity loss, climate change and significant impacts on human health. Several factors including biomass burning, transport and energy sector, wastewater contribute towards N emissions, however agriculture sector contributes about 66% to total N emissions in Pakistan. Use of N fertilizers in the country has increased exponentially during last three decades as more than 10-fold increase in N input has been observed from 1961 to 2021. Pakistan consumed 3835.2 thousand tons of mineral N in 2022 compared to 62.1 thousand tons in 1961 on same arable land. High N application has contributed to enhance cereal-based food security from 6.7 mt production to 42.7 mt in 2020. The nitrogen use efficiency has dropped from 50% to less than 30% in cereal based cropping system. The total nitrous oxide (N2O) emission has increased from 63.99 to 1069 mt CO2eq/yr in last 5 decades with about 82% share from agriculture sector. Similarly, the total NH3 emission has increased from 0.28 mt/yr to about 1.44 mt/yr in last 5 decades. The presentations will overview the nitrogen use in South Asia, and particularly in Pakistan for the past 50 years and its role in crop production as well as environmental concerns.

Key words: Climate change, fertilizer use efficiency, nutrient pollution, sustainability, carbon, emissions.

IC^{3}AF-2025-26

Next-Generation Breeding for Nutritious Crops: Challenges and Opportunities for Food Security under Changing Climate

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Climate change significantly threatens global food security as crop demand continues to rise. Its impacts are evident through rising temperatures, elevated CO_2 levels, melting ice caps, sea level rise, and increased frequency of droughts, all of which negatively affect both the production and quality of food. The most vulnerable farmers and nations, particularly those in marginal environments, face heightened abiotic and biotic stresses and biodiversity loss. Over two billion people suffer from malnutrition due to the lack of essential nutrients in widely cultivated cereals, pulses, and oilseed crops, alongside the mineral deficiencies of soils. Major food crops are often poor sources of micronutrients crucial for human health. Addressing nutritional deficiencies requires identifying genes and quantitative trait loci (QTLs) associated with essential nutrients and incorporating them into elite breeding lines through marker-assisted breeding. The discovery of QTLs for traits such as protein content, vitamins, macronutrients, micronutrients, minerals, oil content, and essential amino acids in key food crops is instrumental in developing nutrient-rich crop varieties. Advances in genomics are facilitating sustainable agricultural intensification and enhancing crop resilience to climate change. High-quality reference genomes, enabled by genome sequencing technologies and population-level genotyping, offer profound insights into genomic variation, crucial for crop improvement. Genome editing technologies, capable of precise and rapid genome modifications, hold significant potential to improve the nutritional profile of elite crop varieties, providing an effective solution to mal nutrition.

Key words: Crop improvement, genomic advances, nutritional stress, quantitative traits loci(QTLs).

IC³AF-2025-27

Where is the Good Life From?

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Currently there is over-supply of world economic goods, thus causes the trade war among countries. Human being is experiencing the wealthiest state in human history in terms of income per capita or population scale. It is long argued that the good life of human society comes from the technological progress, innovation or creation accumulated in human history. Human beings create something from nothing. There is a net benefit from human knowledge progress. It is true from human perspective. But if we viewed issue from ecological system perspective, we find the human history is a zero-sum game among all species. What we gain is what other life lose. Based on the evolution theory of Darwinism, life on earth struggles for survival and reproduction via organic means (teeth, muscle, organs, etc.), and the knowledge of all life has been updated and refined by genetic mutation and inheritance. All species kept in balance on the earth in general in long history until human being came on the stage. This period of evolution, we called organic evolution meaning that all species compete each other for resources by organic means. When human being came on the stage new tools (stone, fire, metal, petroleum, etc.,) were introduced for competition, we called it inorganic evolution. Due to the richness of inorganic materials and their superior characters, human knowledge explodes via industrial revolution. Many kinds of machines and energies have been developed under extreme lab or manufacturing environment (high temperature, high pressure with catalyzers), which gives human a huge advantage when competes with other species in resources and space. This not only kills other species but also change the earth environment permanently. Since organisms are produced in normal mild earth environment, mainly with carbon, oxygen, hydrogen, nitrogen and a few minerals, they can't digest or decompose the inorganic materials or waste that are produced in unique industrial condition with very different kinds of chemical elements. This is what we called environmental pollution. Human being is the only species that can utilize the benefits of inorganic energies and materials and avoid their damage due to his intelligence. Human welfare, freedom or so-called development depends on how much inorganic material and energies could have been utilized. Since human beings originated and evolved from same environments, thus prefers to occupy the same environment as other species, the freedom or development of human society means the contraction of other species' space. There is no such a term as sustainable development. There is no clean technology from ecological perspective. There is no creation from nothing. All development or technological progress of human society means destruction of other species. The good life of human society is built on the massive destruction of other species. For food safety and biodiversity, organic farming and primitive agriculture should be encouraged.

Key words: World trade, technologies, ecological system, organic evolution.

IC³AF-2025-28

Optimizing water-use efficiency of greenhouse vegetable production systems in Qatar

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In a partially controlled greenhouse study, we explored the potential for optimizing water use in vegetable production under greenhouse conditions in Qatar, where high water demand challenges sustainability in agriculture. The research evaluates whether reduced irrigation levels (75% and 50% of standard irrigation levels) can achieve yields comparable to conventional 100% irrigation practices. The primary objective is

to determine water-efficient practices for common vegetable crops in Qatar's arid climate, helping local farmers reduce water use without compromising yield. The experiments were conducted at the Agricultural Research Station, Qatar University in Rawdat Al-Faras (25º 48' N latitude and 51º 200' E longitude). Vegetable crops such as cherry tomatoes (*c/v*, CLAUSE/GOLDWIN, DAEHNFELT/KOSHIMA), cucumber (SEMINIS/RAINBOW), and capsicum (ENZA ZADEN/DENIRO, SEMINIS/LIDO) were cultivated in three different evaporative cooling greenhouses using standard management practices. Three irrigation levels (100%, 75%, and 50%) were set up. Data on climatic variables, crop phenology, growth and yield were collected to assess crop performance across treatments. Our preliminary results show similar crop yields under 75% irrigation compared to 100%, suggesting the feasibility of optimizing water use in Qatar. Full results will determine specific water-saving recommendations for each crop type. This research contributes to water conservation strategies for arid environments, offering data-driven guidelines for Qatari farmers. Findings have implications for sustainable agricultural practices and may guide policies for efficient water resource management in Qatar.

Key words: Irrigation rates, water use efficiency, greenhouse crops, Qatar agriculture, sustainable practices.

IC^{3}AF-2025-29

Effect of Zinc Oxide Nano Particles Application through various Methods on Maize-Wheat productivity, Biofortification and Zinc Use Efficiency in Calcareous Soil

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Effect of Zinc Oxide nano particles (Zno NPs) application through various levels and methods on maize-wheat productivity, biofortification and zinc use efficiency in alkaline calcareous soil was assessed in pot as well as in field experiments. The experiment was consisting of two factors that are various levels of ZnO NPs (0, 100, 200, 300 and 400 g ha^{-1}) and different application methods (soil, seed coating and foliar application). In the pot experiment, ZnO NPs at 300 g ZnO NPs ha^{-1} achieved maximum values for fresh shoot biomass (82.78 g), dry shoot biomass (21.67 g), dry root biomass (1.81 g), chlorophyll content (35.6 SPAD), Zn uptake (557.70 µg pot^{-1}) and phosphorus uptake (50.29 g pot^{-1}). The application of 200 g ZnO NPs ha^{-1} further enhanced certain parameters, showing the highest values for fresh root biomass (13.95 g), Zn use efficiency (0.13%) and soil phosphorus concentration (8.0 mg kg^{-1}).The Zn translocation factor (0.98) and shoot phosphorus concentration (2326.34 mg kg^{-1}) also peaked at 200 g ZnO NPs ha^{-1}, with their lowest values observed at 400 g ZnO NPs ha^{-1}, recorded as 0.84 and 2313 mg kg^{-1}, respectively. ZnO NP application at 400 g ha^{-1} proved effective in enhancing Zn concentrations, achieving maximum values in shoots (37.43 mg kg^{-1}), roots (43.25 mg kg^{-1}), and soil (10.07 mg kg^{-1}). Interestingly, some parameters favored the control treatment (0 g ZnO NPs ha^{-1}); the bioaccumulation factor (4.61 mg kg^{-1}) and root phosphorus concentration (211.44 mg kg^{-1}) were highest in the control, with their lowest levels recorded at 400 g ZnO NPs ha^{-1}, at 2.81 mg kg^{-1} and 155.36 mg kg^{-1}, respectively. The application method significantly influenced yield parameters in the maize pot experiment. Foliar application of ZnO NPs produced maximum values for fresh shoot biomass (78.13 g), dry shoot biomass (18.63 g), chlorophyll content (35.7 SPAD), shoot zinc concentration (34.48 mg kg^{-1}), zinc uptake (462.39 µg pot^{-1}), zinc translocation factor (0.99), zinc use efficiency (308.39%), soil phosphorus concentration (6.7 mg kg^{-1}), and phosphorus uptake (43.16 g pot^{-1}). Parameters like fresh root biomass (13.17 g), dry root biomass (1.75 g), and shoot phosphorus concentration (2324.43 mg kg^{-1}), achieved maximum values with seed coating. Soil application, however, excelled in parameters like root zinc concentration (40.13 mg kg^{-1}), soil zinc concentration (9.00 mg kg^{-1}), and root phosphorus concentration (192.73 mg kg^{-1}).

Key words: Calcareous soil, foliar application, maize yield, seed coating, zinc oxide nano particles.

IC³AF-2025-30

Effect of *Trichoderma* on the availability of boron to common bean (*Phaseolus vulgaris* L.): a pot study

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Boron (B) is an essential micronutrient for plant growth, but its availability and toxicity levels can significantly impact crop productivity. This study investigated the interactive effects of different B levels and *Trichoderma* application on the biomass production, nodulation, and B uptake of bean plants. A greenhouse experiment was conducted using varying B concentrations (0, 0.5, 1.0, 1.5, 2.0, and 3.0 kg ha^{-1}) with and without *Trichoderma* inoculation (1 kg ha^{-1}). The experiment was conducted in the glasshouse of department of Soil and Environmental Sciences, The University of Agriculture, Peshawar where pots containing 5 kg soil pot^{-1} were applied with assigned treatments arranged in CR factorial design with three replications. Boron was applied to soil and mixed with surface soil whereas the *Trichoderma* was applied through seed coating. Each pot was sown with five seeds and grown up for 40 days. Data on plant height, fresh root and shoot biomass and nodulation was recorded at time of harvest and then kept for drying for further analysis. Results showed that *Trichoderma* significantly enhanced shoot and root biomass, with the highest fresh shoot biomass (115.9 g pot^{-1}) and dry shoot biomass (47.2 g pot^{-1}) recorded at 1 and 1.5 kt B ha^{-1}, respectively. Root biomass followed a similar trend but declined at 3 kg B ha^{-1} might be due to toxicity. Nodulation was significantly influenced by B levels, with the highest number of nodules (37.5 per plant) at 1.5 kg B ha^{-1}, while *Trichoderma* had no significant effect on nodulation. Boron uptake increased with higher B applications, with *Trichoderma* further enhancing B accumulation in plant tissues by up to 63.1% at 3 kg B ha^{-1}. Soil B concentration followed a dose-dependent pattern, while *Trichoderma* had minimal impact on residual soil B, pH, and electrical conductivity. These findings suggest that *Trichoderma* application enhances biomass production and B uptake at optimal B levels but may not mitigate the adverse effects of excessive B on nodulation and plant growth.

Key words: Boron, biomass production, nodulation, *Phaseolus vulgaris* L. *Trichoderma* inoculation.

IC³AF-2025-31

Validating the Impact of Water Potential and Temperature onSeed Germination of Wheat (*Triticum aestivum* L.) via Hydrothermal Time Model

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Wheat is the most extensively cultivated crop and occupies a central place in human nutrition providing 20% of the daily food calories. This study was conducted to find both T and ψ effects on wheat germination and the cardinal Ts value; a lab experiment was accomplished using HTT models. Cultivars were germinated under different accelerated aging periods (AAP, 0, 24, 48, and 72 h) at each of the following constant Ts of 15, 20, 25, 30, and 35 ◦C at each of the ψs of 0, −0.05, −0.1, −0.15, and −0.2 MPa. GR, GP, and other germination parameters (GI, GRI, CVG, SVI-I, SVI-II, GE, and MGT) were significantly determined by solute potential, temperature, and reciprocal action in both cultivars ($p \leq 0.01$). Depending on the confidence interval of the model co-efficiently between cultivars, there was no significant difference. Hence, the average of cardinal Ts was 15, 20, and 35 ◦C for the Tb, T0, and Tc, respectively, in the control condition (0 MPa). Hydro-time values declined when Ts was raised to T0 in cultivars, then remained constant at Ts ≥ T0 (2.4 $MPah^{-1}$ in Pirsabak 15 and 0.96 $MPah^{-1}$ in Shahkar). The slope of the relationship between ψb(50) and TTsupra with temperature when Ts is raised above T0 and reaches 0 at Tc. In conclusion, the assessed

parameter values in this study can easily be used in simulation models of wheat germination to quantitatively characterize the physiological status of wheat seed populations at different Ts and ψs.

Key words: Cardinal temperatures, hydrotime model, hydrothermal time, wheat, water potential.

IC^{3}AF-2025-32

Melatonin Enhances Drought Tolerance in Maize by Boosting Antioxidant Defenses and Key Biochemical Pathways, Leading to Improved Yield and Water Use Efficiency under Field Conditions

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Drought stress resulted in significant yield losses of all crops particularly maize thus, drought tolerance methods are critical. Melatonin (MEL) improved plant stress tolerance; however, its pre-treatment with irrigation water for inducing tolerance against drought stress under field conditions remains unknown. Therefore, we examined the influence of MEL (0, 100, and 200 µM) on the antioxidant activities, pigments accumulation, morpho-physiological traits yield and water productivity under mild (80% FC) and severe drought stress (60%FC) in comparison with control (100%FC). Findings indicated a substantial reduction in maize growth and biochemical and yield traits with drought induction although, application of MEL with irrigation water with 100 and 100 µM enhanced relative water content, chlorophyll *a*, *b*, *a*+*b*, carotenoid content, proline content, antioxidant activities, physiological, morphological, growth traits, yielding attributes, water productivity, biological and grain yield whereas leaf water traits including water uptake capacity (WUC) and water situation deficit (WSD) were decreased. Application of 200 µM MEL had enhanced CAT, POD, APX activities and proline accumulation as compared with no MEL under both moderate and severe drought. Data on morphological traits such as CGR, and LAI, were enhanced with 200 µM MEL exogenous application. Yield components, water productivity, grain, and biological yields were also enhanced with 200 µM MEL under drought stress over no MEL. It is concluded that MEL with 200 µM MEL substantially lowered the deleterious impact of osmotic stress by boosting anti-oxidant enzymatic activities and chlorophyll and osmolyte accumulation, thereby enhancing maize yield by 24% and 36% under mild drought while 25% and 42% under severe drought stresses, respectively over no MEL under same conditions.

Key words: Severe drought, Meletonin, Relative water content, water productivity, growth, maize yield.

IC^{3}AF-2025-33

Rice Crop Residue Management Effects on Soil Hydrology and Wheat Yield in Rice-Wheat Cropping System

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The burning of crop residues has remained a common strategy to manage rice residues in rice wheat cropping system, which adversely affects soil physio-chemical properties. Adding the crop or incorporation of residues in soil can alter hydrological characteristics. Management of rice residue with Happy Seeder is the ideal solution, which can work mulching and help to retain moisture. In view this study has been conducted involving three treatments including T_1: Rice residue removal and sowing of wheat, T_2: Rice residue incorporation and sowing of wheat by

Super Seeder, T_3: Rice residue mulching and sowing of wheat by Pak Seeder. The results indicated that rice residue incorporation and sowing by Super Seeder proved better treatment for improving organic carbon in topsoil (0-10 cm), soil moisture content, available water capacity and grain yield, whereas greater bulk density was found in residue removal treatment. Further, rice residue incorporation and sowing of wheat by Super Seeder retained moisture followed by Rice residue mulching and sowing of wheat by PakSeeder and rice residual removal treatment. It was concluded from the data that incorporation of rice residue (sowing with Super Seeder) and its mulching (sowing with Pak Seeder) can alter hydrological characteristics and improve wheat yield in rice wheat cropping system.

Key words: Super Seeder, wheat, rice residue incorporation, moisture conservation.

IC^{3}AF-2025-34

Role of Soil Microbes in mitigation of excess use of nitrogen in soil

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Soil is an exceptional culture media for the growth and development of various microorganisms. Living organisms present in the soil are grouped into two categories as Soiland Soil fauna. Soil is not an inert static material but a medium pulsating with life. Soils give a mechanical support to plants from which they extract nutrients. Microorganisms constitute < 0.5% (w/w) of the soil mass, yet they have a major impact on soil properties and processes. About 60-80 % of the total soil metabolism is due to the microflora. These are the smallest organisms (<0.1 mm in diameter) and are extremely abundant and diverse. Nitrogen is the nutrient needed in largest amounts by plants and is the most commonly applied fertilizer. Excess N can have adverse effects on plant growth and crop quality as well as harming the environment, especially water quality. Excessive N fertilizer application contributes to surge in reactive N emissions from agroecosystem, eventually threatening global ecosystem's quality and security. Microorganisms are able to consume Nitrigen (N) from a wide range of organic and mineral compounds. Microorganisms are vibrant to several ecological processes in agroecosystem such as organic matter decomposition, nutrient cycling, N_2 fixation, phosphate solublization, nutrient aquisition and recently discovered probiotics role. In present study all the experiments will be conducted to find out the beneficiary role of microbes in fixation of Nitrogen. In this study, we employed long term field ex periments and high-throughput sequencing to analyze how varying levels of nitrogen application influence the soil bacterial community structure and co-occurrence networks.

Key words: Nitrogen, microbes, soil fauna, N_2 fixation, phosphate solublization.

IC^{3}AF-2025-35

Impact of Rice Husk Biochar for Improvement of Nutrient Availability on Soiland Maize Crop

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Maize is important crop due to its high nutritional value and multiple uses. It is grown as fodder and cereal crop in Pakistan. The population of Pakistan is increasing at fast rate therefore; production of maize needs to be increased. One of the biggest challenges to agricultural production in Pakistan is a soil-related problem. Biochar is proved to be increasing the production of several crops due to its improved soil water-holding capacity. It increases the availability of plants nutrient and increases growth and biomass of plant. Therefore, the experiment was conducted to

evaluate the efficiency of rice husk biochar to improve soil property and growth of maize plant. The biochar was applied at different dose rate such as 9%, 7%, 4%, 3% and 1%. The impact of biochar on soil properties and plant growth was checked. The results showed that biochar amended soil performed better as compared to control. Maximum plant height, plant fresh weight, plant dry weight, root fresh weight and root dry weight was recorded in case of 9% rice husk biochar, which was 120 cm, 100 g, 80 g, 16.23 g and 9.34 g respectively. Maximum EC, pH, organic matter was recorded in case of 9% rice husk biochar which were 1.75 ds m-1, 8.34 and 2.5% respectively. Maximum available phosphorus in soil was recorded in case of 9% rice husk biochar 24.3 mg/Kg. Highest available potassium was recorded in case of 9% rice husk biochar 170 mg/Kg. Highest total nitrogen was recorded in case of 9% rice husk biochar 0.17 g/Kg. Highest available Fe was recorded in case of 9% rice husk biochar 55 g/Kg. Highest available Zinc was recorded in case of 9% rice husk biochar 16 g/Kg. The results concluded that application of rice husk biochar at dose rate of 9% improve the soil properties and growth of maize plant. So, rice husk biochar might be used as a soil amendment and to enhance the yield of maize and other crops as well.

Key words: Maize, biochar, soil amendment, rice husk, plant biomass.

IC^{3}AF-2025-36

Nitrogen uptake and Maize Yield as Influenced by Iron Pretreated Humic Acid under Alkaline Calcareous Conditions

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The prevalence of Iron deficiency under alkaline calcareous condition can be effectively overcome with the use of iron (Fe) chelated humic acid (HA) via formation of stable HA-Fe complexes in the soil. Therefore, an experiment on "Iron uptake and maize yield as influenced by iron-pre-treated humic acid under alkaline calcareous condition" was conducted at Agriculture Research Station Harichand, Charsadda during Kharif season, 2023. The experiment was conducted using a randomized complete block design (RCBD) with three replications, and each plot measured 3 × 5 m². The experiment comprised of four treatments i.e. [Sole iron sulphate ($FeSO_4$), Humic acid (HA) untreated, HA treated with $FeSO_4$ (HA-$FeSO_4$) and HA treated with $FeCl_2$ (HA-$FeCl_2$)] that were applied to maize as priming of seeds (0.5% solution), foliar application (0.5 % solution), and soil application (10 kg ha^{-1}). The Fe-HA was prepared by treating it 5:1 with $FeSO_4$, or $FeCl_2$ followed by repeated rinsing and drying and was applied to soil at the time of sowing in case of soil application while foliar application was made at knee height stage. Results showed that application of HA-$FeSO_4$ had higher mean leaf dry matter (33.6 g plant^{-1}), stem dry matter (44.9 g plant^{-1}), grains dry matter (92.9 g plant^{-1}), ears m^{-2} (13), grains ear-1 (353), grain yield (4413.2 kg ha^{-1}), and stover yield (7342.3 kg ha^{-1}) when the values were averaged across the application techniques. This treatment also had higher AB-DTPA extractable Fe (6.56 mg kg^{-1}), soil Total nitrogen (0.51 g kg^{-1} soil), soil organic carbon (4.77 g kg^{-1}) and well as grains total N (21.01 g kg-1), Fe (73.1 mg kg^{-1}), and K (3.73 mg kg^{-1}) advocating its supremacy over other treatments. While comparing the application techniques, soil application was significantly better having comparatively higher plant height (215.6 cm), leaf area plant^{-1} (4293 cm^2), leaf dry matter (31.8 g plant^{-1}), stem dry matter (44.7 g plant^{-1}), grains dry matter (90.4 g plant^{-1}), ears m-2 (12), grains ear^{-1} (349), 1000 grains weight (322.6 g), grain yield (4427.9 kg ha^{-1}), and stover yield (7019.8 kg ha^{-1}). Likewise, this treatment also had higher AB-DTPA extractable Fe in soil (6.02 mg kg^{-1}), soil total nitrogen (0.526 g kg^{-1} soil) and leaf and grain N, P, K and Fe concentrations. The overall results concludes that application of HA-Fe as soil application significantly enhanced the yield and quality of maize under the prevailing conditions and such studies should be conducted for different crops and diverse soil and climatic conditions.

Key words: Calcareous soil, iron deficiency, humic acid, maize yield, seed priming.

IC³AF-2025-37

Heritability and Correlation for Yield Traits in CIMMYT Bread Wheat Genotypes for Ensuring Food Security

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Population increase is leading to growing demand of food. It is necessary for crop breeders to develop new high yielding genotypes on global basis to fulfill the demands of food. The current investigation was carried out to determine genetic variability, heritability, genetic advance and traits correlation among CIMMYT wheat genotypes. The experimental material was comprised 24 genotypes along with local check of Swabi-1 during wheat growing season of 2022-23 at Agriculture Research Station (ARS) Swabi. The experimental design was randomized complete block design (RCBD) with three replications. The statistical analysis revealed significant differences for the all the studie d traits among the studied genotypes. The mean performance manifested that genotypes CIM-5 and CIM-24 was earliest to head (123 days), whereas early maturing (142 days) genotypes were CIM-2 and CIM-3. Similarly, shortest grains filling duration (26 days) was taken by genotype CIM-20. Likewise, genotype CIM-5 produced taller plants (99.47 cm), whereas genotype, CIM-1 was outstanding with more (181 spikes m^{-2}) spike $meter^{-2}$. Longest spikes (13.9 cm) were recorded for genotype CIM-19, while more number (20 spikelets $spike^{-1}$) of spikelets $spike^{-1}$were observed for genotypes CIM-1, CIM-7, CIM-9, CIM-10, CIM-17, CIM-19 and Swabi-1. Maximum (66 grains $spike^{-1}$) grains $spike^{-1}$were observed for genotype CIM-6, although genotype, CIM-23 showed high (54.09 g) 1000 grains weight. Maximum (20700 kg ha^{-1}) biological yield was calculated for CIM-10, whereas genotype CIM-10 revealed maximum (5226 kg ha^{-1}) grain yield. Likewise, harvest index was calculated maximum (30.47%) for CIM-19. High heritability along with high genetic advance (h^2=0.65, GA= 22.21%) was estimated for grain yield. Similarly, 1000 grains weight showed high heritability and moderate genetic advance (h^2=0.78, GA=13.25%), likewise, spike length (h^2=0.47, GA= 10.46%) and harvest index (h^2 = 0.36, GA=16.23%) showed moderate heritability and genetic advance. Biological yield was positively correlated with days to maturity (rp = 0.30**, rg= 0.56**), grains filling duration (rg=0.49*), plant height (rg=0 .48*) and spikes $meter^{-2}$ (rg=0.64**) at genotypic (rg) and phenotypic (rg) level, while both type of correlation was observed for 1000 grains weight with days to maturity (rp = 0.35**, rg= 0.48*), grains filling duration (rp = 0.27*, rg= 0.42*) and only genotypic for harvest index (rg= 0.40*). Spike length was significantly correlated with grain yield (rp=0.31**). Grain yield showed positively association with spikelets $spike^{-1}$(rp=0.33**, rg=0.68**), 1000 grains weight (rp= 0.26**, rg=0.49**) and harvest index (rp= 0.62**, rg=0.78**) and biological yield (rg=0.42*). Based on excellent performance for yield and associated traits genotypes CIM-10, CIM-11 and CIM-19 was recommended for further evaluation.

Key words: CIMMYT, High yielding genotypes, heritability, genetic variability, wheat.

IC³AF-2025-38

Integrating AI, IoT, and Drones for Climate-Responsive Smart Greenhouses: A Sustainable Agriculture Approach

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Global food security is at high risk due to climate change. Agricultural productivity has decreased to 20% in some regions due to extreme weather events. Although AI, IoT, and drone technologies are used in precision agriculture but still existing predictive models often fall short in

terms of real-time adaptability, scalability, and seamless integration for autonomous climate-smart greenhouses. The objective of this study is to develop a new Hybrid AI-IoT-Edge Computing framework that will process real-time environmental data from multiple sources to dynamically enhance greenhouse microclimates. Moreover, this study combines machine learning (ML) models that are trained on real-time IoT sensor networks to monitor soil moisture, temperature, humidity, and CO_2levels. Additionally, drones will use multispectral imaging to determine plant health and detect early signs of stress, while edge computing will enhance decentralized decision-making, cutting down dependence on cloud-based processing and improving response times. Predictive accuracy will further improve by multi-modal data fusion, which combines satellite imagery, historical climate data, and real-time greenhouse conditions. A pilot study will be conducted in a controlled greenhouse environment where the autonomous AI-IoT system will manage irrigation, ventilation, and nutrient distribution. The system's performance will be compared with traditional greenhouse systems by determining crop yield, water efficiency, and energy consumption. Previous studies say that AI-enhanced agriculture studies, this study projects a 15-22% increase in crop yield, a 25-30% reduction in water usage, and up to 20% improvement in energy efficiency. This research contributes to climate-resilient smart farming by presenting a scalable, cost-effective, and data-driven framework for real-time environmental control in greenhouses. By integrating AI, IoT, and drones into a unified decision-making system, this study advances precision-driven, autonomous agriculture, contributing to sustainability and global food security.

Key words: Climate-Smart Agriculture, Artificial Intelligence (AI), Internet of Things (IoT), smart greenhouses, drones in agriculture, edge computing in agriculture.

IC^{3}AF-2025-39

OILCROP- SUN Model application for determination of optimum sowing time of sunflower (*Helianthus Annuus* L.)

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Hybrid sunflower was sown at College of Agriculture, Sargodha and Agronomic Research farm University of Agriculture, Faisalabad during autumn season 2021 to evaluate the climate change impact on sunflower cropsown at different dates. The hybrids (FH-331 and ORISUN-648) were sown on 15th July, 31st July and 15th August. Sowing windows were randomized in main plots and hybrids in sub-plots in RCBD. Highest achene yield AY (4644 kg ha^{-1}) was noted for ORISUN-648 hybrid as compared to FH-331 (3965 kg ha^{-1}). In case of sowing dates (31st July) performed best than 15th July and 15th August. Genetic coefficients were adjusted for model calibration by field data parameters. Average error of two hybrids in calibration of AY and total dry matter was (11% and 13.3) at Faisalabad and (15 % and 11.5%) at Sargodha location. In Model evaluation the average error between AY and TDM for 15thJuly was (10.3% and - 8%) at Faisalabad and (14.7% and -9%) at Sargodha field trial. For 15th July error was (17.3% and -7.3) at Faisalabad while, (19.8% and -9.7%) at Sargodha.

Key words: Calibration, dry matter, dates, hybrids, and sunflower

IC³AF-2025-40

Polyphenol-Stabilized Chitosan Edible Films for Sustainable Food Packaging: A Molecular Approach to Enhancing Shelf-Life under Climate Stressors

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Climate change poses significant challenges to food preservation and security, with increased temperature, humidity, and light exposure accelerating the degradation of packaging materials and food quality. This study explores a novel, eco-friendly approach to mitigating such effects by developing polyphenol-stabilized chitosan-based edible films. Using molecular docking, molecular dynamics simulations, and spectroscopic techniques, we investigate the interactions between chitosan and diverse polyphenol crosslinkers to enhance film stability, reduce oxidative degradation, and prevent discoloration. Our findings establish a new stabilization mechanism driven by polyphenol structure, offering improved resistance to environmental stressors. The optimized formulations show promise as biodegradable, climate-resilient packaging solutions, supporting sustainable food systems and reducing reliance on synthetic preservatives. This research contributes to food security efforts by advancing green technologies in food packaging aligned with global climate adaptation strategies.

Key words: Edible films, sustainable packaging, climate resilience, food preservation, bio-polymer stabilization.

IC³AF-2025-41

Pakistan's Forest on the Brink: The Devastating Consequences of Climate Change on Biodiversity

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Anthropogenic activities has increased global average temperature about 1.55°Cabove pre industrial levels. Changes in precipitation patterns, prolongeddroughts, intense rainfalls disrupt forest hydrology, soil PH, nutrient cycling, species composition, seed maturation, ecosystem services and carbon sequestration. Acid rainfall and nitrogen depositions have negative impacts on soil health, which directly or indirectly affects human being. As the planets lungs forests absorb 2.4 billion metric tons of CO2 annually, producing oxygen and supporting biodiversity but faulty practices like deforestation have imbalanced the natural process of carbon cycle and soil stabilization. 80% of global deforestation is a result of agricultural products need. Climate change poses a significant and emerging threat to forest ecosystems worldwide, disrupting their balance, health, and biodiversity. One of the most critical impacts of climate change is it directly affects tree growth, survival, and regeneration. Climate-induced stress weakens trees, making them more susceptible to insect infestations, fungal infections, and invasive species, leading to ecosystem imbalance. These changes not only alter forest productivity but disturbs the delicate balance between flora and fauna, disrupting food webs and migration patterns. Convention on biological diversity also indicated that Pakistan has 195 mammal (6 endemic) ,668 birds (25 endangered) ,177 reptiles (13 endemic) ,22 amphibians (9 endemic) , 198 fresh water fishes (29 endemic) ,5000 invertebrates , 5,7000 species of flowering plants (400 endemic). These challenges require adaptive forest management and restoration initiatives to mitigate adverse effects of climate change on forest ecosystems. Strengthening global commitments to climate action, promoting reforestation, and reducing greenhouse gas emissions are vital steps in maintaining ecological stability and ensuring forests to provide critical ecosystem services for future generations.

Key words: Anthropogenic, biodiversity, climate change, forest ecosystems, and sustainability.

IC^{3}AF-2025-42

Policy Implications for High-Alpine Mammal Conservation in a Changing Cryosphere: A Case Study of Markhor and Snow Leopard in Northern Pakistan

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The changing climate is critically transforming the cryosphere, ecosystem services, and their apex species. The Markhor (*Capra falconeri*) and Snow leopard (*Panthera uncia*) of the alpine areas of Northern Pakistan are changing habitat utilization, synaptic plasticity, and biotic interactions owing to glacial retreat and climate change. Conservation policies in place do not and cannot predict these dynamic changes, mitigate, or adapt to them. In this regard, the study adopts a narrative review approach, combining literature and policy reviews to identify inadequacies in policy and policy documents, analyze gaps in conservation policies, and recommend adaptive climate resilient frameworks. Suggested alterations included adjustment of zoning regulations to allow for climate-responsive prey-predator spatial relationships, advanced cooperation amongst bordering countries, and the shift from top-down to bottom-up conservation. Incorporating behavioral ecology and climate adaptation into planning provides policymakers with the means to avert and manage climactic threats to ensure the viability of the species through appropriate legislative frameworks.

Key words: Climate change, cryosphere, conservation policy, Markhor, snow leopard.

IC^{3}AF-2025-43

Temperature Variability and Trend Prediction: A Spatio-temporal Study Using Mann-Kendall and Sen's Slope

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Thepresent research study discover spatial and temporal trend analysis of temperature using Mann-Kendall (MK) trend test and Sen's Slope (SS) estimator in the Hindu Kush region, Pakistan. Worldwide, climatic change has a strong association with trend in temperature and resultant changes in rainfall pattern. In the current study, temperature is selected as a meteorological parameter for trend analysis and also to find out the magnitude of the predicted temperature. In order to attain objectives of study, temperature data was collected from Pakistan Meteorological Department (PMD) for all the seven meteorological stations. The temperature data were analyzed and simulated using Mann-Kendall test and Sen's Slope Estimator, whereas for the determination of temperature trend and slope magnitude. The analysis reveals that a positive (increasing) trend in mean maximum temperature has been detected for Chitral, Dir and Saidu Sharif met stations. Similarly, the trend in mean minimum temperature has also been recorded for met station Saidu Sharif and Timergara. The analysis further reveals that the concern variation in temperature trend and slope magnitude is attributed to climate change phenomenon in the region.

Key words: Climate change, Trend prediction, Trend magnitude, MK trend test, Sen's Slope estimator

IC³AF-2025-44

Improving Sesame's Biotic Stress Tolerance and Oil Bioactives with Selenium Nanoparticles in a Changing Climate

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Vegetable oil consumption is expected to reach almost 200 billion kilograms by 2030 in the world and almost 2.97 million tons in Pakistan. A large quantity of edible oil is imported annually from other countries to fill the gap between local production and consumption. Compared to other edible oil crops such as soybean, rapeseed, peanut and olive, sesame has innately higher (55%) oil content, which makes it an excellent candidate to be considered to meet local edible oil production. Oil seed crops, especially sesame, are affected by various pathogens, which result in decreased oil production with low quality oil. Selenium nanoparticles (SeNPs) work synergistically, as it has antifungal activity along with improving plant growth. Different concentrations of SeNPs were used, on three different varieties of sesame (TS-5, TH-6, and Till-18). Plant growth and development were accelerated by SeNPs, which ultimately led to an increase in crop yield. Morphological parameters revealed that SeNPs resulted in a growth increase of 55.7% in root length, 48% increase in leaf number/plant, and 38% in stem diameter. Out of three sesame varieties, TS-5 seedlings treated with 40 mg/L SeNPs showed 96.7% germination and 53% SVI at 40 mg/L. Sesame varieties dramatically increased antioxidant capability using SeNPs, resulting in 147% increase in SOD and 140% increase in POD enzyme units in TH-6 and 76% elevation in CAT enzymes in TS-5 (mean ± S.E). GCMS analysis revealed that bioactive compound-I, sesamin, sesamol, and tocopherol contents were increased along with enhanced production of different unsaturated fatty acids. Kegg pathway analysis and MSEA revealed that these compounds were mainly involved in biosynthesis of unsaturated fatty acids, suggesting that SeNPs have elicited the biosynthesis of unsaturated fatty acids such as oleic acid, linoleic acid, and α-linoleic acid. This study concluded that SeNPs (40 mg/L) have an excellent capability to be used for crop improvement along with better oil quality.

Key words: Selenium nanoparticle, Sesame, Edible oil, crop improvement, biotic stress.

IC³AF-2025-45

Impact of Zinc on the Growth and Defence Enzymes of Maize Grown in Calcareous Soil

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The growth and development of demanding crops like maize are getting restricted due to lack of macro and micronutrients, particularly in calcareous soil. The present experiment was carried out during fall 2021 to examine the impact of zinc on the growth and defence enzymes of maize grown in calcareous soil. Treatments used in the experiment were T1 (Control), T2 (0 kg ha^{-1}), T3 (Zn @ 4kg ha^{-1}), T4 (Zn @ 8 kg ha^{-1}), T5, (Zn @12 kg ha^{-1}), T6 (Zn@ 16 kg ha^{-1}). Our results confirmed that various levels of Zinc (Zn) had significantly ($P \leq 0.05$) influenced all the studied parameters except emergence m^{-2}, and shelling percentage (%). Results of the study revealed maximum days to tasseling (61.67), days to silking (70.33), grain yield (5842kg ha^{-1}) and shelling percentage (73.98%) for T6 (Zn @ 16 kg ha^{-1}). Emergence m^{-2} was found 22.67(maximum) both in T6 and control treatments. Maximum values for activities of Phenylalanine Ammonia-Lyase (0.4540) and Polyphenol Oxidase (0.7530) and Polyphenol (1.9367) were recorded in T6, T5 and T5 respectively.

Key words: Defence enzymes, micronutrients, maize, calcareous soil.

IC³AF-2025-46

Impact of Soil-Applied Sulphur and Zinc on Growth, Achene, and Oil Yield of Sunflower (*Helianthus annuus* L.) Hybrids

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Sunflower growth and yield depend on nutrient availability, with a comparatively higher requirement for sulphur (S) and zinc (Zn). Therefore, implementing appropriate agronomic practices, particularly crop fertilization, is essential to enhance productivity and improve crop quality. The current research was carried out in two consecutive years (2021 and 2022) to study the growth and yield response of sunflower hybrids to S and Zn levels at Agriculture Research Station District Swabi of Khyber Pakhtunkhwa province of Pakistan. Four levels of S and Zn each were tested which include 0, 20, 30 and 40 kg S and 0, 10, 15 and 20 kg Zn ha^{-1} applied to two locally produced hybrids i.e. PARSUN-3 and PARSUN-1. The experimental results showed that both S and Zn had significantly affected growth and yield of sunflowers. Applications of 40 kg S and 20 kg Zn ha^{-1} produced taller plants (7.5 and 8%) with delayed flowering (13 and 4.5%) and maturity (3%) over control. Also yield and yield components of sunflower were significantly higher at these levels of S and Zn. Application of 40 kg S and 20 kg Zn ha^{-1} increased yield by 68 and 33% over control. PARSUN-3 hybrid, which is a dwarf genotype and short growth cycle produced higher yield and yield components. Yield and yield components of sunflower were also higher with addition of 30 kg S and 15 kg Zn ha^{-1}. PARSUN-3 with addition of 30 kg S and 15 kg Zn enhanced growth and yield of sunflower and is recommended in the study area. Further research and field trials could provide deeper insights into the long-term impacts of this approach across different crop varieties and environmental conditions.

Key words: Productivity,sulphur and zinc levels, hybrids,sunflower.

IC³AF-2025-47

Optimizing Soil Health and Climate Resilience: Impact of Nitrogen and Sulphur Levels on Maize Growth and Nutrient Uptake in Diverse Soils

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Nitrogen (N) and sulphur (S) are essential nutrients influencing maize (*Zea mays* L.) yield and quality. A greenhouse pot experiment was conducted at the University of Minnesota, USA, to assess the effects of nitrogen and sulphur application on maize growth, nutrient uptake, and soil properties in two soil types (Becker and Rosemount). The experiment followed a completely randomized design (CRD) with two nitrogen levels (100 and 150 kg ha^{-1}) and five sulphur levels (0, 20, 40, 80, and 160 kg ha^{-1}), totalling ten treatments per soil type. Results showed that nitrogen, sulphur, and soil type significantly affected plant height, fresh weight, dry weight, sulphur content in tissue, and nutrient uptake. The application of 150 kg N ha^{-1} increased plant height (125.3 cm), fresh weight (109.3 g), dry weight (17.6 g), nitrogen uptake (186.7 mg pot^{-1}), and sulphur uptake (29.7 mg pot^{-1}). Becker soil produced higher maize yield and nutrient uptake than Rosemount soil. Maximum yield in Becker soil (fresh: 109.1 g, dry: 18.6 g) was achieved with 150 kg N ha^{-1} and 20 kg S ha^{-1}, while in Rosemount soil (fresh: 100 g, dry: 15.1 g), it was obtained with 150 kg N ha^{-1} and 40 kg S ha^{-1}. The optimal N:S ratio in tissue ranged from 8–12 in Becker soil and 4–6 in Rosemount soil. These findings highlight the importance of balanced nitrogen and sulphur fertilization for improving maize productivity and soil fertility. In the context of climate change and its impact on nutrient cycling and soil health, optimizing nutrient management practices is critical to sustain crop production and ensure agricultural resilience.

Key words: Nitrogen, sulphur, maize, becker soil, rosemount soil, nutrient uptake, soil fertility.

IC³AF-2025-48

Study on Storage Stability of Grapes Juice Preserved with Sodium Benzoate, Potassium Sorbate and Potassium Metabisulphite

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This study was carried out to find the effect of potassium metabisulphite, potassium sorbate and sodium benzoate on the preservation and overall quality of grapes juice. Total seven samples were made with this juice which were named as J0, J1, J2, J3, J4, J5, J6.They were kept in plastic bottles and stored at room temperature. All samples were analyzed at fifteen days interval physiochemically (pH, total soluble solids, % acidity, ascorbic acid, reducing and non-reducing sugar) and organoleptically (color, flavor, taste and overall acceptability) for a total period of 90 days. Results obtained from statistical analysis ($\alpha<0.05$) showed that storage interval and preservation had significant effect on physiochemical and organoleptic characteristics. Total soluble solids increased maximum in J0 (7.46%) and minimum in J4 (2.79%). Ascorbic acid reduced maximum in J0 (70.40%) and minimum in J2 (29.14%). pH reduced maximum in J0 (17.23%) and minimum in J4 (4.06%). Acidity increased maximum in J0 (41.00%) and minimum in J4 (11.18%). Reducing sugars increased maximum in J0 (69.51%) and minimum in J4 (8.81%). Non-reducing sugars decreased maximum in J4 (83.33 %) and minimum in J2 (36.22 %). Color score decreased maximum for J1 (53.30%) and minimum for J4 (8.00%). Flavor score decreased maximum for J2(50 %) and minimum for J6 (12.43%). Taste score decreased maximum for J2 (62.66%) and minimum for J4 (8.00%). Overall acceptability score decreased maximum for J2 (54.35%) and minimum for J4 (10.26%). J4 [(grapesjuice + potassium metabisulphite (0.05%) + potassium sorbate (0.05%)] remained very acceptable during storage while J0 [grapes juice + no preservative] was found very bad. Future study is recommended on microflora assessment, micronutrients assessment, flavonoids and polyphenols extraction which can be added to other food products to prevent cancer in population.

Key words: Acidity, ascorbic acid, organoleptic, sodium benzoate, total soluble solids.

IC³AF-2025-49

Enhancing Wheat Yield and Zinc Uptake through Integrated use of Zinc, FYM and Sulphur with and without Beneficial Microbes

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Field trial was conducted at Cereal Crop Research Institute, CCRI Pirsabak Nowshera to test the response of different wheat varieties for optimum Zinc uptake and enhancing yield under the interactive effect of beneficial microbes, FYM and sulfur. Randomized Complete Block Design having split-plot structure was used with a total of 3 replications. Two (02) wheat varieties Zincol-16 and Taskeen-22 allotted to the main plot while, beneficial microbes (culture collected from National Agriculture Research Center (NARC), Islamabad), FYM and sulfur were applied in different combinations to the subplot. The subplot size was maintained as 5m x 2m. Urea, DAP and MOP were used as a sources for nitrogen, phosphorus and potassium, respectively Nitrogen (N) was applied in split dose to the crop, while all other nutrients and treatments were applied to their respective treatment plots during time of sowing. Results revealed that wheat variety Zincol-16 attained significantly optimum plant height (87 cm), spike length (10.3 cm), grains spike (49. 1), Grain yield (4242 kg ha^{-1}) and biological yield (11,006 kg ha^{-1}). Further Zinc when applied in combination with other treatments, significantly increased plant height (93. 2 cm), grain yield and biological yield. It can be concluded from the results obtained that wheat variety Zincol-16 significantly performed better in all the studied parameters complete

the wheat variety Taskeen-22. Similarly, zinc availability and utilization was significantly increased when combined with FYM, Sulfur and Beneficial microbes. Therefore, it can be recommended that wheat variety Zincol-16 could perform better for zinc absorption under the interactive effect of FYM, Sulphur and beneficial microbes

Key words: Zinc Wheat, FYM. Sulphur, Beneficial Microbes

IC³AF-2025-50

ImpactofClimateChangeonForestEcosystem

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Climate change poses a significant threat to global forests, altering their structure, composition, and ecological functions. Rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events contribute to changes in forest biodiversity, carbon sequestration capacity, and resilience. Climate-induced stressors, such as prolonged droughts, wildfires, and pest outbreaks, have led to forest degradation and loss in many regions. Additionally, shifting climatic zones force tree species to migrate, affecting forest ecosystems and dependent wildlife. While forests play a critical role in mitigating climate change by absorbing carbon dioxide, deforestation and degradation release stored carbon, exacerbating the problem. Adaptation and mitigation strategies, including sustainable forest management, afforestation, and conservation efforts, are essential to protect forests and maintain their ecological balance. Addressing the impacts of climate change on forests is crucial for biodiversity conservation, ecosystem services, and global climate stability.

Keywords: Carbon sequestration, afforestation, sustainable forest management.

IC³AF-2025-51

Impact of plant Population, Fertilizer Application and Climate Change on Maize Productivity in Rawalakot Azad Kashmir, Pakistan

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Climate change significantly impacts global food security by altering crop growth conditions, nutrient availability, and overall yields. This study examines the effect of plant population (P.P.), spacing, and fertilizer doses on maize production to identify optimal agronomic practices under changing climatic conditions. The experiment included treatments with different plant spacing (6 inches, 9 inches, 12 inches, and 15 inches) combined with varying fertilizer applications. Key parameters analyzed were plant height (P.H.), leaf area (L.A.), cob count per plant, and fresh weight of maize yield. Results showed that wider spacing (e.g., 15 inches) led to higher fresh weight per plant, while denser planting (e.g., 6 inches) maximized yield per unit area. Fertilizer dose significantly influenced biomass accumulation, with balanced nutrient applications enhancing growth and yield. These findings emphasize the importance of precise fertilizer management and optimized planting density in mitigating climate change impacts, improving maize productivity, and ensuring food security under uncertain climatic conditions.

Key words: Maize, climate change, fertilizer, biomass and planting density.

IC³AF-2025-52

Effect of different storage materials on early seedling growth and grain quality of wheat under laboratory conditions

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Seed is the essential input for any crop production. Especially high-value seed is a serious contribution on which all other inputs will depend for their full value. The laboratory experiment was conducted to investigate the 'Impact of storage materials on germinability and quality of wheat seeds' at Seed Testing Laboratory, Department of Agronomy, Sindh Agriculture University Tandojam, during 2023-2024. The experiment was arranged in CRD with three replications. The seeds of wheat variety TD-1 was stored for six months. Three storage materials were used in this experiment T_1= Hermetic bag, T_2 = Plastic bag, T_3 = Iron bin. The results revealed that the seeds of wheat variety TD-1 significantly (P<0.05) affected by different storage materials. The higher moisture content (10.59%) was recorded from seed stored in iron bin (Farmer's practice), whereas the lowest moisture content (7.97%) was obtained from seed stored in Hermetic bag. Moisture content slowly reduced in all three types of storage materials during the storage period. The maximum seed germination (90.77%), shoots length (28.57 cm), root length (14.22 cm), vigor index (2136 %), seed index (1000- seed weight 41.94 g), were noted in hermetic bag followed by seed germination (81.32 %), shoots length (28.57 cm), root length (12.08 cm), seed vigor index (1838), seed index (1000-grains wt., 37.22 g) were recorded in plastic bag, However lowest seed germination (74.20%), shoots length (20.96 cm), root length (9.22 cm), seed vigor index (1578), seed index (1000 grains weight 33.37 g) were observed in iron bin . The Results further revealed that maximum weight loss (6.21%) of wheat seed was recorded in iron bin and minimum weight loss (0.70%) was noted in Hermetic bag. It can be concluded that maintenance of seed dryness with hermetic storage is useful in preservation of seed quality and related attributes. It is suggested that wheat seed can be stored in Hermetic bags for storage because hermetic bags maintained stored grain quality and protected wheat seed from insect infestation more than other storage materials. Therefore, it is demonstrated that hermetic bags can preserve the freshness and nutritional value of wheat seeds for extended periods, making them a valuable tool for food security in emergency preparedness, long-term storage, and agriculture. They can serve as an effective solution to reduce wheat storage losses in Pakistan.

Key words: Wheat, seed, germination, Hermetic bag.

IC^{3}AF-2025-53

Assessment of Yellow Maize Genotypes for Morphological Characteristics and Grain Yield Performance in the Context of Climate Change and Food Security

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Understanding the genetic diversity present in maize (*Zea mays* L.) germplasm is crucial for developing successful breeding programs that aim to improve crop performance, resilience, and nutritional quality. A study was conducted at the Agriculture Research Station (ARS) Swabi, Khyber Pakhtunkhwa, Pakistan, to evaluate the performance of various yellow maize genotypes and to identify high-yielding open-pollinated varieties (OPVs) suitable for the agro-climatic conditions of Swabi. Eight genotypes were cultivated using a randomized complete block design with three replications, and uniform agronomic practices were applied across all plots. Data were collected on several key parameters, including Anthesis-Silking Interval (ASI), days to 80% tasseling, days to 80% silking, plant height, cob position, cobs plant^{-1}, leaf area, days to maturity, grains cob^{-1}, 1000-grain weight, and grain yield kgha^{-1}.Analysis of Variance (ANOVA) revealed significant differences among

genotypes at the 5% probability level ($P<0.05$). The genotype 'CIMMYT-1 yellow' exhibited the longest anthesis-silking interval, while 'Eidhi' required the most days to reach 80% tasseling. 'SK-2Y' recorded the longest duration for 80% silking. Notably, 'CIMMYT-1 yellow' and 'CIMMYT yellow PYASYN' demonstrated superior plant height and cob positioning. 'Eidhi' showed the maximum leaf area. Overall, 'CIMMYT yellow PYASYN' outperformed other genotypes across most traits, exhibiting early tasseling and silking, a higher number of cobs plant^{-1}, optimal plant height, early maturity, more grains cob^{-1}, and the highest grain yield ha^{-1}. 'BK-2Y' also showed commendable performance in several yield-related traits. Based on their outstanding performance, 'CIMMYT yellow PYASYN' and 'BK-2Y' are recommended for commercial cultivation, farmer distribution, and inclusion in future maize breeding programs in the context of climate change and ensuring food security.

Keywords: *Zea mays* L., Climate change, food security, early maturity, grain yield, genetic diversity.

IC^{3}AF-2025-54

Enhancing Soil Nitrogen through Soybean Cultivation to Improve Soil Health for Sustainable Agriculture

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Leguminous crops play a vital role in sustainable agriculture by improving soil fertility and enhancing crop productivity through biological nitrogen fixation. This study evaluates the impact of different nitrogen fertilizer doses (0, 75, 37.5, and 18.5 kg ha^{-1}) combined with a fixed phosphorus application (50 kg ha^{-1}) on soybean growth, yield, and soil health. A Randomized Complete Block Design (RCBD) was used to assess key parameters, including plant height, number of pods per plant, and average yield (kg ha^{-1}). The results showed that nitrogen application significantly influenced plant growth and yield. The highest plant height (50.95 cm), maximum number of pods (25), and highest average yield (1100 kg ha^{-1}) were recorded in T-4 (18.5 kg N ha^{-1}). In contrast, the control treatment (T-1, 0 kg N ha^{-1}) exhibited the lowest values, with a plant height of 27.375 cm, an average of 8 pods per plant, and the lowest yield of 580 kg ha-1. These findings suggest that moderate nitrogen application optimizes plant development and yield, while excessive nitrogen may not provide additional benefits. The study highlights the importance of legumes in improving soil nitrogen levels, organic matter, and overall soil health. Future research should explore long-term nitrogen application strategies, microbial interactions, and their role in enhancing soil sustainability and productivity.

Keywords: Legumes, nitrogen fertilization, soil health, plant height, number of pods, crop yield, sustainable agriculture.

IC^{3}AF-2025-55

Environmental Pollution: A Major Cause of Climate Change and its Impacts on Plants

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Environmental pollution is an undesirable change in biological, chemical & physical characteristics of any component of an environment that may harmfully affect all living organisms. It is an alarming issue in the world of today which has resulted in climate change. Environmental pollution that results in climate change is an extensive and growing global threat to environment resulting in loss of habitat as well as life. A

clean & green environment generates most suitable surroundings for the survival & growth of all creatures, which are affected indirectly or directly to different types of pollution. It is mainly resulting by rises in the human population explosion, rapid urbanization, industrialization and transportation. Environmental pollution is an alarming issue in the present world of today and here is the rising alertness of the reality that a clean and green habitat is essential for best growth and fitness of organisms. It is our first concern for keeping our country's environment clean &green, as it is a vital part of our religion. In current advances, there is a dire need to build up clean & green areas around and within the polluted places for the existence of healthy environmental situations. As some plant species may have pollution sink properties and act as natural lungs of the environment. It is concluded that if explosive population growth rate and production of new industries goes on without understanding the significance of trees on the planet then here may be serious alarming changes in coming few years.

Key words: Environment, industries, pollution, people, plants, and population.

IC^{3}AF-2025-56

Using biological indicators of soil health to assess the impact of particular cropping practices

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Soil is a complex porous substrate containing mineral particles (sand, silt, clay) bound to well-decomposed organic matter. It also contains larger rock fragments, organic residues, roots, microorganisms, meso and macrofauna. The pore space is occupied by water that contains dissolved inorganic and organic substances, along with atmospheric gases and volatiles. Soil functions depend upon energy flow, fundamentally through the biogeochemical cycling of s soil organic carbon (SOC) and other nutrients. Energy and nutrients fuel the activities of the living soil biota microorganisms and soil fauna, which are a vital component of soil health and the ecosystem multifunctionality supported by soils. Agricultural management practices exert a significant influence on biological health indicators of soils across the world. As compared to conventional practices (deep tillage and removal of residues after crop harvest), conservation tillage or no till practices along with residue retention, amendment of organic fertilizers (manure and compost), cover cropping and crop rotation significantly improves the abundances of soil flora (fungi, bacteria, actinobacteria, archaea) and fauna (microfauna, mesofauna and macrofauna) in the upper 0-15 cm of soil layer where more than 80% of biological activities are carried out. Interestingly, this positive influence of conservation agriculture has been observed across various regions of the world with diverse climatic conditions. Reduced or no tillage practices improve soil health than conventional tillage. However, if this reduction in the frequency and intensity (depth) of tillage is combined with other practices such as cover cropping, residue retention, amendment of organic fertilizers and crop diversification, this further improves the abundances and community structure of soil flora and fauna, which are important soil health indicators.

Key words: Soil fauna, soil flora, conventional practices, conservation agriculture, soil health.

IC³AF-2025-57

ICT-Enabled Deep Learning Approach for Red Rot Disease Detection in Sugarcane Leaves

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Sugarcane stands as a fundamental agricultural product in Pakistan because it supports both the agricultural industry together with the national economy. Pakistan generates annual sugarcane production of approximately 60 million tons, which keeps it among the most significant agricultural outputs. Red rot disease proves to be one of the most destructive entities that affect sugarcane cultivation in Pakistan. Every year the damage from red rot disease results in annual crop losses that amount to approximately 20-25% which burdens sugar industry operations and financial situations of farmers significantly. To overcome this damage a smart solution is designed that consist of a mobile application that automatically detect the red rot disease in sugarcane leaves through deep learning algorithms. The mobile application implements ResNet-50 as its deep learning architecture along with its ability to detect red rot disease effectively. The model is trained using publically available 'Red Rot Sugarcane Disease Leaf Dataset' that serves as the training source for the mobile application through its collection of sugarcane leaf images containing healthy and red rot diseased specimens. This research utilizes deep learning and specifically ResNet-50 to establish a dependable immediate method for identifying diseases in sugarcane crops. The designed model displays high levels of precision in detection so farmers can intervene to control red rot before its spread and deterioration of crops occurs. Use of this technological integration within a mobile app platform will advance agricultural productivity levels and minimize crop damage while supporting sustainable farm management in Pakistan.

Key words: Red rot disease, deep learning, Resnet-50, mobile application.

IC³AF-2025-58

Enhancing Soil Carbon Sequestration with Engineered Organic Amendments and Precision Microbial Inoculants

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Agriculture accounts for approximately 25% of global greenhouse gas emissions while soil degradation greatly impacts carbon sequestration capabilities. Recent Studies have shown that carbon storage can be increased with organic soil amendments but their efficiency varies across different agricultural systems. The objective of this study is to address this gap by developing an optimized, engineering-based approach to improve carbon sequestration through organic amendments. The methodology includes a novel amendment formulation combining compost and crop residues with precision microbial inoculants that will be tailored to specific soil conditions. Previous studies reveal that organic amendments can increase soil organic carbon by 20-50% over time while the innovation of this study lies in the use of microbial inoculants that are specifically designed to break down high-lignin residues such as wheat straw. This will result in the potential increase of carbon retention by an additional 10-15% as compared to standard composting. Additionally, a controlled moisture and aeration system will be integrated to regulate microbial activity, which will not only reduce CO_2emissions but also maximize the sequestration efficiency. Sequestration potential under different conditions will be evaluated by conducting field trials across three soil types (sandy, loamy, and clay), with environmental modeling that predicts long-term impacts. A Life Cycle Assessment (LCA) will quantify the net carbon reduction compared to traditional amendment

applications. The expected outcomes of this study include an increase in soil organic carbon retention, especially in treatments with high lignin residue, and an estimated improvement of up to 40% in long-term carbon stabilization. However, further research would be required as there may be difficulties due to variations in the efficiency of microbial inoculants across different soil types and environmental conditions. The findings will help in improving strategies for agricultural carbon sequestration, offering useful information for farmers, policymakers, and researchers.

Key words: Carbon sequestration, organic amendments, microbial inoculants, soil carbon retention, life cycle assessment, sustainability.

IC^{3}AF-2025-59

Real-Time IoT-Based Fertigation System for Efficient Water and Nutrient Management in Vertical Farms

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Vertical farming demonstrates potential as an agricultural answer because the growth of urban areas continues to surpass diminishing agricultural land. However, efficient resource management—particularly in water and nutrient delivery—remains a critical concern. The IoT technology monitors vertical agriculture by programmable fertigation controls that perform immediate system surveillance for the management of water and nutrients. Environmental sensors track and monitor the growing environment by reporting measurements of humidity level and total dissolved solids (TDS) and pH values and soil moisture. The ESP32 microcontroller interprets sensor data to create fertigation schedules as a part of its data processing work. Actuators activate water and nutrient distribution by receiving inputs from established thresholds in combination with definite control systems. Blynk IoT platform enables users to interact with real-time system analytics and manage the system controls through a simple mobile interface on one platform. Operating the Arduino IDE leads to the development of behavioral logic and programming elements. Labor requirements decreased and resource management improved while maintaining even plant placement when testing proved that the system works efficiently for commercial scale urban production. Sustainable controlled vertical farming development depends on implementing Internet of Things technology according to this research's defined agricultural specifications.

Key words: IoT, ESP32, Arduino, TDS, pH value.

IC^{3}AF-2025-60

Decarbonizing Agriculture in Pakistan: Securing Sustainability and Climate Resilience through Smart Agriculture

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Agriculture remains the backbone of Pakistan’s economy, contributing nearly 20% to GDP and employing over 37% of the labor force. However, this vital sector is increasingly threatened by the accelerating impacts of climate change — erratic rainfall, rising temperatures, and increased frequency of floods and droughts. Simultaneously, agriculture is also a significant source of greenhouse gas (GHG) emissions, particularly methane from rice paddies and livestock, and nitrous oxide from the excessive use of synthetic fertilizers. In this context, decarbonizing agriculture is not just a global concern—it is a national necessity for Pakistan. This paper critically examines the imperative of transitioning towards low-carbon and climate-smart agriculture in Pakistan, highlighting strategies that include sustainable land and water management, precision farming, agroforestry, and the reduction of emissions through improved livestock practices and optimized fertilizer use. The role of regenerative agriculture, with its potential for carbon sequestration in soils and biomass, is explored as a core solution for improving

soil health and climate resilience. Pakistan's unique agricultural landscape—with its dependence on smallholder farmers, mono-cropping systems, and resource-intensive practices—presents both challenges and opportunities. This research underscores the need for policy reforms, farmer education, public-private partnerships, and investment in agricultural innovation to support a national framework for decarbonization. The potential benefits are multifold: improved yields, better soil fertility, water-use efficiency, enhanced livelihoods, and contribution to Pakistan's commitments under the Paris Agreement. While global cooperation is essential, localized, context-specific interventions will determine success in Pakistan. The country's strategic location, youthful agricultural workforce, and increasing climate awareness place it in a strong position to lead the regional discourse on sustainable farming. Decarbonizing agriculture in Pakistan is a transformative pathway to ensure food security, build climate resilience, and foster long-term sustainability. It calls for integrated efforts across scientific, governmental, and grassroots levels. As Pakistan faces the dual challenge of feeding a growing population and mitigating climate risks, transitioning to carbon-neutral agriculture is both a strategic priority and a moral imperative.

Keywords: Decarbonization,climate resilience, regenerative farming, carbon sequestration, GHG emissions, Agricultural innovation, Paris Agreement, NDCs, food security, policy reform.

IC^{3}AF-2025-61

Soil Fertility Status and Digital Mapping of Soil Parameters of the Field Area of Adaptive Research cum Demonstration Institute, Matora, Lakki Marwat

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In precision agriculture, fields are divided into management zones based on the variability of the soil fertility metrics. This allows for more accurate crop yield predictions. This research was conducted in the KP region of Pakistan with the goals of understanding the variability of the soil in the field, classifying the soils into mapping units, and mapping the soils using geostatistics. The research encompassed roughly 0.12 km2 of agricultural land. The terms "management zones" and "soil mapping units" (SMUs) were used interchangeably throughout the course of this research. The pH fluctuated from 7.82 to 8.67 on average. It was discovered that there were differences in the soil's pH, exchangeable alkalinity, nitrate nitrogen (NO3-N), and plant-available phosphorus (P). Also, there were variances in the soil's exchangeable potassium (K). There was a discernible rise in the amount of variation in the soil characteristics with increasing distance. The levels of NO3-N and P found in all the soils that were tested were much below the very low critical thresholds, respectively. The creation of digital soil maps was made possible with the assistance of comprehensive grid sampling, which also demonstrated the variety of the soil across the region. We believe that the low crop output that was the direct result of applying nutrients and chemical amendments in a uniform manner to soils that included large variances can be remedied by splitting fields into management zone.

Key words: Soil fertility, precision agriculture, spatial variability, geostatistics, digital mapping.

IC^{3}AF-2025-62

Climate-Resilient, biofortified Wheat Variety for Enhanced Food Security in Pakistan

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The Wheat Breeding Program at ARI Tarnab-Peshawar developed Tarnab Gandum-I (TRB-4-138), a high-yielding spring wheat variety specifically adapted to both irrigated and rainfed conditions in Khyber Pakhtunkhwa, Pakistan. Derived from the cross MUCUY//MUTUS*2/TECUE#1 and selected from CIMMYT's 38th ESWYT, this variety addresses critical food security challenges through its exceptional yield stability (4.1-10.1% increases over local checks), triple rust resistance, and enhanced nutritional profile (15.1% protein, 34 ppm zinc). Multi-location trials (2017-2022) demonstrated consistent performance across diverse agro-ecologies, with particular advantages in rainfed systems (10.1% yield increase over Pirsabak-19). The variety's superior grain quality (72.9 kg/hL test weight, 29% gluten) and climate resilience make it a sustainable solution for improving wheat production and nutritional outcomes. Approved in 2023, Tarnab Gandum-I represents a significant advancement in Pakistan's efforts to achieve food and nutrition security amidst climate variability.

Key words: Climate resilient, food security, nutrient enriched cultivars. *Triticum aestivum* L.

IC^{3}AF-2025-63

The Role of Climate-Resilient Crops in Ensuring Future Food Security

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The disruption of agricultural output caused by rising temperatures, erratic precipitation patterns, droughts, and an increase in pests and diseases is one of the main threats posed by climate change to global food security. The creation and uptake of climate-resilient crops—varieties bred or genetically modified to tolerate abiotic and biotic stresses—has become a crucial tactic for maintaining food systems in response to these difficulties. These crops, such as salt-tolerant barley, flood-tolerant rice, heat-resistant wheat, and drought-tolerant maize, can preserve or increase production in the face of unfavorable environmental circumstances. This abstract examines the importance of climate-resilient crops in ensuring future food security, with a focus on vulnerable areas where conventional cultivars are unable to withstand extreme weather conditions. In addition to discussing the socioeconomic and policy variables that affect their acceptance, it emphasizes contemporary developments in crop breeding technology, including genetic modification, marker-assisted breeding, and conventional selection. A sustainable and flexible agricultural framework that can satisfy the dietary demands of an expanding population in the face of changing climate circumstances depends on the incorporation of these resilient crops into national and international food systems.

Keywords: Crop breeding technology, conventional cultivars, dietary demands, genetic modification, resilient crops.

IC³AF-2025-64

Unraveling Nitrogen Release Patterns from Innovative and Cost-effective Lignite-Based Fertilizers in Calcareous Soils

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Conventional urea (CU) is prone to rapid mineralization leading to heavy N losses due to limited plant uptake during short period of time. Finding an efficient and cost-effective nutrient carrier for synthesis of slow-release fertilizers (SRFs) is still under investigation. Lignite is a naturally abundant and cost-effective adsorbent capable of extending multiple benefits as a soil amendment. Therefore, it was hypothesized that lignite as an N carrier for the synthesis of lignite-based slow-release N fertilizer (LSRNF) could offer an eco-friendly and affordable option to resolve the limitations of existing N fertilizer formulations. The LSRNF was developed by impregnating urea on deashed lignite and pelletized by a mixture of polyvinyl alcohol and starch as a binder. The results indicated that LSRNF significantly delayed the N mineralization and extended its release to >70 days. The surface morphology and physicochemical properties of LSRNF confirmed the sorption of urea on lignite. The study demonstrated that LSRNF also significantly decreased the NH_3-volatilization up to 44.55%, NO_3-leaching up to 57.01%, and N_2O-emission up to 52.18% compared to CU. So, this study proved that lignite is a suitable material to formulate new slow-release fertilizers, suiting to alkaline calcareous soils favorably where N losses are much higher compared to non-calcareous soils.

Key words:SRFs, Lignite, N release, Urea, NUE

IC³AF-2025-65

Effect of Different Stage of Topping and Different Doses of Sukericide on Yield and Quality of FCV Tobacco under Changing Climate

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To study the effect of different stages of topping and different doses of suckericide (Flumetraline) on yield and quality of FCV tobacco an experiment was conducted in two factorized randomized complete block design (RCBD) having three replications and four treatments at Tobacco Research Station, Khan Garhi, Mardan. Topping treatments studied in the experiment had five levels T_0 (control) that is no spray of flumetraline, T_1 (manual de-suckering), T_2 (10 ml), T_3 (12 ml),T_4 (15 ml), which were repeated three times at button stage, early stage, and late stage. Results indicated that the effects of topping timing and flumetraline was significant for number of suckers, green and dry weight of suckers, leaf area, quality of nicotine contents and reducing sugar. Topping at button stage resulted in deduction of suckers in tobacco, consequently caused to the production of lower sucker weight and maximum tobacco leaf area. Moreover, application of higher concentration of flumetralin at button stage had considerably better effects on sucker growth control and enhances the leaf yield. These results clearly showed that topping at button stage and more application of suckericide (flumetraline) significantly affected the quality and yield of tobacco crops. Different treatments did not influence leaf chemical constituents (nicotine, reducing sugar and chlorides) and are in permissible limits, so as to not pose risk to non-target organisms and to environment as well.

Key words: Quality of tobacco, suckericide, environment, topping, yield attributes

IC^{3}AF-2025-66

Biology and Ecology of the Red Palm Weevil, *Rhynchophorus Ferrugineus* (Coleoptera: Curculionidae), in District Sukkur, Sindh, Pakistan

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The red palm weevil is a significant pest of date palm trees, causing substantial economic losses worldwide. In Pakistan, this weevil is a major threat to Date palm industry, particularly in District Sukkur, Sindh. This research aimed to investigate the biology and ecology of *R. ferrugineus* in Sukkur. The results showed that the weevil's life cycle consisted of four stages: egg, larvae, cocoon/pupa, and adult. The larval stage was the most damaging, causing significant damage to the date palm tree's trunk and roots. The weevil's population dynamics were influenced by temperature, moisture, and rainfall. The host plant preference of *R. ferrugineus* was found to be *phoenix dactylifera*. The study's findings have important implications for the development of effective management strategies of *R. ferrugineus* in District Sukkur, Sindh, Pakistan.

Key words:*Rhynchophorus ferrugineus*, red palm weevil, biology, ecology, and date palm tree.

IC^{3}AF-2025-67

Curative Potential of Leaf and Bark of *Celtis australis* Against Oxidative and Microbial Stress

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Celtis australis with a common namehackberryis an ethnomedicinal important tree usually distributed in mountainous and sub-mountainous Himalayas. Traditionally plant parts including leaves and fruits have been utilized for the treatment of peptic ulcers, amenorrhea, heavy menstrual and intermenstrual bleeding, diarrhea, and dysentery. In this study, *C. australis* leaf and bark crude methanolic extract was evaluated for preliminary phytochemical analysis (phenolic, flavonoid, tannins, saponins and terpenoids). Antioxidant activity was determined using ABTS, DPPH, phosphomolybdate and reducing power assays. The cytotoxicity of *C. australis* leaf and bark extract was evaluated through Brine shrimp lethality. Furthermore, antimicrobial activity was also determined. The result showed that plant methanol extract has phenols, alkaloids, tannins, saponins, terpenoids and flavonoids. There is absence of alkaloids and terpenoids in *C. australis*leave extract. Antioxidant activity indicated IC_{50} of 25.65 µg/mL and 77.08 µg/mL respectively by DPPH assay. Furthermore, by ABTS method IC_{50} value of leaf and bark extract is 26.5 µg/mL and 15 µg/mL respectively. *C. australis*showedbacterialinhibitionfrom3.9 mmto7.1 mm and 2.8 to 6.2 mm respectively against *E.coli*. Antifungal activity of *C. australis* bark and leaf exhibited inhibition of 3-6.9 mm and 2.5-5.8 mm against *Aspergillus flavus* respectively.

Keywords:*Celtis australis*, phytochemicals, antimicrobial activity, antioxidants,cytotoxicity.

IC³AF-2025-68

Agronomic and Monetary Advantages of Maize-Soybean Intercropping Over Sole Cropping at Rawalakot, Pakistan

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Intensive cereals cultivation continuously declines the soil fertility and yield of crops. The current study evaluated the agronomic performance of maize varieties solely or intercropped with soybean at two spatial arrangements to analyze the yield and monetary advantages index. The field trails were conducted at Chotagalla Farm, University of Poonch Rawalakot, Pakistan. Two promising varieties of maize [Kashmir Gold (M_1), Sarhad White (M_2)] and soybean genotypes were sown as sole crop in intercropping at 1:1 and 1:2 row arrangement in a Randomized Complete Block Design (RCBD) having three replications during the year 2022 and 2023. The agronomic data revealed that M_1 variety of maize attained 20-25% higher plant height, 10-20% more leaf area and similarly higher biological and grain yield whether sown solely or in intercropping system. The nodules plant^{-1}, pod number plant^{-1}, pod length, no. of seeds of soybean plants varied in intercropping and expressed superiority at 1:1 over 1:2. Intercropping in comparison to sole cropping enhanced the land equivalent ratio (LER) at 1:1 row arrangement. Soybean intercropped to maize variety M_1 had LER values of 1.49 and 1.58 which was higher than 1:2 arrangement having values of 1.17 and 1.16, respectively during the 2022 and 2023. Further it was observed that, M_1 when intercropped with soybean at 1:1 expressed superiority over 1:2 by attaining 5-10 % higher harvest index values during both years which referred better exploitation of resources such as nutrients especially nitrogen (N) contribution through N fixation. The intercropping advantage accounted as monetary advantage index (MAI) over two years revealed that 1:1 row arrangement was advantageous than 1:2 owing to better utilization of resources and with complementary effect on component crops. In conclusion maize variety M_1 have better compatibility with soybean at 1:1 row arrangement and could attain monetary advantages in intercropping for sustainable crop production.

Key words: Cereals, legume, intercropping, land equivalent ratios, yield, monetary advantage index.

IC³AF-2025-69

Fostering the advancement and promotion of stripe rust resistant wheat germplasm and varieties under changing climate

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Fostering the advancement and promotion of stripe rust resistant wheat germplasm and varieties are being done annually under a national program led by the Pakistan Agricultural Research Council (PARC), Islamabad involving 32 key national institutions including Pakistan Atomic Energy Commission's Agriculture and Biotechnology Institutes. During 2023-24, three distinct sets of wheat germplasm: the National Wheat Disease Screening Nursery (NWDSN), a set of candidate future varieties (National Uniform Wheat Yield Trial-Nursery), and a collection of released varieties totaling around 1203 genotypes were raised under artificially induced stripe rust epidemic conditions for accurate evaluation at Nuclear Institute for Food and Agriculture (NIFA) Tarnab, Peshawar. Throughout the growing season, temporal stripe rust data for each entry in these three sets was meticulously recorded and its synthesis will be presented. These invaluable insights-based data will serve as a critical resource for national breeding programs, provincial and federal seed councils, guiding the strategic release and recommendation of cultivars

under changing climate in Khyber Pakhtunkhwa and Pakistan. This strategic approach is instrumental in averting potential epidemics of *Puccinia striiformis* f. sp. tritici (*Pst*) and ensuring the optimal cultivation of released cultivars, ultimately fortifying the wheat farming landscape under changing climate in the country.

Key words: Wheat, stripe rust, host resistance fostering

IC^{3}AF-2025-70

Rhazya stricta Decne (Apocynaceae) "Harmal": A Medicinal Plant with Biocontrol Potential against*Meloidogyne incognita* in Tomato

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Root-knot nematodes, *Meloidogyne* species are top-ranking polyphagous pests in the world affecting a wide range of crops in Pakistan. Rapid climatic changes and the extensive use of nematicides have strongly impacted human health, the environment, beneficial microbial communities and the soil food web. In the current study the efficacy of crude aqueous and MeOH (methanolic) extracts of the whole plant of *Rhazya stricta* Decne (Apocynaceae), a medicinal Harmal bush was assessed at three different concentrations and exposure periods *in vitro* and *in planta* against *M. incognita* infesting tomato crops in 2020 and 2021. Besides Carbofuran, MeOH extracts @ 75% caused maximum inhibition of egg hatching (79.5 and 80.0%) and J_2s mortality (93.4 and 92.7%) at 24 and 72 hours of exposure in both year trials, respectively. Phytochemical screening of *R. stricta* revealed alkaloids, flavonoids, phenols, saponins, tannins, steroids, and terpenoids. Thin layer chromatography of aqueous and MeOH extracts detected 6 and 12 bioactive compounds, respectively. Quantitative detection of MeOH extracts produced higher amounts of total phenols (30.56 ± 0.16 mg/g), flavonoids (21.85 ± 0.03 mg/g), and alkaloids (96.7 ± 0.17 mg/g). *In planta* greenhouse and field assays on tomatoes, MeOH extracts @ 75% produced highly significant (P = 0.00) results and exhibited no phytotoxic effects. It markedly suppressed a number of galls; galling indices, a number of J_2s 100 cm^{-3} soil, adult females, egg masses and reproduction factor. MeOH extracts substantially increased plant growth and yield parameters under controlled and open field conditions. This research demonstrates the potential of *R. stricta* as a novel sustainable and eco-friendly strategy for *M. incognita* in tomato crops, providing a viable alternative to chemical nematicides with low cost and low environmental risks.

Key words: Nematicidal activity, *Rhazya stricta* Decne, *Meloidogyne incognita*, plant extracts, phytochemical screening, tomato.

IC³AF-2025-71

Soil Carbon and Nitrogen Stocks under contrasting Land-Use Systems of a Western Himalayan Valley

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Land use system influence soil organic carbon (SOC) and nitrogen (N), which are indispensible for soil health and food security. Different types of land use have different capacity to recycle SOC and TN, which is necessary to understand for sustainable ecosystem productivity. In this context, surface (0-15 cm) and sub-surface (15-30 cm) soil was sampled from five different land use types (e.g., cropland, paddy, apple orchard, grassland and forest) of Leepa valley, District Hattian Bala, Azad Jammu and Kashmir (AJK) to assess SOC and TN stocks and associated soil properties. The results showed that, irrespective of soil depth, both SOC and N varied significantly ($p< 0.05$) across the land-use systems, and was highest in soils under forest and lowest in paddy soils. On the other hand, SOC and N contents declined significant ($p< 0.05$) with increasing soil depth being highest in surface soils. The mean total SOC and N stocks ranged from 22.12 to 42.36 Mg ha^{-1} and 2.04 to 3.68 Mg ha^{-1} in surface soils and 18.06 to 40.89 Mg ha^{-1} and 1.95 to 3.54 Mg ha^{-1} in sub-surface soils being highest under forest landuse, respectively. The majority of the SOC and N were associated with macro-aggregates (Ma) in the 0-15 cm layer, with micro-aggregates (Mi) in the 15-30 cm layer, while the silt + clay fraction contained the least SOC and N across all land uses and soil depths. In terms of soil properties, bulk density (ρb), pH and electrical conductivity (EC) were directly proportional to soil depth. The soil pH, EC, and ρb were higher in sub-surface soil than surface soils. The results of the present study showed landuse impact on SOC, TN and associated soil properties. The findings of the study could be used to restore SOC and TN for sustainable livelihood security in the valley.

Key words: Land use system, soil organic carbon, total nitrogen, soil properties, Azad Kashmir.

IC³AF-2025-72

Potash Improves Growth, Forage and Seed Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.) under Irrigated Conditions of Punjab

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Cluster bean (*Cyamopsis tetragonoloba* L.) is a minor pulse, vegetable as well as fodder crop that has gained due importance due to its guar gum having diversified industrial use. There is little understanding about role of potash (K) in enhancing cluster bean fodder and seed yield. A field trial was conducted in the College of Agriculture, University of Sargodha, Pakistan, to assess the growth, forage and seed yields of cluster bean at varying potassium levels. The treatments comprised of six K levels 0, 10, 20, 30, 40, and 50 kg ha^{-1}. Cluster bean (hybrid BR 21) sown with the help of single row hand drill on flat seedbed was used as test crop. The study's findings revealed that increasing the K application rate resulted in a progressive considerable improvement in cluster bean growth, fodder, and seed yields. Significantly the higher plant height (205-219 cm), number of leaves (90-94), leaf area index (2.9-3.3), and fodder yield (33.9-37.7 t ha^{-1}) of cluster bean were attained by 30-50 kg ha^{-1} K levels. However, 20-50 kg ha^{-1} K application resulted in significantly the higher number of branches per plant (4.67-8.33), pods per plant (9-13), and 1000-seed weight (28-31.6 g) while 40-50 kg ha^{-1} K application produced significantly the higher seed yield (3.73-3.85 t ha^{-1}) and biological yield (13.1-14.4 t ha^{-1}) of cluster bean.The economic analysis revealed that 40 kg ha^{-1} K level is the best as it gained the highest benefit: cost

ratio (1.51). Based on the findings of our research, we recommend that 40 kg ha^{-1} is the most profitable K application rate for achieving the highest cluster bean seed and fodder yields under irrigated conditions of Punjab.

Key words: Biological yield, economic analysis,leaf area index, number of leaves, plant height.

IC^{3}AF-2025-73

Fortifying Global Food Systems: Adaptive Strategies for a Changing Climate

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Climate change is significantly undermining the stability and performance of global food systems by affecting agricultural productivity, reducing water availability, increasing pest and disease pressure, and intensifying the frequency of extreme weather events. Key food systems—including crop production, livestock systems, fisheries and aquaculture, forestry, and agri-food value chains are particularly vulnerable to these climate-induced stresses. Strengthening the resilience of these systems is critical for ensuring food security, livelihoods, and nutritional outcomes, especially in climate-sensitive regions. For crop production systems, interventions include the use of climate-resilient and early-maturing crop varieties, conservation agriculture, integrated nutrient and pest management, and crop diversification. In livestock systems, improved breeds, rotational grazing, climate-smart housing, and feed innovations are emphasized. Fisheries and aquaculture benefit from ecosystem-based management, habitat restoration, and early warning systems for ocean temperature changes. In forestry-linked food systems, agroforestry, sustainable harvesting, and reforestation serve as key resilience-building practices. Cross-cutting interventions include the promotion of climate-smart agriculture (CSA), strengthening climate information services, enhancing water harvesting and efficient irrigation technologies, and building resilient infrastructure such as cold storage and rural roads. Equally important are institutional mechanisms such as crop insurance schemes, community-based adaptation programs, market access improvement, and enabling policies that integrate resilience into national food and climate strategies. This abstract underscores the need for inclusive governance, investment in research and extension services, digital innovations, and multi-stakeholder collaboration to ensure long-term impact. Ultimately, enhancing resilience requires a holistic, systems-based approach that fosters adaptive capacity, reduces vulnerability, and supports transformation across all components of the food system. These efforts are essential to protect food security and livelihoods in the face of accelerating climate change.

Key words: Climate Change, climate-smart agriculture, food security, food system.

IC^{3}AF-2025-74

Addressing Climate Threats to Agriculture and Food Systems

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Climate change poses a significant threat to global agriculture and food security, particularly in vulnerable regions with low capacity to adapt. This study examines the complex effects of climate change on agricultural productivity, crop diversity, and food availability based on recent climate models, agronomic research, and food systems analysis. Increased temperatures, changed precipitation patterns, and more frequent

extreme weather conditions are interfering with conventional farming rhythms, lowering the yields of cereal crops like wheat, rice, and maize, and intensifying pest and disease pressures. Additionally, changes in climatic conditions are altering soil fertility and water availability, posing a greater threat to agricultural sustainability. Socioeconomic implications are also analyzed in the study including rural livelihood risks, food price volatility, and nutritional insecurity. Special focus is placed on low- and middle-income country smallholder farmers with increased exposure and reduced resilience. Through a mixed-methods strategy that combines climate data with field surveys and food system analysis. This research identifies the pressing need for climate-resilient agriculture practices, enhanced early warning systems, and inclusive policy interventions to guarantee equitable access to resources and technologies. Tackling climate change impacts on agriculture is essential for ensuring food security, as well as achieving broader goals of poverty alleviation and sustainable development. This research necessitates interdisciplinary research and forward-looking policy intervention to enhance adaptive capacity in the wake of a rapidly changing climate.

Keywords: Climate change, global agriculture, food security, low & middle-income countries, disease pressure, interdisciplinary research.

IC^{3}AF-2025-75

Impact of Seasonal Aerial Fungal Phytopathogens over local agricultural fields of Mansehra

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Monitoring of seasonal fungal spores over agricultural fields could be very effective in controlling of specific plant disease. The control of plant pathogens has become difficult in changing climatic and environmental conditions all over the world. The present study was conducted to monitor the transportation of seasonal aerial fungal phytopathogens over eight agricultural fields in Mansehra for consecutive two years, Qualitative and quantitative analyses of the phytopathogens during different seasons was carried out. It was revealed that diversity and abundance of phytopathogenic fungal species was an evident during various seasons. The seasonal occurrence and abundance of specific fungal spores in air ecould be often correlated with specific crop disease. A total of 18 fungal species were identified under varying meteorological conditions. Species belonging to the genera *Alternaria, Aspergillus, Botyris, Cladosporium, Epicocum Helminthosporium, Fusarium, Mucor, Rhizopus, Rhizoctonia,* and *Penicillium* were dominant. The results of this study provide valuable perceptions about the influence of environmental factors and phytopathogens on local crops. This investigation may help in the development of strategies to manage phytopathogens under different environmental conditions.

Keywords: Seasonal variations, aerial fungi, phytopathogens, plant diseases.

IC^{3}AF-2025-76

Exploring Microalgal Treatment of Municipal Wastewater for Carbon Fixation and Irrigation Applications

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Water scarcity often compels countries to explore alternative water sources, including reusing treated wastewater. However, conventional treatment technologies of municipal wastewater have high operational and maintenance costs and require a large energy input. In contrast, microalgae offer promising applications in wastewater treatment due to their ability to assimilate nitrogen and phosphorous as nutrients, producing valuable biomass. Microalgae are used in the secondary and tertiary wastewater treatment to remove pollutants and generate treated wastewater, which can be used for irrigation. The present study studied the effect of raw and secondary treated municipal wastewater for algal

production and the treatment of raw and wetland-treated municipal wastewater. Moreover, the microalgal-treated wastewater was assessed for the irrigation of cucumber. Results indicated that maximum biomass production and carbon fixation of microalgae was 1.32 g L^{-1} and 148 mg L^{-1} d^{-1} in raw municipal wastewater, respectively. In raw municipal wastewater, the maximum removal efficiency of NH4+ - N, TKN, and PO43- - P was 94.32%, 79.17%, and 82.61%, respectively. No bactericidal effects were observed when cucumber plants were irrigated with microalgal-treated wastewater. The findings of this study demonstrate the feasibility of using microalgae for the economical and cost-effective recovery of nutrients from wastewater and its use in agriculture.

Keywords: Microalgae, carbon fixation, municipal wastewater, wastewater reuse, irrigation.

IC^{3}AF-2025-77

Crop Residue Application: Impacts on Yield, Soil Properties, and Erosion Losses in Wheat–Common Bean Cropping

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Erosion-induced depletion in soil fertility leads to degraded soil quality due to its negative impact on soil properties. It further increases in runoff, soil loss and decline in agronomic productivity. The main objective of the experiment was to study the response of crop yield and water erosion to residues incorporation. The experiment was laid out in a randomized complete block design in experimental fields of the University of Poonch, Rawalakot. The organic amendments were pine needles and wheat husk/straw. The treatments included: T1: control, T2: NPK (recommend rate of NPK fertilizers), T3: SD (pine needles 4 $Mgha^{-1}$), T4: WS (wheat husk/straw @ 6 $Mgha^{-1}$). The crop grown was common bean in rotation with wheat. In common beans, Wheat husk reduced surface runoff by 55% and sediment yield by 42%, compared to the check treatment. Pine needles reduced surface runoff by 35% and sediment yield by 32%, compared to the check treatment. The grain growth and grain yield of common beans were statistically higher ($P \leq 0.05$) in organic amendments. The growth indicators, including plant height, spike length of peduncle, tiller count, spikelets per spike, and flag leaf area, were higher under WH + NPK and PN + NPK treatments. However, NPK had similar growth to WH + NPK and PN + NPK and was higher than the control. The grain yield showed the same trend. The nutrient losses, sediment load and runoff losses were less in treatment WH + NPK and PN + NPK. Locally available organic amendments have the potential to increase crop yield and to reduce soil and water losses in eroded lands. This study showed that organic amendments can enhance wheat growth and yield by reducing soil erosion.

Keywords: Wheat husk; pine needles; sediment losses; runoff losses; wheat; common bean

IC^{3}AF-2025-78

Climate Change and Water Crisis in Pakistan

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Pakistan is currently facing the major threat of a water crisis. The country's water resources are seriously threatened by climate change. Pakistan is currently facing a severe water crisis. An agricultural country, Pakistan's economy largely depends on water for its crops. The country ranks 4th in the world for water consumption and 3rd in the world for water stress. Per capita water availability in Pakistan has been declining over time. To understand the state of water stress in Pakistan, we analyzed the scientific literature for this review article. The results showed that

population growth, urbanization, and climate change have reduced the quantity and quality of water. Due to dwindling water reservoirs and an inefficient water management system, the problem is worsening day by day. A significant portion of freshwater (90 -93%) is consumed by the agricultural sector. For all these reasons, Pakistan crossed the "water scarcity threshold" in 2005. The water storage capacity is only 30 days. Pakistan receives a total of 145 million acresof water, but only 13.7 million acres are saved. While per capita water availabi lity has fallen below the water scarcity threshold (1,000 cubic meters), if this situation continues, Pakistan could faceabsolute water scarcity by 2040. To avoid water loss, experts suggest adopting techniques to minimize water consumption for agricultural and domestic purposes. Moreover, building dams could be a good initiative to control water losses.

Keywords: Water shortage, agriculture, per capita, water consumption, water loss, water management.

IC^{3}AF-2025-79

Predicting methane emissions from paddy rice soils under biochar and nitrogen addition using DNDC model

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Methane (CH4) is a second largest contributor of global warming after carbon dioxide (CO2), and it is crucial to understand how management practices affect CH4 emissions. Among field crops, paddy rice alone has accounted for about 10–12% of the total CH_4 emission in 2010. The process-based DeNitrification and DeComposition (DNDC) model can be applied to quantify greenhouse gas (GHG) emissions from agricultural soils. Capturing both the daily time-scale and cumulative growing season CH_4 fluxes by DNDC may help to devise appealing mitigation approaches for better rice management. In this study, DNDC was calibrated with a parameter adjustment approach under two treatments: 140 kg N ha^{-1} without biochar and 140 kg N ha^{-1} with 2% biochar. Simulation results show that the model predicted the daily CH_4 fluxes in good agreement with measurements under both treatments. Next, DNDC was validated with the adjusted parameters against the remaining biochar and N treatments, and the model performed well in prediction of CH_4 fluxes as indicated by several statistical indexes: RMSE ranged from 6.74 to 7.62 g CH_4 $ha^{-1}d^{-1}$, the D-index varied between 0.92 to 0.98, and MPD and nRMSE were at 10.94–17.43% and 17.54–24.52%, respectively. In terms of cumulative growing season CH_4 efflux, DNDC under-simulated all treatments except the control. Further DNDC predicted above-ground dry weights and volumetric water contents in good agreement with the measurements. Moreover, model poorly predicted soil temperature, pH, and soil moisture content. The value of the D-index varied from 0.12 to 0.38 for both soil temperature and pH. Subsequently, DNDC successfully identified the significant impact of biochar on CH_4 emission, and model error was strongly correlated with pH of soils with no biochar amendments. In conclusion, the DNDC model can capture the daily time-scale as well as annual-scale CH_4 fluxes, though DNDC must be validated by intensive measurements of additional soil variables, including dissolved organic carbon (DOC) and microbial composition under different biochar types.

Key words: Methane, paddy rice, DNDC model, parameter-adjustment calibration,biochar

IC³AF-2025-80

Assessing the Influence of Climate Change on Sugar Recovery in Early Medium Mid-Late and Late Maturing Sugarcane Varieties

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Understanding the dissimilarity in sugar content among different maturity sugarcane varieties throughout the crushing season is crucial for sugar mills and farmers, particularly in the context of climate change. Rising temperatures, shifting rainfall patterns, and increased weather variability are influencing crop development, maturity, and juice quality, thereby impacting sugar recovery potential. This study examines the variation in sugar content among early, medium, mid-late, and late maturing sugarcane varieties during the 2023–2024 crushing season at the Sugarcane Research Institute, Faisalabad, Pakistan. Results revealed significant fluctuations in sugar content across maturity groups and throughout the crushing season, driven in part by changing climatic conditions. Early maturing varieties exhibited higher sugar content in November, offering a timely advantage for early-season crushing. However, under rising end-season temperatures and inconsistent weather, these varieties experienced a sharper decline in sugar content by March. In contrast, medium and mid-late varieties maintained a more stable sugar profile, while late maturing varieties, though slower to mature, retained higher sugar content into the later months of the season. These findings highlight the importance of climate-adaptive planning in varietal selection and harvesting schedules. A strategic mix of varieties with staggered maturity can help mitigate the impacts of climate variability, optimize sugar production, and extend the crushing season for improved sugar recovery.
Keywords: Climate change, sugar recovery, sugarcane varieties, crushing season.

IC³AF-2025-81

Risk Assessment of Soil Erosion under Variable Land uses in District Poonch, Azad Jammu and Kashmir

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Soil erosion threatens agriculture, grasslands and forests in Poonch, Azad Jammu and Kashmir, where steep terrain, intense rainfall and inadequate soil conservation measures exacerbate the problem. The current study was designed to investigate soil erosion risk under various land use types in selected areas of District Poonch using the Revised Universal Soil Loss Equation (RUSLE) in the geographic information system (GIS) environment. Rainfall data from three meteorological departments were collected to calculate soil erosivity. A total of 45 soil samples were collected from 15 selected sites, including forest cover, grassland, and cultivated land. Soil erodibility variables were determined by analyzing sand, silt, clay, and organic matter percentage samples. Landsat ETM plus image data of 2022 and Aster Digital Elevation Model (DEM) 30 m data were processed to identify characteristics like land cover/land use, elevation and slopes. Spatial variation of soil erosion was measured after integrating RUSLE factors i.e. Rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), cover management (C) and conservation practice factor (P) through the GIS technique. A soil erosion risk map comprising shallow, low, medium, high and very high-risk zones was prepared. The raster layers of rainfall erosivity, soil erodibility, topography, cover management and conservation practices were processed and multiplied in the GIS platform. Results indicated that the mean soil erosion in district Poonch was about 71.56 tons ha^{-1} yr^{-1}. The high-risk zone (30-100 tons ha^{-1} yr^{-1}) possesses the maximum coverage of 44% of the study area while; low-risk zone (1-10 tons ha^{-1} yr^{-1}) covers

54% of the study area. The results of the study can provide a base for planners and policymakers to organize better soil conservation plans for sustainable agriculture.

Key words: Cover management, low-risk zone, land use, rainfall erosivity, soil erosion.

IC^{3}AF-2025-82

International Wheat and Maize Improvement Centre- A Pivotal Contributor of Wheat Productivity Enhancement with Climate Resilience

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Wheat is the staple crop of Pakistan with the major diet of 60% of the population. Current population growth of Pakistan is 2% and it is predicted with average 125 Kg per capita yearly consumption the country would need 34.3 million tons by 2030. An average yield increase of 3.8 tons per ha of the country will be needed to fulfil the demand of wheat requirements. This demand will need a significant increase in per acre productivity. This could be achieved by both genetic improvement of the varieties along with reducing the gap of genetic potential and farmer field productivity. CIMMYT international is contributing to both avenues through science innovation, knowledge and germplasm sharing, capacity building and seed dissemination via involvement of stakeholders from research, extension, NGOs and farming communities. Innovative germplasm improvement strategies have been implied with emphasis on climate resilience, better nutrition and improved input efficiency leading to qualitatively and quantitatively better yielding varieties through close partnership with NARES. This enabled to establish a partnership with 24 partners in 45 districts across Pakistan. Novel approaches like informal dissemination of seed through community-based seed producer groups have shown a strong impact with the role NGOs like NRSP, LSF and others. Contribution has been made to capacity building of NARES partners with training of around 20000 farmers, 500 researchers and 2100 agricultural professionals along with provision of funds for infrastructure development. Among around 200 varieties released, 80% are based on CIMMYT germplasm. An estimate of CIMMYT contribution have shown around 12-40% increase the wheat yield contributing to food security in Pakistan.

Keywords: Wheat, sustainability, food security, climate resilience, community engagement.

IC^{3}AF-2025-83

Evaluation of Okra Genotypes for Growth and Yield Traits Towards Enhancing Food Security

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With the global population steadily rising and food demand increasing, the development of high-yielding crop genotypes is crucial for ensuring food security. Okra (*Abelmoschus esculentus* L. Moench), a valuable vegetable crop in tropical and subtropical regions, is prized for its tender green pods. In the spring of 2023, a study titled *"Assessment of Okra Varieties Using Growth and Yield-Related Characteristics"* was conducted at the Agricultural Research Station in Swabi. The research evaluated five okra genotypes—Arka Anamika, 19212, 20329, 24792, and 24799—based on several vegetative and yield-related traits. Data were collected on parameters including number of pods per plant, number of seeds per pod, number of leaves per plant, plant height, pod length, pod girth, yield per plant, and 1000-seed weight. The findings revealed significant

differences among the genotypes in most traits, except for pod girth, which showed no significant variation. Genotypes 24799, 20329, and 24792 recorded the highest number of pods per plant, while genotypes 24799 and 19212 produced the longest pods. The highest yields were observed in genotypes 24799, 20329, and Arka Anamika. Taller plants were noted in genotypes 24792, 20329, and Arka Anamika, whereas genotypes 24792, 24799, and 20329 had the greatest number of leaves. In terms of seed production, genotypes 24792, 20329, and Arka Anamika produced the highest number of seeds per pod. The heaviest seeds were found in genotypes Arka Anamika, 24799, and 19212. Overall, genotype 24799 emerged as the most superior across several traits and is recommended for future cultivation and breeding programs to contribute toward enhanced food security.

Key words: Okra, vegetative characters, yield characters, genetic diversity, food security.

IC^{3}AF-2025-84

Resilience in Action: Strategic Approaches to Combat Climate Change-Induced Disasters

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The change in climate patterns mostly brought about by greenhouse gas emissions from human activities and natural processes is known as climate change. Anthropogenic activities have raised global temperatures by roughly 1.0 °C over pre-industrial levels thus far and if current emissions rates continue, this is expected to rise by 1.5 °C between 2030 and 2052. There were 315 natural disasters worldwide in 2018, and most of them were caused by climate change. About 68.5 million people suffered storms, floods, wildfires, and droughts were responsible for roughly 93% of the $131.7 billion in economic damages. It is concerning that the economic losses caused by wildfires in 2018 alone nearly equaled the total losses from wildfires over the previous ten years. Additionally, it has been determined that the most vulnerable sectors to climate attack include infrastructure, food, water, health, ecosystems, and human habitat. The three primary methods for mitigating climate change are radiative forcing geo-engineering, negative emissions, and conventional mitigation. The goal of traditional mitigation technologies is to lower CO_2 emissions from fossil fuels. The goal of negative emissions technology is to lower carbon dioxide levels by capturing and storing atmospheric carbon. To stabilize or lower global temperatures, geo-engineering approaches that use radiative forcing modify the earth's radiative energy budget. Traditional mitigation measures by themselves will not be enough to achieve the goals; as a result, using alternate routes seems to be unavoidable. While some of the technologies on display may still be in their infancy, biogenic-based sequestration methods are somewhat developed and ready for immediate use.

Keywords: Climate change, greenhouse gas, economic losses, technologies, global temperature, biogenic-based sequestration.

IC^{3}AF-2025-85

Empowering Food Security and Combating Malnutrition through Rapid Test Kits amidst Climate Change

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The role of rapid test kits (RTKs) in combating malnutrition and ensuring food security has become increasingly vital in light of profound impact of climate change on agriculture. Unpredictable weather patterns, life threatening droughts and sudden shift of ecosystems are disrupting food production, leading to a global rise in malnutrition, particularly in vulnerable regions. RTKs, which are designed for on-spot qualitative micronutrients assessment, provide an innovative solution for identifying and addressing malnutrition in real time. These portable, easy-to-use

and cost-effective tools enable healthcare providers, humanitarian organizations and field workers to quickly diagnose deficiencies of essential nutrients i.e. vitamins (especially vitamin A & D) and minerals (Iron, Iodine, Zinc etc.). By facilitating early interventions, these test kits can mitigate the long-term health effects of malnutrition and enhance the resilience of compromised populations. Furthermore, by implementing more targeted & effective nutritional intervention national program, kits can significantly improve the food security situation, particularly in far flung areas with scarce resources and limited access to healthcare. The current study aims to explore the significance & potential impact of rapid kits in the fight against malnutrition, focusing on their role in facilitating timely responses to nutritional deficiencies and supporting sustainable agricultural practices to bolster food security in the face of climate change. Additionally, this paper will highlight the invaluable efforts of NIFA, Peshawar, in advancing national food security and combating malnutrition among marginalized populations in Pakistan. NIFA has contributed significantly in this national cause by developing and disseminating various RTKs to key stakeholders across the country. These kits include NIFA Iodine, Iron, Vitamin A and POV kits, which enable the qualitative assessment of iodine in salt, iron in wheat flour, vitamin A in dietary fats/oils and the level of rancidity in edible oils and fats respectively. The kits are portable, user-friendly and cost-effective, providing accurate and precise qualitative results on-site.

Key words: Food security; climate change; rapid test kits; malnutrition; sustainable agriculture; nutrition assessment.

IC^{3}AF-2025-86

Stress Responsive miRNA Locus Driven by Hitchhikes with Massive Segregation Distortion in the Arabis Hybrids

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This study aimed to investigate the physiological and molecular responses of *Arabis nemorensis* and *Arabis sagittata*, two plant species thrive in floodplain meadows. This study investigated the physiological and molecular responses of *A. nemorensis* and *A. sagittata* under drought stress. A controlled dry-down experiment revealed that *A. sagittata* had a significantly higher recovery rate at 5% soil water content (90% vs. 50%). Transcriptome analysis showed a stronger transcriptional response in *A. sagittata*, with 3,034 genes upregulated and 3,145 downregulated, compared to 2,175 up- and 2,286 downregulated in *A. nemorensis*. Functional enrichment analysis revealed the activation of genes related to water deprivation, protein autophosphorylation, and stress signaling pathways in *A. sagittata*, while *A. nemorensis* emphasized translation, ribosome biogenesis, and chloroplast organization. During recovery, A. sagittata upregulated leaf senescence and starch metabolism genes, whereas *A. nemorensis* shifted to cytoplasmic translation. miRNA profiling identified a drought-responsive miRNA locus in *A. sagittata* targeting oxidative stress and ABA signaling regulators. A ~6kb upstream retrotransposon insertion in the promotor region of *A. nemorensis* miRNA locus may influence its expression. Notably, miRNA locus maps to a segregation distortion region on chromosome 4 in an F4 Arabis mapping population, meiotic drive favoring *A. sagittata* all, suggesting possible genetic hitchhiking and a role in local adaptation through non-Mendelian inheritance.

Keywords: miRNA, gene expression, transcriptome, *Arabis*, drought stress, segregation distortion.

IC³AF-2025-87

Nutritional Enrichment of Green Instant Tea with Olive, Moringa, and Stevia

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The aim of this research was to develop a nutritious and health-enhancing green instant tea, considering its widespread consumption. Various combinations of olive and *Moringa* leaves were formulated and evaluated through sensory trials to identify a blend that would be both marketable and well accepted by consumers. Six formulations (OM-1 to OM-6) were prepared using different proportions of olive and *Moringa* leaves. OM is the abbreviation of *Olive* and *Moringa*. Based on sensory evaluation, the most preferred formulation (OM-4) was further enhanced by incorporating stevia powder in varying concentrations, resulting in new blends labelled OMST-0 to OMST-5.The OMST is the combination of Olive, Moringa and Stevia. Physicochemical analysis of the tea bags revealed protein content ranging from 15.16% to 15.85%, pH values between 6.31 and 6.38, ash content from 7.80% to 8.45%, and moisture content between 6.47% and 6.64%. The instant tea formulations also exhibited acidity levels of 0.09–0.11, ascorbic acid content of 0.29–0.34 mg/mL, and total phenolic content ranging from 118.64 to 162.27 mg/L. Sensory evaluation identified OMST-4 as the most favorable formulation in terms of color, taste, and overall acceptability.These findings indicate that the addition of olive, *Moringa*, and stevia can significantly enhance the nutritional value and sensory appeal of green tea, making it a promising functional beverage, particularly beneficial for individuals with diabetes.

Keywords: Green tea,Olive addition, *Stevia*, herbal ingredients.

IC³AF-2025-88

Utilizing GIS for Mapping Dengue Mosquito Breeding Sites under the Influence of Climate Change in District Swat, Khyber Pakhtunkhwa"

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Dengue fever is a major public health problem in the world. Pakistan has been a victim of this disease since 1990s. The scenario of dengue is getting worse from time to time with severe outbreaks in the country. However, source reduction through vector surveillance is the most effective way to determine when and where to take the control action against the culprits (Aedes) of this disease. Here we have used a combination of the Global Positioning System (GPS)/Geographic Information System (GIS) technology to find the larval breeding sites of *Aedes albopictus* in the surveyed houses as well as containers in the two close areas (badly affected by dengue in 2013) in District Swat. A hand-held GPS unit was used to record the location of surveyed houses. The survey data and the GPS coordinates of house location were combined into GIS maps showing distribution of immature density and clustering of immature stages and positive containers. The larval indices indicated a huge breeding of dengue vector. Three larval indices were estimated by standard formula, House index (HI), Container Index (CI) and Breatue index (BI). The HI in Saidu Sharif (Mingora city) was recorded as 79.6 %, CI 73.86 % and BI 65 %. Gul kada had HI 77.5 %, CI 67.14 % and BI 58.75 %. The ratio of the HI varies between Saidu Sharif and Gul kada. However, the values of CI and BI remain nearly same between these

areas. Our observations show that Saidu Sharif is more infested with the dengue larvae (high breeding) as compared to Gul Kada (slightly lower). Similarly, the pupae ratio recorded were 0.26 in Saidu Sharif and 0.21 in Gul Kada. However, the pupal indices were reciprocal and showed highest infestation in Gul Kada as compared to Saidue Sharif. Breeding of *Aedes albopictus* larvae was observed mainly in six type of domestic water holding containers i.e. water tanks (plastic water tank) 81 %, tires had 83 %, cemented water tanks had 83 % , commode and wash basin 83%, Jars had 77.77%, fountain had 72.72%. Subsequently, the breeding sites were marked using GIS for targeted vector control program. These results show that the studied areas are at higher risk of massive dengue outbreak at the onset of favorable environment for vector mosquito. Moreover, using this approach will improve the efficiency and accuracy of dengue vector surveillance for targeting vector control.

Key words:*Aedes albopictus*, GIS, GPS, house index, container index, Breatue index.

IC^{3}AF-2025-89

Role of Mushroom Farming Popularization in Mitigating Climate Change and Food Security

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Mushroom farming can play important role in mitigating climate change by promoting sustainable agriculture, utilizing agricultural waste, and enhancing soil health, while also offering a nutritious food source with a relatively lower carbon footprint compared to some other food crops. Nuclear Institute for Food and Agriculture (NIFA), Peshawar has a strong mushroom program conducting R&D which has resulted in the cultivation optimization of nutritional mushroom strains (Pearl Oyster, Grey Oyster, Pink Oyster, King Oyster, Milky, Button) and medicinal mushroom (Ganoderma). The program has popularized mushroom cultivation in Pakistan for mitigating climate change and has organized several training workshops in Khyber Pakhtunkhwa, Upper Punjab, and Baluchistan and trained 3141 participants. NIFA technical guidance coupled with provision of quality mushroom spawn has resulted in the development of dozens of private mushroom farms for nutritive food production as climate resilient crop for food security and created self-employment/business opportunities to increase sources of income.

Key words: Climate change, mushroom farming, medicinal mushroom, Pink oyster, soil health.

IC^{3}AF-2025-90

Study of increased atmospheric CO_2 on protein content of staple crops and its Impact

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Agricultural production has been significantly influenced by the elevation in atmospheric CO_2 concentration, which is considered the main factor in climate change. This increased CO_2 activates photosynthesis and contributes to maximizing crop yields. The crops' nutritional quality gets affected, especially the protein content, which is critical regarding the global food security aspect. This study analyzed the CO_2 impact on some major crops like wheat, rice, maize and soybean protein content through the comprehensive research of extensive experimental data. Under elevated CO_2 conditions, the trend of decreasing protein content in major staple crops was analyzed. Depending on different conditions such as the level of CO_2 enrichment, crops breeds and experimental design identified the magnitude of reduction. Observation of various physical mechanisms underlying phenomena like partitioning in plants and nitrogen assimilation alteration. This study also included monitoring the decreased protein content implications in major crops for human nutrition. It helps regarding food security in the future to mitigate any negative

impacts on crops' physiology and nutritional quality, particularly due to high-CO_2 climate and help in implementing strategies to avoid any risk related to food security

Key words: Carbon dioxide, food security, climate change, staple crops.

IC^{3}AF-2025-91

Elevated Risk of Salmonella Contamination in Poultry under Changing Climate

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Increased intensity and frequency of heat waves due to climate change, including in the tropical regions of Pakistan. This study focused on the hypothesis that higher salmonella contamination incidence in poultry products is related to the ambient temperature elevation. During the sampling period of historical temperature records, these records correlate with the existence of salmonella contamination in surveillance data of poultry and the processing industry, mostly in tropical regions. This research investigates the impact of heat elevation on poultry physiology and the mechanism responsible for this relationship. Salmonella contamination occurs during transportation, processing and farming. Its prevalence rate is high in warm environments, which affects the poultry gut microbiome and immune system. The relationship between salmonella aggregation and warm environment is quantified. It helps in creating the risk management strategies that safeguard poultry products and promote general public health. It also provides suitable insights into developing targeted interventions for maintaining basic food safety standards. Food safety protocols get updated and inform policy decisions primarily aimed to mitigate climate-based health risks in Pakistan and other similar climate regions.

Key words: *Salmonella* contamination, warm environment, poultry products.

IC^{3}AF-2025-92

Enhancing Canola (*Brassica napus*) Growth Under Salinity Stress: The Role of Salt-Tolerant Rhizobacteria in Sustainable Agriculture and Food Security

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Canola, an essential industrial crop of the *Brassicaceae* family, is the third largest oil crop globally, following palm and soybean. However, soil salinity exacerbated by climate change, poses a significant challenge to its productivity, threatening food security and sustainable agriculture. This study evaluates the potential of salt-tolerant rhizobacteria to enhance canola growth in saline conditions. A pot experiment was conducted in a controlled environment at the Land Resources Research Institute, National Agriculture Research Center (NARC), Islamabad. The pre-isolated and characterized salt-tolerant PGPR strains were tested on canola crops under greenhouse conditions. Compatibility teste were performed before application, and treatments were replicated three times. The electrical conductivity (EC) of the saline soil was measured at 4.9 dS/m, indicating moderate salinity, while the pH was recorded at 10.8, highlighting alkaline stress conditions. The study included seven treatments, including a control, and utilized two salt-tolerant rhizobacteria strains capable of surviving at a 30% salt concentration. Results indicated that proline accumulation, a key indicator of plant stress response, was significantly higher under saline condition conditions. Similarly, TSS levels were elevated in saline soil compared to non-saline conditions, confirming the osmotic stress imposed by salinity.

Furthermore, sucrose levels, which play a vital role in osmotic adjustment and energy supply under stress conditions, were significantly higher in saline soils than in non-saline conditions. Despite these biochemical adjustments, morphological parameters such as shoot length, root length, and biomass production were dramatically reduced under saline conditions, indicating the detrimental effects of salinity on plant growth. However, Plants treated with salt-tolerant PGPR exhibited improved growth and stress tolerance compared to untreated plants, suggesting their potential to mitigate the adverse effects of salinity.

Key words: Soil salinity, PGPRs, climate change, food security.

IC^{3}AF-2025-93

Effectiveness of Siderophore producing (SP) bacteria under iron-limited conditions in Changing Climate Scenario

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Siderophores are iron-binding compounds that are categorized based on the ligands that bind ferric iron. Scavenging iron and facilitating its accessibility to the cell is the function of siderophores. Applications in research, medicine, industrial and environmental cleanup are vital. Siderophore-producing (SP) bacteria activity and abundance may serve as a biological indicator of the fertility of agricultural soil. Exploring the effects of SP bacteria on soil quality and plant growth is essential to achieving this goal. SP bacteria can be effective in changing climatic conditions by promoting plant growth and nutrient uptake, especially under iron-limited or stressed conditions and can also contribute to biocontrol by limiting iron availability to pathogens. By inoculating seeds with these siderophore-producing bacteria, biofortification can be achieved at a lower cost through soaking. Sixty rhizobacterial isolates based on PGPR traits from the wheat rhizosphere soil of the Faisalabad area was collected for the current study. The PGPR characteristics of these isolates, such as phosphorus solubilization, the formation of indole acidic acid (IAA), oxidase, catalase, and the methyl red test, were further studied. After further screening, thirty strains undergo the quantitative and qualitative Chrome Azurol Sulfonate agar test for siderophores producing bacteria (SP), and only twenty strains- showed positive results when cultivated in iron-deficient succinate medium in an incubator shaker for 48 hours at 120 rpm. There were 60 bacterial isolates in total, 20 of which tested significantly positive for siderophore production and nutrient solubilization. Following the selection of the effective strains, a growth room experiment was designed to evaluate the effect of these isolates on the growth parameters of wheat. In the growth room study, 3 (S-29, S-7, S-57) of the 20 positive isolates considerably outperformed the control in terms of root and shoot growth. When plants were inoculated with bacteria that produce siderophores, their height significantly increased. The results of this study indicated that rhizobacteria might also assist plants to absorb insoluble forms of nutrients from the soil and effectively transfer nutrients to them. It shows the strains' potential as effective siderophore producers and provides a noteworthy view for future scientific applications.

Key words: Siderophore, iron, rhizosphere, growth room, PGPR, wheat, biofortification.

IC³AF-2025-94

Potential Applications of Plant Growth Promoting Rhizobacteria in Sustainable Agriculture and its Adaption to Climate Change

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Contemporary agriculture faces twin challenges: sustainability and resilience against climate change. This article explores the potential of Plant Growth Promoting Rhizobacteria (PGPR) in addressing these issues. PGPR, beneficial soil bacteria, foster plant growth and health, playing crucial roles in sustainable agriculture and climate adaptation. Conventional farming relies on synthetic chemicals that harm the environment and degrade soil. PGPR provides an eco-friendly alternative by enhancing plant growth through nutrient solubilization, nitrogen fixation, and disease control. They boost crop yields, reduce chemical dependency, and improve soil structure. In the context of climate change, PGPR offer a lifeline to crops facing environmental stresses. Their ability to improve nutrient uptake, enhance drought resistance, and mitigate soil salinity is invaluable. Moreover, PGPR sequester carbon, mitigating greenhouse gas emissions. PGPR's adaptability to diverse climates makes them assets for farmers contending with unpredictable weather. They bolster crop resilience, ensuring stable yields even under adverse climate events. PGPR can also be integrated with other sustainable farming practices, like no-till farming and organic agriculture. To maximize PGPR's potential in sustainable agriculture and climate resilience, challenges related to product development, knowledge dissemination, and farmer adoption must be addressed. Collaborative efforts involving scientists, policymakers, and farmers are vital to promote PGPR's widespread use and tailor solutions for various crops and regions. In conclusion, Plant Growth Promoting Rhizobacteria hold immense potential for addressing sustainability and climate resilience challenges in agriculture. Their benefits, including enhanced nutrient uptake, disease control, and improved soil quality, make them valuable allies in the pursuit of more sustainable and climate-resilient farming systems.

Key words: Plant growth promoting rhizobacteria, sustainable agriculture,climate resilience change.

IC³AF-2025-95

Performance Evaluation of Chinese and Brazilian Sugarcane Clones under Semi-Arid Conditions of Faisalabad, Pakistan

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This study assessed the performance of fourteen sugarcane clones introduced from China and Brazil under the semi-arid agro-climatic conditions of Faisalabad, Pakistan. The evaluation was conducted through adaptability trials at the Sugarcane Research Institute, Faisalabad, using a Randomized Complete Block Design (RCBD) with three replications during the 2023–24 growing season. The clones were compared against two local standard varieties, HSF-240 and CPF-253, based on six agronomic traits and their resistance to red rot disease. Statistical analysis using Two-sided Dunnett's Multiple Comparisons revealed that certain clones, including ZHONGZHE-6 and RB-867515, outperformed the check varieties in cane yield. However, some clones demonstrated poor adaptation to local conditions. Red rot screening identified both resistant and susceptible genotypes among the tested clones. Despite exhibiting higher cane yield, most exotic clones recorded lower sugar recovery percentages compared to local checks. These findings underscore the need for further multi-location trials to confirm the clones' stability, adaptability, and potential for inclusion in the varietal development pipeline.

Key words: Check varieties, genotypes, sugarcane, semi-arid

IC³AF-2025-96

Role of Microbes for Addressing the Climate Change and Food Security

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Investigating the potential of bacteria presents a viable and sustainable answer in light of growing concerns about food security and climate change. This analysis explores the intricate relationship between microbial communities and the dual problems of food security and environmental crises. From bacteria to fungus and archaea, ubiquitous microorganisms influence the ecosystems of our world and are essential for nutrient cycling, soil health, and plant-microbe interactions. This article highlights the extraordinary adaptability of microorganisms to a wide range of situations by dividing them into different habitats. The reciprocal effects of environmental changes brought about by humans on microorganisms and their habitats are then emphasised. The review addresses these issues and portrays bacteria as effective partners in climate change mitigation. They are investigated for their capacity to improve soil fertility, lower greenhouse gas emissions, and sequester carbon. Microbial technologies have the potential to transform agriculture and guarantee global food security, as evidenced by innovations such as biofertilizers and biopesticides. The review concludes by highlighting the mutually beneficial relationship between microorganisms and sustainable food production. By improving soil moisture retention and solving water scarcity, microbial technology can help agriculture adjust to changing climatic circumstances. It emphasises their potential to increase productivity in precision and conventional agriculture under a range of climate circumstances. For a sustainable future, this assessment urges the immediate identification and utilisation of microbial power. Adopting microbial technologies opens the door to a resilient and resource-efficient agricultural future while also encouraging environmental responsibility.

Keywords: Biotech for resilience, climate-smart agriculture, sustainable food systems, symbiotic solution.

IC³AF-2025-97

Genetic Variability, Heritability, Genetic Advance and Traits Correlation in CIMMYT Bread Wheat Genotypes

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Population increase leading to growing demand of food, it is necessary for plant breeder to introduce the new high yielding genotypes to fulfill the demands of food. The current investigation was carried out to study genetic variability, heritability, genetic advance and traits correlation among CIMMYT wheat genotypes. The experiment was laid out on 24 genotypes along with local check of (Swabi 1) during the growing season of 2022-23 at Agriculture Research Station (ARS) Swabi. The experimental design was randomized complete block design (RCBD) with three replications. The statistical analysis revealed highly significant differences among the studied parameters with exception of plant height, spikes meter^{-2}, grains spike^{-1} and harvest index for these traits significant variances among the genotypes were identified. The mean performance disclose that CIM--5 and CIM-24 (123 days) was early heading genotypes whereas early maturing lines were CIM-2 and CIM-3 (142 days). Shortest grains filling period were taken by genotypes, CIM-1, CIM-3 and CIM-22 (18 days). Tallest plants were recorded in the genotypes, CIM-5 (99.47 cm). Maximum number of tillers were found in the genotype, CIM-18 (8 tillers plant^{-1}), whereas highest number of spikes meter^{-2} (181 spikes m^{-2}) were produced by genotype, CIM-1. The longest spikes (13.9 cm) were recorded for genotype; CIM-19, while genotypes,

CIM-1, CIM-7, CIM-9, CIM-10, CIM17, CIM-19 and CIM-25 were found for maximum (20 spikelets spike^{-1}) spikelets spike^{-1}. The more number of seed ear^{-1} was counted for Genotypes, CIM-6 (66), although Genotype CIM-23 (54.09 g) showed high 1000 grains weight. Maximum biological yield was calculated for CIM-19 (12828.67 g), whereas maximum grains yield was estimated for CIM-10 (5225.85 g). Likewise the harvest index was calculated maximum for CIM-10 (42.76%). High heritability along with high genetic advance was estimated for grain yield (h2=0.65, GAM%= 22.21), similarly 1000 seeds weight (h2=0.78, GAM%=13.25) showed high heritability and moderate genetic advance whereas spike length (h2=0.47, GAM%= 10.46) and Biological yield ((h2 = 0.46, GAM%=13.86) showed moderate heritability and genetic advance. Thousand grains weight (rp= 0.3511**, rg= 0.4826*) was significantly correlated with days to maturity, while grains filling duration were also significantly associated with 1000 seed weight (rp=0.2683*, rg= 0.4163*). Plant height revealed significantly positive association with grains per spike (rp = 0.2491 *, rg= 0.5352 **). Spike length was significantly correlated with Grains yield (rp=0.3086**), biological yield (rp=0.2496*) and harvest index (0.5904**). Grain yield (rp=0.3023**, rg=0.6084**) and biological yield (rp=0.3321**, rg=0.6778**) showed positively relationship with spikelets spike^{-1}. The Thousand grains weight was significantly correlated with biological yield (rp= 0.2672*, rg=0.4905*). While Biological yield showed significantly positive correlation with grain yield (rp=0.7904**, rg=0.9104**) and 1000 grains weight (rp= 0.4919**).

Key words: Genetic variability, heritability, genetic advance, wheat genotypes.

IC^{3}AF-2025-98

Immobolization of Chromium Metal in Spinach (*Spinacia Oleracea* L.) Crop using Nano Composites of Biochar and Zinc Oxide

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Fresh water shortage represents a huge challenge for worldwide agriculture. Wastewater was being used for irrigation purposes, which had adverse effects on crop quality and soil health due to high levels of heavy metals (HMs). The present study was performed to assess the immobilization of Cr in spinach crop by using nanoparticles (NPs) of zinc oxide (ZnO) and biochar. Biochar NPs were synthesized by sonication method, to immobilize Cr in spinach crop. The physicochemical properties of these materials assumed a fundamental role in their viability for Cr immobilization. A pot experiment was conducted with eight treatments and three replications using a completely randomized design (CRD). ZnO concentrations of 1 and 10 mg and 1% and 2% of untreated biochar NPs were utilized. Prior to harvesting, physiological parameters including SPAD, plant height, and after harvesting, we measured agronomic parameters like root length, fresh and dry weight of the shoot and root, number of leaves and Cr concentration in roots and shoots. The impact of different treatments on plant growth, immobilization of Cr were compared with control. Statistix 8.1 was used to statistically analyze the recorded data. Combination of ZnO NPs 1mg + biochar NPs 2% (T8) significantly reduced chromium uptake in spinach compared to the other treatments. Same treatments showed the most significant improvement in spinach growth and physiological parameters compared to the control (T1). Treatments involving ZnO NPs and biochar NPs individually also enhanced plant growth, with biochar NPs at higher concentrations generally performing better than ZnO NPs alone.

Key words: Zinc Oxide Nanoparticles (ZnO NPs), biochar, chromium immobilization, environmental remediation.

IC³AF-2025-99

Altitude and Temperature Effects on Leaf Senescence in *Prunus armeniaca*: A Comparative Study of Skardu and Sadpara

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This research examines how altitude and temperature affect leaf senescence in Prunus armeniaca by comparing samples from two different areas: Skardu and Sadpara. The findings indicate that leaves from Sadpara, which is at a higher altitude and experiences cooler temperatures, show more advanced senescence than those from Skardu. Nonetheless, there were differences in senescence among the samples, implying that variations in plant variety might affect how they respond to environmental conditions. This study underscores the intricate relationship between altitude, temperature, and plant variety in influencing leaf senescence.

Key words: Senescence, apricot, altitude, temperature difference.

IC³AF-2025-100

Removal of Heavy Metals from Wastewater by using Coconut Fiber and Farmyard Manure

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Environmental concern about chemical and biological contamination of water has grown to be a significant problem for both society and the government. The majority of domestic and industrial activities add toxic contaminants in water. There are many factors that contribute to water pollution including energy use, urban development, sewage water, pesticides, radioactive waste and industrial waste. The accumulation of heavy metals is a significant issue in all developing countries such as in Pakistan where crops in some areas are irrigated using wastewater. Thus, the aim of this study was to minimize the concentration of highly harmful metals like cadmium (Cd) and chromium (Cr) in water, agricultural soil and vegetable crops like spinach. Wastewater was used for irrigation with the addition of coconut fiber (CF) and farm yard manure (FYM) for the reduction of Cd and Cr concentration in spinach. The recommended dose of fertilizer was applied as a basal dose. There were eight treatments which included T1: control (tap water), T2: control (wastewater), T3: 10% CF, T4: 20% CF, T5: 30% CF, T6: 10% FYM, T7: 20% FYM, T8: 30% FYM with three replications. The experiment was conducted under CRD and the recorded data was analyzed using appropriate tests at a probability level of $p<0.5\%$. Growth, physiological and chemical parameters were recorded at maturity. The highest increase was observed in plant height as 38.67 cm, root length as 12.83 cm, shoot length 31 cm, No. of leaves as 53 leaves per pot and chlorophyll content (SPAD) as 34.67%. The Cd and Cr content in leaves reduced to 92 and 85% as compared to the control having wastewater. The results showed that application of 30% FYM reduced the heavy metals uptake in spinach and increased the plant height.

Key words: Farmyard manure, coconut fiber, wastewater, spinach, cadmium, chromium

IC^{3}AF-2025-101

Molasses-based Waste Water Irrigation: A Friend or Foe For Carrot (*Daucus Carota* L.) Growth, Yield and Nutritional Quality

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Management of molasses-based wastewater generated in yeast and sugar industries is a major environmental concern due to its high chemical oxygen demand and other recalcitrant substances. Several strategies have been used to reduce the inland discharge of wastewater but the results are not satisfactory due to high operating cost. However, reuse of molasses-based wastewater irrigation in agriculture has been a major interest nowadays to reduce the freshwater consumption. Thus, it is crucial to monitor the impacts of molasses-based waste water irrigation on growth, metabolism, yield and nutritional quality of crops for safer consumer's health. In present study, carrot seeds of a local cultivar (T-29) were germinated on filter paper in Petri dishes under controlled conditions. The germinated seeds were then transplanted into pots and irrigated with three different treatments normal water (T0), diluted molasses-based wastewater (T1), and untreated molasses-based wastewater (T2), in six replicates. Results revealed that carrot irrigated with untreated molasses-based waste water had exhibited significant reductions in growth, yield, physiology, metabolism, and nutritional contents. Additionally, accumulation of Cd and Pb contents in carrot roots irrigated with untreated molasses-based waste water exceed the permissible limits suggested by WHO and their consumption may cause health risks. While, diluted molasses-based waste water irrigation positively enhanced the growth, yield of carrot plants without affecting the nutritional quality. This strategy is cost effective, appeared as most appropriate alternative mean to reduce the freshwater consumption in water deficit regions of the world.

Keywords: Carrot cultivation, waste water remediation, water scarcity.

IC^{3}AF-2025-102

Assessment of Climate-Mediated Changes in Freshwater Fish Diversity at Chashma Lake, Mianwali, Punjab, Pakistan

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Fresh water is a vital and sustainable resource facing threats directly from climate change. Indus River is the country's longest river, which is a lifeline for millions of people for their domestic and agricultural needs. Pakistan hosts 171 freshwater fish spp., but aquatic habitats are under continuous threat due to various environmental and ecological factors. This study explored the influence of climate change on freshwater fish diversity and abundance in the Chashma Lake located at District Mianwali, Punjab. Water and fish samples were collected for six months, starting from 1stDecember 2023 till 30thMay 2024. Fish samples were collected at each month, and water samples were taken fortnightly at four sites of Chashma Lake. All analyses were performed at the Fish Biodiversity Hatchery Chashma. Results showed that water temperature, electrical conductivity, calcium, ammonia, and magnesium values fluctuated significantly during six months, suggesting a significant impact of climate-mediated changes on the water quality of Chashma Lake. Significant differences in fish size among different species were also observed. This highlights the need for in-depth analysis to examine the climatic effects on freshwater fish and emphasizes the need to regularly upgrade

native fish diversity indices to advise suitable conservation strategies. Overall, inclusive monitoring is essential to lessen threats to aquatic habitats and biodiversity.

Keywords: Indus river, biodiversity, Chashma, water quality, climate change.

IC^{3}AF-2025-103

Synergistic Effects of N-Fertilization on Crop Productivity and Soil Quality in Wheat-Pea Intercropping

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Optimizing nitrogen fertilization in wheat-pea intercropping is essential for enhancing both crop productivity and soil quality. Wheat-pea intercropping offers promising strategy for sustainable agriculture by enhancing the nitrogen use efficiency. This study ass essed the influence of different recommended nitrogen fertilization (RNF) rates on crop productivity and soil quality parameters. This experiment ca rried two-factor design term as A and B, where factor A consisted of solo wheat, solo pea, and wheat-pea intercropping. Factor B represented RNF rates (N0, N1, N2 and N3). The different nitrogen rates for wheat were applied at 0, 100, 135 and 170 kg N ha^{-1} rates, and for peas were applied at rate of 0, 55, 85, and 115 kg N ha^{-1}. The Land Equivalent Ratio (LER) for the wheat-pea intercropping system was calculated to be 1.88, indicating a substantial advantage over sole cropping. This value suggests that intercropping wheat and pea resulted in 88% greater land use efficiency compared to growing the crops separately. Specifically, intercropped wheat achieved approximately 86% of the biomass yield of sole wheat, while intercropped pea slightly exceeded the biomass of sole pea by around 2%. Soils were analysed for pH, electrical conductivity (EC), moisture content, total organic carbon (TOC), water-soluble carbon, microbial biomass, extractable nitrate and ammonium-N, available phosphorus and enzymatic activities to determine the impact of varying nitrogen fertilization rates. Overall, findings support the design of integrated nutrient management strategies that align with sustainable intensification goals in cereal-legume cropping systems.

Key words: NUE, intercropping, mineralization, dual cropping, organic carbon.

IC^{3}AF-2025-104

Bioagents Assisted Rock Phosphate Enriched Vermicompost as a Climate Smart Technology Improved Onion Growth and Nutrients Uptake under Pot and Field Trials

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Vermicomposting can be adopted as a cost-effective climate smart technology for improving P mineralization from rock phosphate (RP) and increasing soil-plant health. The current study was conducted to convert the RP blended degradable organic wastes into phosphorus (P) rich vermicompost through earthworms and phosphate solubilizing microbes (PSMs) and assessed its role on onion growth and soil health. Three

types of RP enriched vermicomposts were produced by mixing of powdered RP with biodegradable wastes in the presence of earthworms and PSMs in vermi-boxes, pits and piles. The efficiency of each vermicompost was evaluated on onion growth and nutrients uptake in a pot trial. Then, the most efficient vermicompost selected for pot trial was further assessed on onion growth parameters and soil health under field conditions. The results expressed that under pot trial, half fertilization of RP enriched vermicompost together with half doses of inorganic fertilizers (Urea, SSP, SOP) significantly enhanced the post-harvest shoot biomass (17.66 g pot^{-1}), bulb weight (94.65 g pot^{-1}), plants height (34.33 cm) as well as N (242.33 mg pot^{-1}) and P (20.06 mgpot^{-1}) uptake by onion as compared to control. Similarly, compared to sole RP vermicompost, the N and P uptake, shoot dry biomass, height and bulb weight of onion plants under field conditions were also significantly improved by the treatments supplemented with half doses of both inorganic fertilizers and RP enriched vermicompost. The current experiments concluded that half dose of RP enriched vermicompost in combination with half inorganic fertilizers has great potential to improve soil health, nutrients uptake, and growth parameters of onion under pot and field conditions. The RP enriched vermicompost can be used as a cost-effective and climate smart strategy to increase vegetable growth and minimize the usage of chemical fertilizers in alkaline calcareous soils.

Key words: Onion growth, Organic wastes, Nutrients uptake, Rock phosphate, Vermicomposting.

IC^{3}AF-2025-105

Epigenetic modifications as modulators of environmental stressors

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Epigenetics is the study of heritable changes in gene expression and cellular function that occur without altering the underlying DNA sequence, often mediated by environmental influences. Various environmental stressors—such as chronic inflammation, toxins, or metabolic dysregulation—drive epigenetic dysregulation in pancreatitis and pancreatic cancer. Using a genetic model of chronic pancreatitis, and using genome-wide approaches, we identified key developmental and functional molecules that are directly targeted by epigenetic reprogramming. Importantly, we demonstrate that these environmentally triggered epigenetic modifications are reversible, highlighting their potential as therapeutic targets.

Key words: Chronic stress, epigenetic reprogramming, pancreatitis.

IC^{3}AF-2025-106

Effect of Phosphorous Solubilizing Bacteria and Trichoderma Applied with Cattle Manure on Yield and Nutrient Uptake by Maize Plant

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Maize is an important cereal crop whose yield is often limited by phosphorus deficiency in alkaline, calcareous soils. This study evaluated the combined use of phosphate solubilizing bacteria (PSB) and *Trichoderma* with cattle manure to improve maize yield nutrient content in plant and availability in soil. The field experiment was conducted at the Research Centre Harichand in Charsadda using a split-plot Randomized Complete Block Design (RCBD) with three replications. The study tested four treatments (Control, PSB, *Trichoderma* (TD), and a combination of PSB+TD) each applied both with and without cattle manure (10 t ha−1). Results showed that combined application of PSB+TD with cattle

manure produced the tallest plants (184.3 cm), highest grain yield (3588 kg ha^{-1}), and greatest biological yield (9462 kg ha^{-1}). This treatment also maximized nutrient uptake, including shoot nitrogen (79.3 kg ha^{-1}), phosphorus (22.5 kg ha^{-1}), and potassium (139.9 kg ha^{-1}), as well as root nutrient contents (5.68 g kg^{-1} N, 2.13 g kg^{-1} P, respectively). Similarly, cattle manure exerted a pronounced positive effect for all parameters such as plant height (174.7 vs. 146.9 cm), grain yield (3584 vs. 2797 kg ha^{-1}), and biological yield (9284 vs. 8097 kg ha^{-1}) being significantly higher in manure-treated plots compared to non-manure treatments. Cattle manure also increased Stover yield (5669 vs. 5300 kg ha^{-1}), shoot P content (2.31 vs. 1.48 g kg^{-1}), and root K content (15.33 vs. 9.88 g kg^{-1}). Conversely, manure slightly reduced soil pH (7.63 vs. 8.00). The efficacy of PSB and TD increased with cattle manure and as such the positive interactions between beneficial micro bes and cattle manure were observed for thousand grain weight and shoot nitrogen uptake, where PSB + TD combined with cattle manure produced greater results with 212 g and 95.9 kg ha^{-1}, respectively. Soil parameters improved significantly with manure application, including increase in total nitrogen (0.06% vs. 0.03%), and AB-DTPA extractable P (3.32 vs. 2.79 mg kg^{-1}) and K (106.08 vs. 92.04 mg kg^{-1}) with resultant decrease in postharvest soil EC and pH. Theresults concludes that the integration of cattle manure with PSB + TD emerged as the optimal strategy for enhancing maize productivity, nutrient assimilation, and soil fertility. Therefore, this combine application is recommended for getting higher and sustainable yield in the experimental area.

Key words: Nitrogen, maize, *Trichoderma*, phosphorus solubilizing bacteria nutrient uptake, soil fertility.

IC^{3}AF-2025-107

Analysis of Mycopathogens Stress on Wheat Crop and Find Their Management for Sustainable Agriculture from District Bhimber, Azad Kashmir

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Thisresearch work exploredtwo most dominant fungal diseases of millet *(Pennisetum glaucum*) crop and their invitro bio-management collected samples Chamba Gali District Sudhnoti Azad Jammu and Kashmir (AJK), Pakistan.The invitro biological management of the two identified diseases were completed by use of Agar Well Diffusion Method (AWDM), Agar DiskDiffusion Methods (ADDM) and Agar Plug Inoculation Method (APIM). Three medicinal plant extracts (*Debregeasia salcifolia, Zanthoxylumarmatum* and *Oleaeuropaea*) *in* methonal, ethanol and distilled water solvents were prepared and used against two fungal pathogens during experimental techniques of AWDM, ADDM and APIM. The findings indicated the incidence of downy mildew (80%) and Pyricularia leaf spot (60 %) diseases in the study area. It was observed that the downy mildew and Pyricularia leaf spot diseases were reduced significantly during invitro experimental trials as compared with controlled conditions. The results were measured after treatment of bark, leaves and fruit extracts of *Zanthoxylum armatum* while bark and leaves extract of *Debregeasia salcifolia,Oleaeuropaea* medicinal plants against two fungal diseases. It was indicated that methanolic bark extracts of *Debregeasia salcifolia* which indicatedmaximum zone of inhibition (ZI) 24.93 mm at 250 mg/ml concentration against downy mildew fungal disease as compared to control treatment (Tetraconazole). The methanolic leave extract of *Debregeasia salcifolia* indicate maximum zone of inhibition (ZI) 22.2mm at 250mg/ml concentration against downy mildew fungal disease. And leave extract of *Debregeasia salcifolia* indicate minimum zone of inhibition (ZI) in distilled water showed 9.2mm at 25mg/ml. In other hand the methanolic leaves extract of *Zanthoxylum armatum*indictaethe highest value zone of inhibition 27.3mm at 250mg/ml concentration against downy mildew fungal disease as compared to control treatment (Tetraconazole). The lowest value of *Zanthoxylum armatum*showed in distilled water indicate lowest zone of inhibition 16.3mm at 25mg/ml. while the methanolic fruit extract of *Zanthoxylum armatum*indicatethe highest value zone of inhibition 23.3mm at

250mg/ml concentration against downy mildew fungal disease. The highest value of bark extract *Olea europaea*showed in methanolic extract in zone of inhibition (ZI) 25.4mm at 250mg/ml concentration against downy mildew fungal disease as compared to control treatment (Carbendazim). The lowest value of *Olea europaea*showed in distilled water bark extract in zone of inhibition (ZI) 17.2 at 25mg/ml concentration against downy mildew fungal disease. The maximum value of leave extract *Olea europaea*showed in methanolic extract in zone of inhibition (ZI) 29.0 at 250mg/ml concentration against downy mildew fungal disease as compared to control treatment (Carbendazim). The maximum value of leave extract *Olea europaea*showed in methanolic extract in zone of inhibition (ZI) 22.6mm at 250mg/ml concentration against Pyricularia leaf spot disease as compared to control treatment (Carbendazim). The minimum value of *Olea europaea*showed in distilled water leave extract in zone of inhibition (ZI) 19.2mm at 25mg/ml concentration against *Pyricularia* leaf spot disease. Hence, it was summarized that the leave extract of medicinal plant of*Olea europaea* showed highest ZI against downy mildew disease. While the lowest value of leave extract of *Debregeasia salcifolia* showed in distilled water indicate 9.2mm at concentration of 25mg/ml. Therefore, it was concluded that the plant *Oleaeuropaea* Have maximum medicinal potential to mitigate and reduce the downy mildew fungal disease of *P. glaucum*. It was recommended for further study on *Olea europaea* Medicinal plant to isolate the specific bioactive compound to target the disease.

Key words: Dominantfungi,fungal diseases,*Pyricularia* leaf spot,*Pennisetum glaucum*,biological protocols.

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Enrichment of FYM Compost with Rock Phosphate and Solubilizing Bacteria for Enhancing Maize Production and Phosphorus Use Efficiency

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The availability of phosphorus from rock phosphate (RP) may increase in alkaline calcareous soil if it is pre-treated with composting materials. In this regard The FYM was pre-treated with RP or SSP at 2% P and 0.05 % PSB and were let to decompose for 60 days in covered cemented pits. The prepared compost was applied to soil at 90 kg P_2O_5 ha^{-1} and treatments and treatments were arranged in Randomized Complete Block Design (RCBD) with three replications. The experiment was conducted on maize cv*Azam* at Research Farm of the University of Agriculture, Peshawar during 2023. Results revealed that plant height, biomass, 1000-grain weight, and grain yield all increased with enrichment of compost with P irrespective of P sources where significant differences were observed among no-compost, FYM composts and FYM+PSB composts. As such, the plot receiving RP in combination with FYM and PSB had a plant height, leaf area, 1000 grain weight, grain yield and biomass of 136.4 cm, 343.33cm^2, 175 g, 3427 kg $ha^{-1,}$ and 9783 kg ha^{-1}, respectively that were significantly higher than plots receiving SSP alone. The P use efficiency of RP was 4.24 % that was increased to 13.24 % upon its pre-treatment with alone FYM and to 23.15% when added with FYM in presences of PSB that was better than alone SSP as well as SSP+FYM. Though the efficacy of SSP was better than RP, but still owing to cheaper source, the pre-treatment of RP with FYM in absence or presence of PSB could be more profitable. The overall results concluded that the application of RP in combination with FYM and PSB significantly enhanced crop yield, nutrient uptake end P use efficiency with the additional benefit of reducing bulk of compost otherwise required for optimal crop production.

Key words: FYM, fertilization, soil fertility, nutrient uptake.

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