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ABSTRACTS BOOK OF

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Dr. Muhammad Tanveer

Assistant Professor
Department of Mathematics
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Development of Herbal Cheese Incorporated with *Asparagus racemosus* (Hathawariya) and Determination of Its Quality Parameters

G.M.H. Galadeniya, V.S. Jayamanne

Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya Sri Lanka

E-mail: vsjayamanne@fst.ruh.ac.lk

Cheese is a widely used dairy product in the world. *Asparagus racemosus* is rich in nutrients, and it has antioxidant and bioactive properties. This study aims to determine the optimal mixing ratio of *A. racemosus* cheese, to evaluate the impact of *A. racemosus* on the sensory properties of the final cheese product, and to assess the physicochemical properties and shelf-life of the final product. Experiments were carried out to determine the 0.1% (T1), 0.2% (T2), 0.3% (T3), 0.4% (T4), and 0% (T0) level (w/v) of air-dried *A. racemosus* leaf powder for herbal cheese production. Each treatment was replicated three times. The sensory evaluation was done using 30 panelists and nine-point hedonic scale was used, and the 0.1% sample was selected as the most acceptable. There was significant difference between samples ($P < 0.05$) according to the sensory evaluation. The addition of 0.1% *A. racemosus* leaf powder did not affect protein and fat content. The T1 sample contained 0.025% fiber, whereas no fiber was detected in the control (T0). The syneresis percentage (12.02%) and moisture content (45.81%) of the T1 sample were significantly lower ($p < 0.05$) than those of the control sample (14.31% and 46.32%, respectively). The ash content of the T1 sample was 4.6%, and it was significantly higher ($p < 0.05$) than the control sample (2.63%). During the 8 weeks of the storage period at 4°C, the control cheese sample (T0) pH was always higher (5.7-4.9pH) than the herbal cheese sample (T1) (5.6-4.8pH), while the control cheese sample & titratable acidity (0.21%-0.34%) was always significantly lower ($p < 0.05$) than the herbal cheese sample (T1) (0.23%-0.36%). The antioxidant, flavonoid, and phenol contents of the herbal cheese were 0.8 μM Trolox/g, 495 μg QE/g, and 1050 μg GAE/g, respectively, while the control sample values were 0.25 μM Trolox/g, 86 μg QE/g, and 260 μg GAE/g. Herbal cheese's (T1) aerobic plate counts (4.3–5.4 CFU/g) and yeast and mold counts (1.6–4.2 CFU/g) were lower than those of the control (T0) (4.5–5.8 CFU/g and 1.9–5.2 CFU/g, respectively). The study concluded that Cheese antioxidant, phenolic, and flavonoid contents were greatly enhanced by adding 0.1% *A. racemosus* leaf powder, while microbial growth and syneresis were decreased. The 0.1% level was the most successful formulation for creating a functional herbal cheese according to the results of the study.

Unlocking Digital Agriculture: Determinants of Farmers' Willingness to Pay for Artificial Intelligence in Punjab, Pakistan

Muhammad Aseeb Azam¹, Muhammad Yaseen¹, Muhammad Luqman¹, Muhammad Usman¹, Zulqarnain Haider²,
Muhammad Shahbaz Zafar²

¹Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha, Sargodha, Pakistan

²Department of Agricultural Economics, College of Agriculture, University of Sargodha, Sargodha, Pakistan

³Interdisciplinary Research Centre for One Health, University of Sargodha, Sargodha, Pakistan

E-mail: muhammad.azam@uos.edu.pk

Agriculture, along with other sources like fishing, is essential to human life as a key source of food. In order to develop environmentally friendly farming that can support the world predicted ten billion individuals in thirty years from now, major automation and technological advances are required. Moreover, AI holds immense potential for making advancements that have positive impacts on sustainability in the agriculture industry through a myriad of applications. It was always understood that AI could alter the perception that people have of the agriculture industry/ utilize an influence on farmers as being change makers especially in the countryside. The present study was designed to study the farmers' willingness to pay for application of artificial intelligence in agriculture: a case study of Punjab, Pakistan. The study was conducted in the Punjab province of Pakistan. Result indicated that Maximum participants (38.9%) were using more than 16 acres land for cultivation. 33.5% were using only 11-15 acres land and 16.7% were using 6-10 acres land for cultivation. While, 10.8% were using less than 5 acres land for cultivation. Result showed that most respondents (42.9%) were moderately familiar with AI technology. The results indicated that 143/203 respondents were familiar with AI techniques such as GIS and computer vision being used in agriculture. Result indicated that most respondents (65.5%) were familiar with AI-based systems used for pest detection and management in agricultural settings. The results have shown that most respondents 179/203 were using AI-based tools for managing crops. It was recommended that AI technology will in the future provide creative and accurate answers to the main farming problems that face farmers all over the world.

Beyond the Fertilizer Bag: An Integrated Strategy for Nitrogen, Climate, and Food Security

Tariq Aziz¹, Muhammad Aamer Maqsood², and Masood Iqbal Awan¹

¹UAF Constituent College, Depalpur Okara, University of Agriculture Faisalabad, Okara 56300 Pakistan

²Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

E-mail: draziz@uaf.edu.pk

Globally, nitrogen is a dual-edged sword: essential for feeding humanity but a primary driver of environmental pollution. This presentation examines the intricate link between nitrogen use, climate change, and food security, drawing lessons from the critical case of Pakistan. To meet the food demands of a growing population, nations worldwide, particularly in South Asia, have dramatically increased their use of nitrogenous fertilizers. This has delivered undeniable gains in food production. In Pakistan, for instance, cereal output soared from 6.7 million tons to 42.7 million tons between 1961 and 2020, largely fueled by a more than tenfold increase in nitrogen fertilizer inputs. However, this success has come at a profound cost, illustrating a global challenge. Excessive and inefficient application has led to a cascade of reactive nitrogen compounds—such as N_2O , NH_3 , NO_x , and NO_3 —polluting our environment. These emissions degrade soil, water, and air, threaten biodiversity, and accelerate climate change. Pakistan experience is a stark example: nitrogen use efficiency in its cereal systems has plummeted from 50% to below 30%, creating a massive nitrogen surplus. Consequently, over the last five decades, agriculture-driven N_2O emissions have risen from 64 to over 1,000 million tons of CO_2 -equivalent

annually. This case underscores a critical global policy dilemma: mitigation efforts must be systemic. Addressing one form of nitrogen pollution (e.g., water contamination) can exacerbate others (e.g., air pollution or greenhouse gas emissions).

Socio-Psychological Determinants of Farmers' Continuance Intention toward Conservation Agriculture: A PLS-SEM Approach

Sana Rashid^{1,2}

¹*UAF Constituent College, Depalpur Okara, University of Agriculture Faisalabad, Okara 56300 Pakistan*

²*Institute of Business Management Sciences (IBMS), University of Agriculture Faisalabad Pakistan*

Email: dr.sanarashid@uaf.edu.pk, drsanarashid1@gmail.com

Conservation Agriculture (CA) has become a resource-efficient and climate-smart agricultural system, which improves soil health, productivity, and environmental sustainability. Nevertheless, CA usage is low in Pakistan regardless of its established advantages. The behavioral and psychological characteristics of the farmers rather than the economic or purely technical ones seem to be relevant in the willingness of the farmers to adopt and remain in the CA practices. The research was intended to understand socio-psychological factors that would affect the attitudes and behavioral intentions of Pakistani farmers towards further use of CA. It particularly aimed at incorporating the Diffusion of Innovation (DOI) and Technology Acceptance Model (TAM) models to effectively describe the perceptions, adoption, and maintenance of innovative agricultural activities among farmers. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used as a quantitative research design. The sample size used was 201 farmers to gather primary data. The model also incorporated reflective and formative constructs and it comprised variables like relative advantage, compatibility, low complexity, attitude and intention. The findings showed that relative advantage, compatibility, and low complexity had a significant impact on the attitude of farmers, whereas attitude had the most significant impact on behavioral intention. The results have shown that farmers who perceive CA to be beneficial and compatible with their existing operations and easy to conduct their operations will be willing to persist with CA significantly. It is the first empirical research in Pakistan that incorporates the DOI and TAM in explaining the CA adoption behavior. It provides a comprehensive image that how psychological factors impact the decision of farmers.

Waste Reduction Strategies for Sustainable Urban Development In The Punjab, Pakistan

Muhammad Usman¹, Muhammad Luqman¹, Muhammad Yaseen¹, Moulabux Peerzad²

¹*Department of Agricultural Extension & Rural Studies, University of Sargodha*

²*Department of Agricultural Economics, University of Sargodha*

Email: muhammad.usman@uos.edu.pk

Punjab, the most populous province of Pakistan, generates more than half of the country's municipal solid waste, with major contributions from its largest urban centers Lahore, Faisalabad, Multan, and Rawalpindi. Despite significant public spending, municipal waste management remains inadequate, dominated by open dumping and uncontrolled landfilling, with minimal

household-level recycling and segregation. This study aimed to assess the current status of solid waste generation and management in Punjab and propose strategies for sustainable improvement. A mixed-methods research design was employed, including household surveys, focus group discussions, and key informant interviews across the four major cities. Findings revealed that organic waste constitutes over 60% of the waste stream, indicating strong potential for composting and biogas initiatives. However, weak regulatory enforcement, lack of segregation infrastructure, low public awareness, and institutional challenges hinder effective waste management. The informal recycling sector contributes significantly to resource recovery but remains poorly integrated into formal systems. The study recommends an integrated waste minimization framework based on the 3Rs and circular economy principles, alongside community-based segregation programs, small- to medium-scale waste-to-energy projects, and strengthened public-private partnerships. These measures could reduce environmental degradation, improve resource efficiency, and support progress toward the Sustainable Development Goals.

Impact of Religious Motivation On Rate of Recidivism in Rural Areas of District Okara

Khawar waheed

Punjab Probation and Parole services, Home Department, Okara.

Email: Khawarwaheed46@gmail.com

The present study “Impact of religious motivation on rate of recidivism in rural areas of district Okara” sees the critical review of religious component of probation system in community correction and would provide an insight into the overall effectiveness of religious element in probation system as this is based on empirical and scientific research. In this research human universe is all the muslim offenders (residing in rural areas of district okara) referred to probation officer for resocialization and have completed their rehabilitation process. Sampling Frame was obtained from office of district probation officer Okara whereas a sample 308 was selected from district Okara by using simple random sampling. Data was collected by researcher himself by developing two interview schedules, named Religious Motivation Scale (RMS) and Rate of Recidivism Scale (RRS), and analyzed by using Statistical Package for Social Sciences (SPSS) Version 20 and Microsoft Excel 2010. All the respondents were male and belonged to rural areas of district Okara. Majority of participants (76.0%) were businessman whereas ratio of Unemployed respondents is 9.75%. Most of participants (92.0%) fall in the age group of 26 to 45 years while (72.9%) were married. The distribution of participants based on income depicts that majority of participants (57.3%) are having income between 6100- 10,000 whereas 32.6% respondents have income more than 10000 rupees. A large no. of participants (80.9%) have more than three children. There was a significant difference among participants’ rate of recidivism mean scores based on age group and income. Hence, it was found that mean difference of religious motivation was (.15972) between participants belonging to (26-45 years) and (46 & above) age groups was significant at $p < 0.05$. The mean difference of religious motivation was

(.38810 & 34314) between respondents belonging to (3100-6000) and (10000 & above) income group.

Investigating the Optoelectronic Properties and Third-Order Nonlinear Optical Susceptibility of Cross-Shaped Molecules: From Molecular Insights to Material Applications

Rao Aqil Shehzad¹, Shabbir Muhammad^{2,3}, Javed Iqbal¹

¹Department of Chemistry, University of Agriculture Faisalabad, 38000, Faisalabad Pakistan.

²Research Center for Advanced Material Science (RCAMS), King Khalid University, Abha 61413, P.O. Box 9004, Saudi Arabia

³Department of Physics, College of Science, King Khalid University, Abha 61413, P.O. Box 9004, Saudi Arabia

E-mail: raoaqil.shehzad@uaf.edu.pk

In the present investigation, we use a dual computational approach (at single molecular and solid-state levels) to explore the optoelectronic and nonlinear optical (NLO) properties of crossed shaped derivatives. The solid-state electronic band structures of the compounds 1-3 (the derivatives of tetracarboxylic acid in cross-shaped having the core of benzene (1), pyrazinoquinoxaline (2) and tetrathiafulvalene (3)) are calculated. The calculated band gaps for compounds 1-2 are found to be direct band gaps and compound 3 to be indirect band gap with energy gaps of 2.749, 1.765 and 0.875 eV, respectively. The important optical properties including refractive index, absorption coefficients, loss functions and extinction coefficient of these semiconductors are calculated at bulk-level to seek their potential applications as efficient optoelectronic materials. Additionally, we use the Lorentz approximation to calculate the third-order NLO susceptibilities of compounds 1-3 using the molecular hyperpolarizability and solid-state parameters. The calculated third-order NLO susceptibilities of compounds 1-3 are found to be 6.92×10^{-12} , 64.0×10^{-12} and 26.3×10^{-12} esu, respectively. Thus, the present study not only provides a way to connect the calculated third-order molecular NLO polarizability to NLO susceptibilities for compounds 1-3 through Lorentz approximation but also highlights the importance of central core modifications on their NLO susceptibilities.

Electro-Optical and Charge Transport Properties of Chalcone Derivatives: A Dual Approach from Molecular to Material-Level Simulations

Rao Aqil Shehzad¹, Shabbir Muhammad^{2,3}, Javed Iqbal¹

¹Department of Chemistry, University of Agriculture Faisalabad, 38000, Faisalabad Pakistan.

²Research Center for Advanced Material Science (RCAMS), King Khalid University, Abha 61413, P.O. Box 9004, Saudi Arabia

³Department of Physics, College of Science, King Khalid University, Abha 61413, P.O. Box 9004, Saudi Arabia

E-mail: raoaqil.shehzad@uaf.edu.pk

In this study, three chalcone derivatives with basic skeleton [1,100-biphenyl]-4-yl)-3-(3-nitrophenyl) prop-2-en-1-one are investigated. The basic skeleton was modified with the addition of three terminal groups including hydrogen (1), methyl (2) and methoxy group (3). Using CASTEP Module, the optoelectronic properties are evaluated. The solid-state geometries of these systems are explored within the periodic boundary conditions (PBC). Among these systems, only

system 3 is found much better in terms of optical properties such as dielectric function, absorption, conductivity, reflectivity, loss function and refractive index. Our system 3 showed a higher dielectric function value about 3.7 at 1.8 eV thereby absorption $6.9 \times 10^4 \text{ cm}^{-1}$ at 300 nm and conductivity 1.2 fs^{-1} at 3.5 eV in the (001) plane. Furthermore, system 3 exhibited a high reflectivity and loss function in the (010) plane. Furthermore, system 3 exhibited a high reflectivity and loss function in the (010) plane. Electronic band structure, the density of state and electronic coupling analysis also reveal that system 3 has a potential application in charge transport devices. This system can transport charge about ~ 25 times higher as compared to systems 1 and 2. The methoxy group in system 3 has two lone pairs on the oxygen atom, thereby more contribution for electron π -conjugation in the system through resonance. However, hydrogen and methyl moiety participate through hyper conjugation and their involvement in π -conjugation is negligible.

First-Principles Study of Structural, Electronic and Magnetic Properties of Fe-Doped MgS

Sanam Saleem¹, Sehrish Saleem¹, Muhammad Nouman¹, Hira Ashfaq², M Umair¹, Faiza Ishtiaq³, Raheela Hanif⁴, Alisha Gull⁴

¹Department of Physics, University of Agriculture, Faisalabad, Pakistan

²Department of Management Sciences, Constituent College Depalpur, Okara Pakistan

³Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

⁴Department of Physics, University of Agriculture, Faisalabad Constituent College, Depalpur, Okara, Pakistan

Email Corresponding author: sanam.saleem@uaf.edu.pk, umair.uaf@gmail.com

This study aims to predict the structural, electronic, and magnetic properties of the $\text{Mg}_{1-x}\text{Fe}_x\text{S}$ ($x = 0.25, 0.50, 0.75$, and 1) compound in cubic phase using a first-principles approach. The structural properties were evaluated with the Perdew–Burk–Ernzerhof generalized gradient approximation (PBE-GGA). The electronic and magnetic properties were calculated using the modified Becke–Johnson potential combined with LDA correlation (mBJ-LDA), which offers a better description of electronic behavior than PBE-GGA. The findings indicate that this compound shows half-metallic ferromagnetism with 100% spin polarization at the Fermi level. For all Fe concentrations ($0.25, 0.50, 0.75$, and 1), the total magnetic moment remains $4\mu_B$, with a small local magnetic contribution on the Mg and S atoms. In addition, the local magnetic moments of the Fe atom decrease compared to their free-atom values.

Stakeholder Influence under AKIS for Sustainable Agricultural Development in Pakistan

Muhammad Luqman, Muhammad Yaseen and Muhammad Usman

Department of Agricultural Extension & Rural Studies, University of Sargodha

Email: muhammad.luqman@uos.edu.pk

AKIS characterizes the linkage among institutions, farmers, and academia for the purpose of knowledge generation, dissemination and utilization for sustainable agricultural development. In the context of Pakistan, it is very much critical for bringing improvements in the livelihoods of rural people. Though the impact and functionality of AKIS is associated to strengths of institutional linkages and consequences of different stakeholders i.e. researcher, extension worker, farmer,

NGOs, private sector (input-suppliers) and policy makers. Considering this scenario, current study explores the dynamics of institutional linkages and stakeholders influences within AKIS framework in Pakistan. A mix-method research approach using cross-sectional survey design was adopted for the study. A total sample of 2250 was selected from 15 districts using semi-structured interview schedule as survey research instrument for quantitative data and interview guide was used for qualitative data collection. Results revealed that amongst the stakeholders; farmers, private sector/input supply agencies and research organizations are more prominent in AKIS with mean scores of $\bar{x}=3.81$, $\bar{x}=3.80$, & $\bar{x}=2.84$ respectively. Moreover, dealers of grain markets, agricultural marketing, and extension workers & progressive farmers are top three influencers respectively in AKIS framework for rural development in Pakistan. In the context of stakeholders' linkage analysis; farmers meeting ($\bar{x}=2.89$), trainings ($\bar{x}=2.77$), and on-farm visits ($\bar{x}=2.76$) are most important factors for developing strong linkages among stakeholders. Among the functional linkages of AKIS stakeholders; extension-farmer linkage ranked as highest ($\bar{x}=2.77$), extension-education linkage ranked 2nd ($\bar{x}=2.73$), whereas research-extension linkage and research-education linkage ranked 3rd ($\bar{x}=2.64$ for both). As the AKIS in Pakistan is farmer-oriented therefore, it is dire need to strengthen agriculture extension and advisory services by developing strong and resilient linkage among other stakeholders for effective knowledge management and delivery.

Emerging Technology and Sustainable Innovation's in Food and Allied Sciences for Ensuring Future Food Security

Amber Naeem¹, Syed Muhammad Ali Imran²

¹Department of CS & IT, University of Agriculture Faisalabad

²UAF Constituent College, Toba Tek Singh, University of Agriculture Faisalabad, Toba Tek Singh, 36050 Pakistan

E-mail: dr.ali.imran@uaf.edu.pk

Emerging technologies and sustainable innovations in Food and Allied Sciences are rapidly reshaping the global landscape of food production, processing, and distribution. As the world faces increasing pressures from population growth, environmental degradation, climate change, and resource scarcity, the need for resilient, efficient, and sustainable food systems has become a critical priority. This article represented how advanced scientific approaches and technological breakthroughs can collectively address these challenges and contribute to long-term food security. Recent developments such as precision agriculture, remote sensing, genetic improvement, controlled-environment farming, and smart irrigation systems are enabling farmers to optimize crop yields while minimizing environmental impact. In the food processing sector, modern technologies including automation, artificial intelligence, Internet of Things (IoT) devices, and advanced preservation techniques are enhancing product quality, reducing food losses, and improving nutritional value. Biotechnology, functional food development, and microbial innovations also offer promising solutions for creating nutrient-dense, affordable, and sustainable food products. Sustainable packaging materials, circular economy practices, and renewable resource utilization are further contributing to eco-friendly food value chains.

Additionally, climate-resilient agricultural strategies, post-harvest innovations, and digital monitoring tools are helping communities adapt to changing climatic conditions and maintain stable food supplies. By integrating technological innovation with responsible resource management, Food and Allied Sciences can play a transformative role in safeguarding future generations against food insecurity.

Deep-Feature X-SN: A Contrastive Learning Framework for Cross-Dataset Generalization in Deep-fake Detection

Aiman Atif, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: aimanatif107@gmail.com

The rapid evolution of Generative Adversarial Networks (GANs) and Diffusion Models (DMs) in the past years has led to the development of very realistic deep-fakes and synthetic content, causing serious risks to digital security and public trust. Current deep-fake detection models attain high performance on specific datasets but strive to generalize well on new datasets or manipulation methods. This drawback occurs due to dataset bias, insufficient feature discrimination, and the dependence on single-domain learning frameworks. Earlier studies on conventional CNN architectures and manual forensic indicators have strived to maintain robustness across emerging generative models. In order to address these issues, we propose to use Deep-Feature X-SN, an advanced deep learning framework that uses a tripartite structure of specialized feature extractors trained with Siamese networks and contrastive learning to detect discriminative features of real, GAN-generated, and diffusion-generated images. The extracted features are merged through a CNN-based classifier to improve classification. Experimental calculations across multiple datasets verify higher cross-dataset generalization, gaining 97.29% detection accuracy and exceeding prior approaches by over 10%. The proposed framework indicates improved flexibility and strength to unseen and new generative frameworks, which contributes in the development of a more robust and secure AI-driven cyber-security ecosystem.

An Interpretable, Multimodal Deep Learning Framework for Early Alzheimer Disease Detection: Synergizing MRI, Quantitative EEG, and Clinical Biomarkers

Hafiza Somia Tariq, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: somiabqjwa23@gmail.com

Early detection of Alzheimer disease (AD) is difficult due to its gradual and variable onset, along with the complex, nonlinear relationships between the loss of brain tissue and cognitive decline. Current diagnostic methods frequently struggle to efficiently integrate various data sources, such as brain imaging, electrical brain activity readings, and clinical evaluations. We created an innovative multimodal deep learning system to address this issue by integrating patient

demographics, quantitative electroencephalography (qEEG), and structural brain MRI scans into one clear diagnostic framework. Our design incorporates three concurrent processing streams: (1) a 3D Residual Network for extracting advanced spatial features from T1-weighted MRI; (2) a Temporal Convolutional Network to detect frequency and timing patterns in qEEG data; and (3) a Multi-Layer Perceptron for analyzing cognitive test scores and demographic details (MMSE, MoCA). These varied data representations are combined using a Context-Aware Gated Attention mechanism that strategically evaluates each data type impact to enhance overall learning. We confirmed our method utilizing data from 840 participants (220 cognitively healthy individuals, 380 exhibiting Mild Cognitive Impairment, and 240 with Alzheimer disease). Brain imaging and clinical information were sourced from the Alzheimer Disease Neuroimaging Initiative, whereas qEEG recordings were gathered from the Temple University Hospital EEG Corpus and Open Neuro databases. We integrated SHAP (Shapley Additive Explanations) to guarantee that our model choices could be linked to clinically pertinent factors. The system showed remarkable capability in identifying early-stage AD, attaining an AUC of 0.93 [95% CI: 0.91–0.95] in differentiating MCI from healthy subjects outperforming models based on single data types (MRI alone: 0.87 AUC; qEEG alone: 0.84 AUC). The model achieved an accuracy of 88.5% in predicting which MCI patients would advance to AD over a three-year period. Analysis indicated that hippocampal atrophy (from MRI), reduced alpha brain activity in posterior areas (from qEEG), and APOE ϵ 4 genetic status were the most significant predictive indicators consistent with recognized knowledge of AD pathology. This work delivers a reliable, interpretable, and validated multimodal system that successfully integrates structural and functional brain data. With its combination of explainable risk assessment and high predictive performance, this approach offers valuable potential for AI-supported clinical decision-making in early dementia detection.

Mitigating Unauthorized Access in Data Security Using IDs and IPs

Misal Noor, Haris Pervaiz

*Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara,
Pakistan*

Email Address: raoarifrnk@gmail.com

In modern highly connected era, digital devices are more closely linked together than ever. So, the demand for protecting these devices & data is also increasing rapidly. Neglecting this need can lead to the potential danger of accessing sensitive data without authorization. This unauthorized access is creating threats like financial loss, data breach & reputational damage. Traditional protective systems like firewalls, access controls & weak passwords are not enough to safeguard data from sophisticated intrusion techniques used by attackers today. Challenges like Brute-force attacks, Phishing, SQL injection Insider misuse require advanced protection strategies to ensure confidentiality, integrity & availability—three core principles of CIA triad. Addressing these challenges is a technical requirement but if left untreated, can lead to damaging customer's trust & credibility of organization. This study outlines the role of more efficient defense mechanisms like IDS & IPS to tackle unauthorized intrusions in digital

environments. These offer a better security tier to track & block malicious activities. IDS monitors access to data or files & identifies potential threats. It works by comparing monitored activities with known attack patterns. If there a match, it give alerts to administrators. It only detects attacks does not block them automatically. IPS not only detects but also blocks suspicious activities instantly. This can be seen when a financial institution is facing brute-force login attempts, IDS detected that there a great number of failed logins originating from a single IP address. But, IPS terminated the origin ensuring confidentiality & integrity of system. Both IDS & IPS function like signature & pattern based systems to secure sensitive data from unauthorized access at early stages. Their limitation lies in the fact that both systems cannot identify unknown (zero-day) attacks but this can be overcome by using Anomaly-Based methods.

Soliton Dynamics and Stability in a Higher-Order Dispersive Cubic–Quintic Nonlinear Schrödinger Equation

Muhammad Arshad

Department of Mathematics and Statistics, Constituent College Depalpur, University of Agriculture Faisalabad, Pakistan

Email: dr.marshad@uaf.edu.pk

This work focuses on the derivation of multi-peak solitons and a variety of other nonlinear wave structures for a higher-order nonlinear Schrödinger equation with cubic–quintic dispersion, employing the modified exponential rational function method (mERFM). The proposed model is significant in several scientific and engineering fields, such as quantum mechanics, electrical transmission lines, oceanography, and optical fiber communications. Incorporating higher-order dispersive and nonlinear effects particularly the cubic–quintic nonlinear terms allow the model to more accurately describe the evolution of ultra-short pulse propagation in optical fibers as well as nonlinear wave dynamics in oceanic media. A rich family of exact solutions is obtained, including bright and dark solitons, as well as trigonometric, hyperbolic, rational, exponential, and singular wave forms. These solutions enhance the understanding of complex nonlinear wave interactions and oceanic wave phenomena in both shallow- and deep water regimes. Moreover, graphical representations are presented to demonstrate the impact of key physical parameters on soliton behavior, providing clear physical interpretations. Overall, the results confirm the effectiveness of the mERFM and illustrate its potential for addressing a wide class of nonlinear problems arising in mathematical physics.

Fractal Geometry and Nonlinear Dynamics of Agricultural Models with Allee Effect

Muhammad Tanveer

UAF Constituent College, Depalpur Okara, University of Agriculture Faisalabad, Okara 56300 Pakistan

Email: m.tanveer@uaf.edu.pk

Agricultural and ecological systems often exhibit nonlinear behavior due to density dependence, environmental variability, and human interventions such as harvesting. One important nonlinear mechanism in population-based agricultural models is the Allee effect, which introduces threshold-dependent growth and can significantly alter system stability. In this talk, we

investigate discrete-time agricultural models incorporating the Allee effect using tools from fractal geometry and nonlinear dynamical systems. By applying fixed-point iterative schemes, we analyze equilibrium points, stability conditions, and bifurcation phenomena including period-doubling and Neimark–Sacker bifurcations. The emergence of fractal structures, such as Julia-type sets and complex basins of attraction, reveals strong sensitivity to system parameters representing growth rate, harvesting effort, and environmental stress. These fractal patterns provide valuable insight into multistability, sudden population collapse, and sustainable parameter regimes. The results demonstrate that fractal analysis is not only a powerful visualization tool but also a meaningful indicator of resilience and risk in agricultural systems. This interdisciplinary study bridges advanced mathematical theory with applied agricultural modeling and supports improved decision-making for sustainable crop and population management.

Computational insights into phthalimide-core non-fullerene acceptors for next-generation organic solar cells

Zunaira Khan, Syed Muhammad Kazim Abbas Naqvi, Haq Nawaz Bhatti, Rasheed Ahmad Khera
Department of Chemistry, University of Agriculture Faisalabad 38000 Pakistan
E-mail: rasheedahmadkhera@uaf.edu.pk

Traditional fullerene-based acceptors in organic solar cells (OSCs) suffer from limitations such as poor tunability, narrow absorption spectra, and limited morphological stability, restricting further improvements in device efficiency. To address these challenges, non-fullerene acceptors (NFAs) with tunable energy levels and broad optical absorption have gained increasing attention. In this study, seven novel phthalimide core-based donor–acceptor molecules (BPDM1–BPDM7) are computationally designed by modifying the terminal units of a reference molecule (BPDF). Using density functional theory (DFT) and time-dependent DFT (TD-DFT) calculations at the B3LYP/6-31G (d,p) level, photovoltaic parameters such as bandgap, frontier orbital energies, absorption maxima, light harvesting efficiency (LHE), reorganization energies (λ_e , λ_h), dipole moments, open-circuit voltages (V_{oc}), and fill factors (FF) are systematically evaluated. The designed derivatives exhibit narrow bandgap (1.84–2.18 eV) and red-shifted absorption (681–829 nm). BPDM3 shows the lowest bandgap (1.84 eV). BPDM7 achieves the highest dipole moment (3.88 D), V_{oc} (1.93 V), and FF (92.96%), while BPDM4 displays the lowest λ_e and λ_h values, indicating superior charge mobility. The reduced exciton binding energies across all derivatives suggest enhanced charge separation capabilities. These results not only provide a pathway for rational NFA design but also serve as a theoretical foundation for future experimental development of high-efficiency OSCs.

Identifying Pathways for Scaling Alternate Wetting and Drying (AWD) as a Climate-Smart Technology in Punjab

Masood Iqbal Awan, Abdul Jabbar, Wasi-ud-Din, Yawar Abbas, Moez Khalid
Department of Agronomy, UAF Constituent College Depalpur, Okara
E-mail: masood.awan@uaf.edu.pk

Alternate Wetting and Drying (AWD) has emerged as a climate-smart water management technique for rice cultivation, offering substantial potential to reduce irrigation water use, labor and energy costs, and greenhouse gas (GHG) emissions without compromising yield when properly implemented. Despite its proven benefits and recognition as an IPCC-accepted GHG mitigation practice, the adoption of AWD in Punjab, Pakistan remains limited. This study synthesizes a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to identify practical entry points for scaling AWD across diverse rice-growing domains of Punjab. Key strengths of AWD include water and energy savings, reduced lodging through improved root anchorage, broad adaptability across soil types and climates, and compatibility with sustainable rice production frameworks. However, adoption is constrained by limited farmer awareness, knowledge-intensive management requirements, drainage challenges in heavy soils, the warabandi irrigation system, tenant farming arrangements, and prevailing perceptions that higher water inputs guarantee higher yields. Significant opportunities exist to enhance water productivity, earn carbon credits, improve fertilizer use efficiency, reduce salinity under brackish water irrigation, and integrate AWD with resource-conserving technologies such as laser land leveling, zero tillage for wheat, and hybrid rice cultivation. Entry points for AWD promotion include targeting water-scarce tail-end farmers, establishing demonstration plots and farmer field schools, deploying smart water tubes, incentivizing rational water use, and strengthening institutional support for GHG quantification and carbon financing. Addressing threats related to subsidized solar pumping, weak extension services, and institutional gaps will be critical for sustainable scaling. Overall, strategically leveraging AWD's strengths and opportunities while addressing systemic constraints can enable its effective mainstreaming as a cornerstone of climate-smart rice systems in Punjab.

Automated Detection of Cyberbullying-Driven Hate Speech on Social Networks Using a Stacked Ensemble Learning Approach

Tahrim Asif, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email: heyitstem01@gmail.com

As a result of the increasing use of online networks platforms such as Twitter, YouTube, and Facebook, the hate speech has grown. Nevertheless, implementing automated detection methods has been difficult because distinguishing hate speech from general offensive language requires analyzing user-generated posts, which are often short, informal, and constantly evolving. It is particularly difficult to recognize hate speech in text since it requires accurate context detection to distinguish between offensive language and neutral statements. As web-based meetings can have negative results for both minority and majority teams, escalating disputes between them. This study introduces a classification framework that categorizes tweets into three distinct groups: hateful content, abusive expressions, and neutral statements. The

current system applies TF–IDF features derived from the tweet text and employs SVM, Random Forest, XGBoost, and Logistic Regression as its primary classification models. The final model performs exceptionally well when combined with the main training model in an ensemble configuration. The model was trained using Kaggle & Hate Speech dataset, which contained 24,784 tweets with eight attributes. By excluding manually derived features, the accuracy of the model was significantly improved. The proposed ensemble model achieved a high degree of accuracy of 96 %, exceeding the accuracy rates of the individual classifiers, SVM achieved 93%, Random Forest reached 94%, and XGBoost recorded 88%. The findings indicate that the stacking approach significantly strengthens hate-speech detection systems used on social networking platforms.

Resistance Potential of Different Potato Cultivars Against Early Blight Caused By *Alternaria Solani* And Its Management

Muhammad Bilal¹, Nasir Ahmed Rajput², Khalid Naveed¹

¹*Department of Plant Pathology, University of Agriculture Faisalabad, Constituent College Depalpur, Okara.*

²*Department of Plant Pathology, University of Agriculture, Faisalabad.*

Email Address: khalid.naveed@uf.edu.pk

Early blight caused by fungal pathogen *Alternaria solani* is an important disease of potato that results in 20-30% yield losses in potato crop worldwide. Symptoms of disease on infected potato plants include brown to black colored spots on leaves. In this study, six potato cultivars were grown under field conditions to assess their resistance potential to early blight disease. Randomized complete block design (RCBD) with three replications was used to carry out the experiment. Different potato cultivars responded differently to early blight. Data of disease incidence and severity was recorded starting from the onset of disease till harvest. The influence of environmental parameters including maximum and minimum temperature, relative humidity, rainfall and wind speed on disease development was investigated. A correlation analysis was conducted to check the interaction of environment and early blight disease development. Management of disease was conducted by using extracts of *Azadirachta indica* and *Allium sativum*. The extracts were applied at 10 days interval and their efficacy in combating the disease severity was checked. It was found that three cultivars Musica, Kuroda and Sante showed moderately susceptible response whereas Florous, Roccoo and Esmee were moderately resistant. Early blight incidence was influenced by temperature and relative humidity. Maximum disease incidence was recorded at 30°C while least was observed at 20°C. The results showed that 20 to 30°C is optimal temperature for early blight. There was negative correlation found between relative humidity and disease incidence. Results showed that increasing humidity increased the percentage of disease incidence. Results showed that application of 5% neem extract proved useful for the control of early blight of potato.

Biology and Management of Blackleg Of Potato In Punjab And Its Management

Mubashra Fatima, Saqlain Mushtaq, Khalid Naveed

Department of Plant Pathology, University of Agriculture Faisalabad, Constituent College Depalpur, Okara

Potato (*Solanum tuberosum* L.) is a worldwide cultivated crop that is used as a staple food in many countries. However, a number of diseases harm potatoes, lowering their yield and market value. Blackleg of potato is one of the most devastating diseases, reducing potato yield by 30–40%. In this study, sampling of potato blackleg disease specimens was performed in four districts of Punjab: Kasur, Okara, Sahiwal, and Pakpattan to study the incidence of blackleg disease. *In-vitro* evaluation of biocontrol agents *Pseudomonas* spp. and *Trichoderma hamatum* against blackleg of potato performed. A field trial was established in research area of UAF sub-campus Depalpur, Okara to study disease epidemiology. The research revealed that Potato blackleg disease causes 30-40% damage to crop. Moreover *in-vitro* analyses showed that biocontrol agents play positive role against disease. *Trichoderma hamatum* not only control the disease but also provides nutrients to plant and helps in increase in yield. Moreover, meteorological agents also play important role in disease occurrence. Disease occurs between 18°C -28°C, high humidity 82-89%. Disease favored by high temperature and increase at low temperature. Data of blackleg disease incidence was recorded at weekly intervals. Through correlation analysis, the effects of environmental parameters such as wind speed, relative humidity, rainfall, and maximum and minimum temperatures on the development of disease was examined. Biocontrol agents i.e., *Pseudomonas* spp. And *Trichoderma hamatum* evaluated for their antagonistic potential against blackleg bacterium under *in vitro* conditions. Efficacy of biocontrol agent's shows antagonistic effect against blackleg pathogen was measured. The data was analyzed statistically by using standard protocols.

Training Needs Assessment for Strengthening Women-oriented Rural Entrepreneurships in District Sargodha

Muhammad Yaseen¹, Gomathy Palaniappan², Tim Sun², Muhammad Luqman¹, Muhammad Irfan Ullah³,
Muhammad Ahsan Qureshi⁴, Saima Sadaf¹, Humera Amin¹, Ayesha Arshad¹

¹Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha, Sargodha, Pakistan

²School of Agriculture and Food Sustainability, the University of Queensland, Australia

³Department of Entomology, College of Agriculture, University of Sargodha, Sargodha, Pakistan

⁴Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan

Corresponding E-Mail: yaseen.baksh@uos.edu.pk

Current study was conducted to assess the Training Needs Assessment (TNA) of rural women for participation in Women Business Groups (WBGs) in District Sargodha under the Australian Centre for International Agricultural Research (ACIAR) funded project HORT/2020/129, which supports livelihood improvement through the establishment of women-led business groups (WBGs). Two FGDs were conducted in Village 118-NB (Sillanwali) and Village 10-NB with participants from 9-NB (Bhalwal), involving 20 rural women in total (10 per group). The results showed that most participants were young (21–30 years), had 5–16 years of education, and were directly or indirectly involved in agriculture. About 70% of their households depend on agriculture for livelihoods. Although the women expressed strong motivation to engage in entrepreneurship,

they faced significant barriers, including limited involvement in household decision-making, cultural constraints, poor access to financial services, and lack of transport facilities. All participants expressed interest in capacity-building programs for WBGs. They preferred training in kitchen gardening, value addition and food processing, stitching and embroidery, and arts and crafts. They favored short, village-based programs with support for transport, mentoring, business start-up kits, and assistance with business registration, branding, and marketing. Women's preferences for practical, village-based training and start-up support highlight the need for market-oriented, accessible programs that build skills, expand opportunities, and strengthen their participation in WBGs.

Harmful Effects of Pesticides on Human Health and Environment: Case Study of Punjab, Pakistan

Liaqat Ali, Muhammad Luqman, Muhammad Yaseen

Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha

Email address: liaqat.ali786786@gmail.com

Pesticides are chemical compounds that are used to kill pests. Since many decades there is a debate regarding beneficial and harmful use of pesticides in Agriculture and its impact on human health and environment. The study was conducted in randomly selected three districts of Punjab province. For the purpose, the questionnaire was used as a research instrument containing various study related factors. Total sample consisted of 384 respondents from three selected districts. Total sample size was equally distributed among three districts resulting in 128 respondents per district. Findings of the study revealed that majority (108) of the respondents was in age group of 26-40 years (28.1%) and 89 were in the age group of 41-45 years (23.2%). Out of 384 people 17.2% were illiterate with no formal education. Matriculation was the most common educational level among the respondents as majority (43.0%) of respondents belongs to this group. The largest percentage, 63% depend solely on farming as their principal source of income supporting the fact that the community is mostly engaged in farming activities. However, 37% combine farming with other off-farm income sources, though the level of diversification is low. All the respondents (100.0%) used to apply pesticides in order to increase their farm production and to control pests. It was found that decision of the farmers generally in the Punjab province and particularly in the targeted research areas is mainly influenced by socio-economic, agronomic and institutional factors. There exists a complex interaction of these factors particularly for the farmers of targeted research area. In the research area pesticides' application was most common on wheat and cotton as reported by 94.01% and 92.19% of respondents, respectively. A wide variety of insects, weeds and diseases widely present in the research area that damage the crops. This is fact that farmers in the Punjab (Pakistan) mostly rely on pesticides for gaining maximum production and this is due to the availability of insufficient knowledge and expertise regarding safe use of pesticides. Other than the synthetic pesticides, some farmers were also using plant-based pesticides, but the ratio of these farmers is very few mainly due to the non-availability of these pesticides at market competitive rate. Awareness about advantages of naturally occurring and plant-based pesticides over synthetic pesticides among farming

community was also identified as the major reason. Pesticide application disturbs the pH of soil. High effect of pesticides on bio-diversity and environment is through contamination of soil and water. Use of oil and sun glasses by the farmers were very common precautionary measure adopted. The ill-Health Symptoms after Pesticide Application table classify the minor health complaints made by farmers. The studies presented here show health effects from pesticide exposure, both current and future, should pesticide use persist. Safe application training for farmers should also be provided and adequate medical treatment for farmers exposed to these threats should also be made available. The results of correlation analysis showed a significant association between adoption levels of protected measures and occurrence of different ill-health symptoms reported by the respondents. A negative correlation was found between the use of mask/respirator and the incidence of cough ($p=0.42 < 0.01$). Before buying a pesticide, identify the pest correctly was the best tip for minimizing pesticide risk for environment and health.

Modeling of surface plasmon polaritons in indium antimonide embedded between plasma layers

Sanam Saleem¹, Muhammad Nouman¹, Sehrish Saleem¹, Hira Ashfaq², M Umair¹, Faiza Ishtiaq³, Areeba Fatima⁴, Areeba Usman⁴, Hamza Ali⁴, Kainat Sattar⁴, Ali Ahmad⁴

¹Department of Physics, University of Agriculture, Faisalabad, Pakistan

²Department of Management Sciences, Constituent College Depalpur, Okara Pakistan

³Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

⁴Department of Physics, University of Agriculture, Faisalabad Constituent College, Depalpur, Okara, Pakistan

Email Corresponding author: sehrishsaleem456@gmail.com, rumair.uaf@gmail.com

Numerical and analytical investigations will be carried out in indium antimonide (InSb) embedded between plasma layers. Maxwell's equations in differential form will be used to solve the numerical problem. Impedance boundary conditions will be employed to obtain the characteristics equation. Influence of tensorial permittivity parameters i.e., plasma frequency and cyclotron of different characteristics of surface plasmon polaritons will be analyzed. Furthermore, influence of InSb temperature and plasma features on effective mode index, propagation length, phase velocity, group velocity, and figure of merit and propagation loss versus THz plasmonic frequency will be analyzed. Normalized field distribution will also be analyzed to verify the conditions of surface plasmon polaritons. These results will contribute in nanoplasmonic devices, thermo optic applications and near field communication in THz frequency spectrum.

Transverse magnetic mode in black phosphorus sandwiched between uniaxial chiral layers

Sanam Saleem¹, Muhammad Nouman¹, Sehrish Saleem¹, Muhammad Umair¹, Hira Ashfaq², Faiza Ishtiaq³, Areeba Fatima⁴, Areeba Usman⁴, Hamza Ali⁴, Kainat Sattar⁴, Ali Ahmad⁴

¹Department of Physics, University of Agriculture, Faisalabad, Pakistan

²Department of Management Sciences, Constituent College Depalpur, Okara, Pakistan

³Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

⁴Department of Physics, University of Agriculture, Faisalabad Constituent College, Depalpur, Okara, Pakistan

Email Corresponding author: sehrishsaleem456@gmail.com, rumair.uaf@gmail.com

Numerical analysis of transverse magnetic mode in black phosphorus sandwiched between uniaxial chiral layers will be carried out THz frequency region. Different cases of uniaxial chiral medium will be studied to tune the EM waves. Impedance boundary conditions and transfer matrix technique will be used to obtain the dispersion relation. Influence of chirality, black phosphorus thickness, carrier concentration and number of black phosphorus layers with respect to operating frequency on effective mode index, propagation length, phase velocity, group velocity, and figure of merit and propagation loss will be analyzed along armchair and zigzag conductivity of black phosphorus layers. Power flux distribution will also be analyzed to explore the behavior of EM wave. These results will provide an additional degree of freedom due anisotropy of black phosphorus which control the EM wave for modulators, sensing, communications and waveguides.

Dyakonov surface wave supported at plasma dielectric interface

Sanam Saleem¹, Muhammad Nouman¹, Sehrish Saleem¹, Muhammad Umair¹, Hira Ashfaq², Maryam Amin³, Raheela Hanif³, Alisha Gull³

¹Department of Physics, University of Agriculture, Faisalabad, Pakistan

²Department of Management Sciences, Constituent College Depalpur, Okara Pakistan

³Department of Physics, University of Agriculture, Faisalabad Constituent College, Depalpur, Okara, Pakistan

Email Corresponding author: rumair.uaf@gmail.com, noumanmuhammad062@gmail.com

Theoretical analysis will be performed in plasma dielectric interfaces in THz frequency regime. The extended electromagnetic wave theory will be used to solve numerical problem. Transfer matrix technique will be used to obtain the characteristics equation. Influence of isotropic plasma parameters and anisotropic plasma parameters of the different characteristics of electromagnetic surface waves i.e., real part of propagation constant, imaginary part of propagation constant, normalized propagation length, normalized phase velocity and group velocity as the function of THz wave frequency will be analyzed. Wolfram Mathematica Software will be used for numerical modeling of proposed structure. Field profile for plasma medium will also be analyzed to verify the electromagnetic surface wave condition. These results will provide an additional degree of freedom due anisotropy of plasma medium which control the EM wave for advanced THz devices.

Light plasmon coupling at anisotropic chiral-graphene interface

Sanam Saleem, Muhammad Nouman, Sehrish Saleem, Muhammad Umair

Department of Physics, University of Agriculture, Faisalabad, Pakistan

Email: rumair.uaf@gmail.com, sanam.saleem22@gmail.com

Light plasmon coupling at anisotropic chiral graphene will be analyzed at THz frequency regime. For the physical modeling of graphene conductivity Kubo formulism will be used. Advanced electromagnetic wave theory will be used to solve the numerical problem. Anisotropic chiral provides additional degree of freedom to control the chirality. Due to anisotropy of chiral medium two types of modes appeared namely as: lower plasmonic frequency mode and higher plasmonic frequency mode. Impact of physical parameters of anisotropic chiral i.e., chirality and

gyrotropy will be studied to tune the characteristics curves. Furthermore, effect of graphene conductivity parameters i.e., chemical potential, scattering rate, number of graphene layers and temperature on effective mode index, normalized propagation constant, normalized propagation length, normalized phase velocity, figure of merit, cut-off frequency will also play a crucial role to modulate plasmon mode. This research will open a new avenue in chiral sensing, microwave devices, antennas, and magnetic resonance imaging (MRI) applications operating in the terahertz (THz) frequency range.

Aqualitative study of the issues in adopting entrepreneurial skills in the livestock business among women farmers in the central punjab, pakistan

Hira Ashfaq¹, Asif Ali², Ashfaq Maan³, Sanam Saleem⁴, Fiaza Ishtiaq⁵

¹UAF Constituent College, Depalpur Okara, University of Agriculture Faisalabad, Okara 56300 Pakistan

²University of Okara.

³Department of Social Sciences, University of Agriculture Faisalabad

⁴Department of Chemistry, University of Agriculture Faisalabad.

⁵Department Physics, University of Agriculture Faisalabad.

Email: hira.ashfaq@uaf.edu.pk

Entrepreneurship has emerged as an upcoming field in attracting and making men and women to have their own start-ups in different field of business. The rural women are contributing a lot in the field of livestock management. However, they have been lacking in having their own independent initiatives to come forward with new ideas & start-ups in the livestock business. This can play a great role in making women farmers empowered and enhancing their status and roles in the society by empowering them. Therefore, this study was designed to know the factors influencing the adoption of entrepreneurial skills among women farmers involved in the livestock business in the Central Punjab, Pakistan. A multistage sampling technique was used for data collection from the women farmers in the Jhang district. At the first stage a rural tehsil was selected and a union council was selected, at the second stage. At the third stage, a village was selected. Two groups of women farmers were selected for conducting focus group discussions (FGDs). An Interviewing-Guide was developed and used for discussing different issues in the adoption of entrepreneurial skills in the livestock business. The discussion participants were asked to sit in a semi-circle. A moderator was trained to conduct the discussion and a note-taker was arranged to take the notes. The recording was made and checked twice in between the discussion for its proper working. The qualitative information was analyzed by using the "Analysis-Continuum" and "Content-Analysis" techniques. The results show that illiteracy, lack of participation in the decision-making process, both at the farm & household levels and lack of awareness, knowledge & training opportunities were the three most important factors hindering the adoption of the entrepreneurial skills among women livestock farmers. Furthermore, improper knowledge of the animal diseases and their treatment, poor knowledge and practices about balance-feed and bi-products value-addition also had negative implications for quantity & quality of milk-production, selling-price of the animals and bi-products. It is suggested to arrange training sessions at village/farm level to learn entrepreneurship skills in

livestock business. The attitudinal and behavioral change sessions should also be conducted by the experts with husband and elders of the household to make them convinced for women's participation in the decision-making process and entrepreneurship-training sessions.

A Kap Survey of The Wheat-Losses During And After Harvesting Process In Southern Punjab, Pakistan

Hira Ashfaq¹, Asif Ali², Ashfaq Maan³, Faiza Ishtiaq⁴, Sanam Saleem⁵

¹UAF Constituent College, Depalpur Okara, University of Agriculture Faisalabad, Okara 56300 Pakistan

²University of Okara.

³Department of Social Sciences, University of Agriculture Faisalabad

⁴Department of Chemistry, University of Agriculture Faisalabad.

⁵Department Physics, University of Agriculture Faisalabad

Email: hira.ashfaq@uaf.edu.pk

The wheat-harvesting mechanism in the Punjabi society, including the Southern Punjab, has been, mainly, shifted from manual harvesting to mechanical harvesting. Again, small farmers who are still practicing manual harvesting are used to hire thresher for threshing their wheat. Modern thresher harvests and threshes wheat, simultaneously. A very considerable amount of wheat losses occurs during the wheat-harvesting & wheat-threshing process. Similarly, a reasonable amount of grain-loss happens while shifting wheat from farm to household or market and in the storage. In all these processes, this is knowledge, attitude and practices (KAP) of the farmers that make their mindset to follow various ways & means for the purpose. However, farmers have been facing low to medium losses of wheat-grains which can be a good source of ensuring food-security at household and national level, if controlled by having proper knowledge, attitude and practices. The study was carried out both at the farm and household levels in Tehsil Chowk Sarwar Shaheed of district Muzaffargarh. A combined methodology was used for data collection, both, at the farm and household levels. A participatory observation, a checklist and in-depth interviews were used as methods of data-collection. The checklist was used to record the approved or non-approved practices of saving wheat-losses both at the farms and households and also while shifting wheat grains to market or selling to the middle-man/dealer. The results show that although the wheat-grains dropped at the farm were collected by the poor servant or small farmer's family members, yet that was not weighted/counted towards the total production per acre. The wheat-grains loss on the way during shifting from farm to house/ market were also causing economic loss to the farmers. The small farmers were particularly suffering economically as well as socially. Similarly, the traditional methods of wheat-storage and carelessness during storing-process caused losses in the shape of different diseases or leakage of grains. This was also causing, both, food security and food safety at the household level. This leads to food shortage in the shape of wheat shortage towards the end of the year. The Agriculture Department, Govt. of the Punjab, has been running wheat campaign, every year, in collaboration with the staff & students of the Agricultural Universities in the province, during the wheat-sowing season. It is suggested that these teams should also visit farms and households or gather men & women of the farming household at a common place, during the wheat-harvesting season, to make their

knowledge, attitude and practices favorable towards saving wheat losses during and after its harvesting.

Electrochemical corrosion behavior of chitosan-hydroxyapatite coated dental implant

Areeba Usman¹, Sana Shahzadi², Saleem Abbas¹

¹*Department of Physics, University of Agriculture Faisalabad, Depalpur campus 03802, Pakistan*

²*Lahore College for Women University*

Email: saleem.abbas@uaf.edu.pk

The article investigates the electrochemical corrosion behavior of chitosan-hydroxyapatite (CS-HA) encapsulated rust resistant steel (SS) substrate which are commonly used in dental plant. Chitosan a naturally derived polymer from chitin, exhibit biodegradable and biocompatible properties whereas hydroxyapatite (HA) is a synthetic calcium phosphate-based ceramics, replicates the mineral composition of bone, making it an ideal material for bone tissue engineering. Utilizing a sol gel dip encapsulating technique, a thin layer of (CS-HA) composite was assembled onto the (SS) substrate. The result show that (CS-HA) encapsulating improves the corrosion resistance on the substrate in oral environment. The study also evaluates the tensile power of the CS-HA encapsulating on the SS substrate which is critical for ensuring the long-term durability of the implant. The finding of this research has important suggestion for the development of more reliable and the long-lasting dental implant.

Effect of temperature on mechanical and bioactive properties of glass ceramic

Areeba Fatima¹, Sana Shahzadi², Saleem Abbas¹

¹*Department of physics University of Agriculture Faisalabad, Depalpur campus 03802, Pakistan*

²*Lahore College for Women University*

Email: saleem.abbas@uaf.edu.pk

The research shows that antibacterial properties of metal-ceramic composites, consisting of titanium (Ti) or stainless steel (SS) and hydroxyapatite (HA) or alumina (Al₂O₃), were investigated. The composites were fabricated using a powder metallurgy technique and their purifying activity was performed averse to (E. coli) and (S. aureus) using the disk diffusion process. The results showed that the metal-ceramic composites shows significant antibacterial activity, with the Ti-HA composite showing the highest activity. The antibacterial activity was assigned to the release of metal Ions, which disrupted the bacterial cell membrane. The study proves the potential of metal-ceramic composites as antimicrobial materials for biomedical applications.

Review of Effects of Ag, Cu, or Fe Addition on Microstructure and Properties of Biodegradable Zn–Mg Alloy

Hamza Ali¹, Sana Shahzadi²

¹*Department of Physics, University of Agriculture Faisalabad, Depalpur campus 03802, Pakistan* ²*Lahore College for Women University*

Email: hamzachaudhary355@gmail.com

Zn–Mg alloys are promising candidates for biodegradable implants due to their superior corrosion resistance compared to Fe- and Mg-based alloys. This review investigates the influence of Ag, Cu, and Fe additions on the microstructure, morphology, and electrochemical behavior of Zn–0.5 wt% Mg alloys. Results indicate that Zn–0.5 wt% Mg–0.2 wt% Cu exhibits the highest corrosion resistance (0.0120 mm/year), strong optical absorbance at 230 nm, and improved conductivity with low resistivity ($1.335 \times 10^{11} \Omega \cdot \text{m}$). The alloy also forms stable MgZn and Mg₂Zn₁₁ phases, enhancing both mechanical and biomedical performance. Overall, Zn–0.5 wt% Mg–0.2 wt% Cu is identified as a promising material for cardiovascular and orthopedic implant applications.

Biological investigation of metal (Ag, Cu, Fe) and Ceramic Composites

Kainat Sattar¹, Sana Shahzadi², Saleem Abbas¹

¹Department of Physics, University of Agriculture Faisalabad, Depalpur campus 03802, Pakistan

²Lahore College for Women University

Email: saleem.abbas@uaf.edu.pk

The antibacterial activity of the composites can be attributed to the release of metal ions (Ag⁺, Cu²⁺, and Fe³⁺) from the composite surface, which disrupt the bacterial cell membrane and inhibit bacterial growth. The Ag-containing composites showed the highest antibacterial efficacy due to the strong antimicrobial properties of silver ions. The Cu-containing composites also exhibited significant antibacterial activity, which can be attributed to the antimicrobial properties of copper ions. The Activity was evaluated against Staphylococcus aureus (S. aureus) and E. coli using disk diffusion. The result showed that Fe doesn't show the antibacterial Activity as it is highly toxic to microorganisms whereas the Ag-containing composites showed the highest antibacterial efficacy followed by the Cu-containing Composites.

Machine learning assisted prediction of the mechanical properties of Graphene/Aluminum nanocomposite based on molecular dynamics simulation

Warda Saheer, Ali Raza, Saleem Abbas

Department of Physics, University of Agriculture Faisalabad, Depalpur campus 03802, Pakistan

Email: seharwarda28@gmail.com

Predicting the mechanical properties of graphene-reinforced metal matrix nanocomposites typically involves atomistic simulations, which are computationally intensive and difficult to scale, or micromechanics models like the Halpin-Tsai model, which can often produce significant errors. In this research, we integrate molecular dynamics (MD) simulations with machine learning (ML) techniques to forecast the mechanical behavior of graphene-reinforced aluminum (Gr/Al) nanocomposites and to improve the Halpin-Tsai model accordingly. We generate extensive MD data for Young's modulus and ultimate tensile strength, varying parameters such as graphene volume fraction, alignment angle, chirality, and temperature. This data is used to train and enhance ML models capable of predicting Young's modulus and tensile strength. Finally, we adjust the classical Halpin-Tsai model by incorporating the modulus values predicted through MD

and ML, resulting in a straightforward explicit formula with markedly better accuracy. This combined approach allows for quick and reliable estimation of the composite's mechanical properties, supporting the design and analysis of Gr/Al nanocomposite structures.

Genetic Investigation Of Potential Intraspecific Hybrids Of Canola For Seed Yield Using Diallel Analysis

Uzair Ahmed¹, Shama Ali¹, Muhammad Qasim¹, Zulqar Nain¹, Ahmed Raza², Sidra Iqbal¹

¹Department of Plant Breeding & Genetics, University of Agriculture Faisalabad Constituent College Depalpur, Okara.

²Punjab Agriculture Food and Drug authority (PAFDA), Punjab, Pakistan.

Email: dr.sidraiqbal@uaf.edu.pk

Canola (*Brassica napus* L.) is considered as one of the most significant oilseed crops globally that is appreciated due to the presence of healthy edible oil and meal, which is rich in protein. To examine the genetic determination of seed yield and other related characteristics, a full 6x6 diallel (including reciprocals) was carried out with *B. napus* L. genotype. Hybridization among these cultivars was done during the crop season of 2024-25, the resultant F₁ seeds, and their parents, are going to be assessed under a randomized complete block design with two repeats in the 2025-26 growing season. Some of the important morphological and physiological characteristics including Plant height, siliquae per main raceme, days to 50 percent flowering, days to flowering, days to physiological maturity etc. will be recorded. The combination of ability effects (GCA and SCA), gene action (additive and non-additive), and heritability estimates will be assessed. As presented in earlier research, these methods allow considerable insights into the pattern of inheriting traits of yield and are helpful to determine the best hybrid combinations. The results of this study are expected to build breeding plans to develop high yielding canola cultivars with high oil content and incorporating the available information on the recently achieved innovations of canola genetic enhancement.

Exploring Genetic Diversity and Key Yield Traits in Soybean (*Glycine Max* L.) Genotypes through Principal Component Analysis for Breeding Strategies

Tayyaba Sajid¹, Ramin Munir¹, Javeria Ramzan, Zaheer Ahmed², Rizwan Shafiq¹, Muhammad Qasim¹, Sidra Iqbal^{1*}

¹Department of Plant Breeding and Genetics, UAF Constituent College, Depalpur Okara.

²Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan

Email: dr.sidraiqbal@uaf.edu.pk

A diverse gene pool enables breeder to select and combine desirable traits and make significant gain in genetic makeup of existing germplasm. An experiment was conducted using seventy exotic and local soybean accessions along with two local check varieties at the University of Agriculture Faisalabad Constituent College Depalpur, Okara to assess genetic diversity and key yield traits in Soybean (*Glycine max* L.) accessions through Principal Component Analysis (PCA). Data were recorded for major morphological yield related traits and analyzed using R software. The GCV values were inferior to the PCV values among all traits signifying that the traits were more influenced by their surrounding environment. Higher PCV, GCV, heritability and genetic

advance as a percentage of the mean (GAM) for traits including pods of plant, primary branches of plant, interval to maturity, 100 grain mass and flowering interval indicated that traits were effective for use as selection criteria in breeding projects. In PCA, out of eleven principal components (pcs), only five revealed an Eigen value more than 1.00, accounting for approximately 75.29% of the variability between the studied traits. The first principal component (PC1) displayed the highest variation at 29.54%, followed by the second PC with 13.72%, the third PC with 12.45%, the fourth PC with 10.11%, and the fifth PC with 9.47%. PCA displayed that the traits including pod width, days to maturity, number of pods of plant, primary branches of plant, seeds of pod, leaf area, Interval to flowering and plant height were essential yield contributing traits, and putative accessions identified as COKER 237, Coker Hampton266A and AGRIPRO 25. These results can be a valuable addition for breeders to develop high yielding soybean varieties and to set new breeding protocols for crop improvement.

Genetic Variability and Character Association Studies For Grain Yield And Its Related Parameters In Maize (*Zea Mays* L.)

*Muhammad Saddam Mustafa, Uswa Nazir, Ali Husnain Chishti, Ali Haider Abbas, Rizwan Shafiq
Department of Plant Breeding and Genetics, University of Agriculture Faisalabad.
Email: rizwan.shafiq@uaf.edu.pk*

Maize (*Zea mays* L.) ranks third in global cereal production after wheat and rice. It serves not only as a staple food for human consumption but also as a vital source of livestock feed and silage. Beyond its dietary role, maize is rich in essential nutrients, providing significant quantities of vitamins, minerals, and high-quality proteins that contribute to both human and animal nutrition. Due to its high yield potential and economic importance, maize holds a key position in agricultural systems. The present research was conducted to investigate the genotypic variation among different maize accessions and to determine the association between various agronomic traits and grain yield. The experiment was carried out at the research farm of the University of Agriculture Faisalabad, Constituent College Depalpur, Okara, using a Randomized Complete Block Design (RCBD) with three replications to ensure accuracy and reliability of results. A total of 13 plant traits were recorded, including days to germination, plant height, days to 50% tasseling, days to 50% silking, tassel length, ear length, ear diameter, ear height, rows per ear, kernels per row, 100-grain weight, and grain yield. Analysis of variance (ANOVA) revealed highly significant differences among the genotypes for most of the traits studied, indicating substantial genetic diversity within the evaluated germplasm. The Tukey's HSD test confirmed the presence of significant mean differences among genotypes. Furthermore, R software was employed to compute both phenotypic and genotypic correlations. Most traits, except days to germination and days to 50% silking, showed a positive association with grain yield, suggesting their potential role in yield improvement. Principal Component Analysis (PCA) was conducted on two sets of variables, identifying two major components that explained 37.5% and 18.5% of the total variance, respectively. Strong and positive genotypic as well as phenotypic correlations were observed among ear length, ear diameter, and rows per cob, signifying that these parameters

are vital contributors to grain yield. The study concludes that these traits can be effectively exploited by maize breeders in future breeding programs aimed at enhancing grain yield and overall crop performance.

Estimation of Genetic Variability, Combining Ability and Heterosis in Bitter Gourd (*MomordicaCharantia*L.) For Yield and Yield Contributing Traits.

Ghulam Murtaza, Ali Husnain Chishti, Ali Haider Abbas, Uswa Nazir, Sidra Iqbal , Rizwan Shafiq Department of Plant Breeding and Genetics, University of Agriculture Faisalabad.
Email: rizwan.shafiq@uaf.edu.pk

Bitter gourd (*Momordicacharantia* L.), a member of the Cucurbitaceae family, is an economically important horticultural crop in Pakistan. However, its productivity is adversely affected by several edaphic constraints, including temperature fluctuations and unfavorable soil conditions, which reduce growth and yield due to the limited adaptability of existing cultivars. Major yield-reducing factors include biotic and abiotic stresses as well as poor seed quality. Hybrid seed development is a promising strategy to enhance yield performance. The success of hybrid breeding largely depends on the appropriate selection of parents and the identification of superior heterotic combinations. In the present study, four female lines were crossed with four testers following a Line $\times$ Tester mating design to develop sixteen F₁ hybrids. Data were recorded at maturity for various yield and yield-related traits including days to male and female flowering, days to maturity, node-to-node distance, number of primary branches, fruit length and width, number of seeds per fruit, hundred-seed weight, number of fruits per plant, leaf area, and per plant yield. Analysis of variance revealed significant genetic variability among the genotypes for most traits. Genotypes CKD-4574, CKD-4572, and CKD-4771 exhibited superior performance for the number of primary branches, while CKD-4471, CKD-4572, and CKD-4574 matured earlier. High-yielding genotypes included CKD-4474, CKD-4573, CKD-4671, and CKD-4774. Sixteen hybrids, along with their parents and two commercial checks, were evaluated for genetic variability, combining ability, and heterosis estimation under a randomized complete block design (RCBD) with three replications. Data analysis was performed using TNAUSTAT and R software.

Assessment of Genetic Variability In Tomato (*SolanumLycopersicum* L.) For Yield And Its Associated Attributes.

Muhammad Saad Tahir, Ali Haider Abbas, Ali Husnain Chishti, Uswa Nazir, Sidra Iqbal, Rizwan Shafiq Department of Plant Breeding and Genetic, University of Agriculture Faisalabad.
Email: rizwan.shafiq@uaf.edu.pk

Tomato (*Solanumlycopersicum*L.), a member of the Solanaceae family and genus *Solanum*, possesses a diploid chromosome number of $2n=24$. Globally, tomato is one of the most important vegetable crops, ranking second after potato in production and consumption. Owing to its economic and nutritional significance, the assessment of yield components and morphological traits is vital for tomato crop improvement. In the present study, twelve tomato genotypes were evaluated to identify those with superior breeding potential. Analysis of variance revealed highly

significant differences among genotypes for traits such as single fruit weight, branches per plant, plant height, and number of locules. However, traits including days to germination, flowers per cluster, clusters per plant, leaf area, fruit width, fruit length, fruits per cluster, fruit setting percentage, and yield per plant exhibited non-significant variations. Correlation analysis indicated that the number of flowers per cluster, clusters per plant, leaf area, fruits per cluster, fruit width, fruit length, number of locules, and branches per plant had a positive and highly significant genotypic correlation with yield per plant. Path coefficient analysis further showed that days to germination, clusters per plant, leaf area, fruits per cluster, fruit width, fruit length, plant height, and branches per plant had positive and direct effects on yield, while flowers per cluster, single fruit weight, number of locules, and fruit setting percentage exhibited negative direct effects. Among the genotypes, Advataand Kiban Red showed the best performance for FYPP, Roma and Moon Star for BPP, UAF-3, TM-2301, Hybrid Bilal, and Moon Star for FS%, while UAF-3, TM-2301, and Moon Star performed best for LA. TM-2301 and Hybrid Bilal excelled in FL, UAF-3, TM-2301, Moon Star, UAF-5, and Hybrid Bilal in FW, and Dona-55, UAF-2, and UAF-4 in FPC. Roma, Advanta, Kiban Red, and UAF-4 showed better performance for CPP, while Dona-55 and Moon Star were best for FPC. Dona-55 also performed well for DG. These results suggest that the evaluated genotypes can be effectively utilized in breeding programs aimed at improving fruit quality traits and developing high-yielding tomato varieties.

Integrative Ai Approaches for Genomic Prediction Of Abiotic Stress Tolerance In Soybean.

Ali Haider Abbas, Zulqar Nain, Uzair Ahmad, Ali Hasnain Chishti, Rizwan Shafiq
Department of Plant Breeding and Genetics, UAF Constituent College, Depalpur Okara
Email: rizwan.shafiq@uaf.edu.pk

Soybean (*Glycine max* L.) is an important crop for maintaining food security worldwide. Its productivity is threatened by environmental stresses such as drought, heat and salt stress because it is highly sensitive to abiotic stresses. These stresses often lead to reduced crop growth, poor seed quality and ultimately reduced grain yields. All problems that together pose a serious challenge to meet the growing global demand for soy based food, feed and industrial products. Traditional breeding methods are very time consuming and may not be easy to overcome with the rapid beginning of these abiotic stresses. While developing new varieties using traditional methods may take much longer than the pace of climate change. This article aims to focus on the use of artificial intelligence (AI) in genomic prediction to accelerate the development of soybean varieties. By combining genomic and high throughput phenotyping data to train machine learning models, one can predict the performance of soybean lines under different stress conditions. This approach can also reveal complex genetic interactions that are difficult to capture with normal breeding methods. By focusing on designing AI based genetic markers that can help emphasize stress resilience. It will enable breeders to select superior genotypes in less time. The AI based model will greatly help in reducing breeding cycles, increasing genetic gain and developing soybean varieties that can withstand the risks of climate change and ensure food security for future generations.

Global Frontiers in Plant Phenomics: Emerging Trends, Innovations, And Collaborations

Taiba Tehseen, Sajida, Zulqarnain, Uzair, Ahmed, Muhammad Ahmad, Muhammad Qasim,

Sidra Iqbal

Department of Plant Breeding and Genetics, University of Agriculture Faisalabad.

Email: dr.sidraiqbal@uaf.edu.pk

Phenomics has rapidly become a transformative field in modern agriculture, connecting the gap between genomics and environmental responses to better understand how plants grow, adapt, and perform under varying conditions. By combining advanced imaging systems, automation, and powerful data analytics, high-throughput phenotyping has completely changed the way complex plant traits are measured, from the microscopic to the field scale. Modern phenomics platforms whether microscopic, ground-based, or aerial allow scientists to capture detailed information on plant morphology, physiology, and stress responses with remarkable speed and accuracy. These innovations are essential for assessing key agricultural traits such as yield potential, disease resistance, biomass production, and resource-use efficiency across diverse environments. The rapid expansion of phenomics research worldwide can be attributed to cheaper imaging tools, improved data accessibility, and the growing collaboration between disciplines. Recent trends in patents and publications show China's impressive rise as the global leader in patent filings since 2011, while the United States continues to dominate in scientific influence, accumulating 81,023 citations between 2011 and 2021. China follows with 30,863 citations, indicating its growing impact in this area. Patent data were mainly sourced from Espacenet, while publication records came from Web of Science (WOS) and Scopus. Private industries also play key role by developing artificial-intelligence-based high-throughput phenotyping platforms that make data processing faster and more efficient. Overall, phenomics is driving innovation in precision breeding, enhancing crop resilience, and promoting sustainable agriculture for future global food security.

Unraveling The Molecular Genetics And Functional Genomics Of Abiotic Stress Tolerance In Brassica Napus L.: Current Discoveries And Future Outlook

Zuha Binte Suhail¹, Ramin Munir¹, Shama Ali¹, Muhammad Athar Tahir¹, Hassan Atiq¹, Ahmed Raza², Sidra Iqbal¹

¹Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Constituent College Depalpur, Okara, Pakistan

²Punjab Agriculture Food and Drug authority (PAFDA), Punjab, Pakistan.

Email: dr.sidraiqbal@uaf.edu.pk

In an era dominated by climate instability, abiotic stresses such as drought, salinity, cold, and heavy metal toxicity severely reduce Brassica napus (oilseed rape) yields, often by more than 50% posing a major threat to global food and biofuel security. As the world's third most important oilseed crop, B. napus urgently requires genetic upgrades driven by molecular genetics and functional genomics, leveraging insights from model species like Arabidopsis and rice. Advanced technologies, including next-generation sequencing (NGS), SNP and ISBP mapping, CRISPR/Cas9-based multiplex gene editing, and quantitative trait loci (QTL) analysis, are revolutionizing trait

improvement, while proteomics and metabolomics uncover critical stress responses through altered dehydrins (e.g., COR25, Bn115) and metabolites like proline. Transgenic interventions such as *codA* for salinity tolerance and *DWF4* for yield enhancement highlight biotechnological success, complemented by emerging evidence from epigenetic studies revealing latent stress resilience. Key regulatory genes *BnNAC485* (drought and ABA signaling), *BnNCED3* (hormone biosynthesis), and *BnSIP1-1* (osmotic signaling) serve as central stress “compass” genes guiding adaptive pathways. Despite notable progress, breeding remains slow; thus, integrating multi-omics strategies with CRISPR-based pyramiding offers the potential to accelerate development of multi-stress-tolerant super-varieties. As global temperatures rise and soils degrade, this integrative blueprint marks the dawn of a biotechnology-driven revolution, transforming *B. napus* from a vulnerable crop into a climate-resilient cornerstone of sustainable agriculture.

Quantum Chemical Analysis of Z-Shaped Heptazethrene Derivatives: Structural Parameters, Singlet Fission, and Photovoltaic Potential

Rao Aqil Shehzad¹, Javed Iqbal^{1,2}

¹Department of Chemistry, University of Agriculture, Faisalabad-38000, Pakistan.

²Punjab Bio-energy Institute, University of Agriculture, Faisalabad-38040, Pakistan

E-mail: raoaqil.shehzad@uaf.edu.pk

A variety of organic solar cells has been discovered, but there is a need for efficient optoelectronic material to obtain high power conversion efficiency. In this study, we derived new molecules from Z-shaped heptazethrene. We measured its photovoltaic parameters, including frontier molecular orbitals (where the energy gap decreases to 16% as compared to the reference), molecular electrostatic potential maps (more nucleophilic core), the density of states (partial and total), absorbance in Vis-IR region (in the range of 650-1000 nm), transition density matrix, and hole-electron mobility in terms of reorganization energy that showed 11% higher electron mobility (λ_e) and 52% higher hole mobility (λ_h) as compared to the reference. A comparable power conversion efficiency (~9%) is obtained from a single photon. Using the concept of singlet fission, we can increase the efficiency twice using a single photon (based on the diradical character of the molecule). The diradical character of the entitled molecules was also calculated. The designed molecules fulfil the criteria of singlet fission that generate two excited triplets from a single photon (E S1 & 2E T1). The designed molecules are more stable than the reference indicated by the singlet-triplet energy gap, which is 37% higher. Hence this work assists the researcher in enhancing the efficiency of the solar cell.

Quantum Chemical Study of TIPSTAP Derivatives with Minimized Crystal Roughness: Enhancing Photovoltaic Performance with Over 20% PCE

Rao Aqil Shehzad¹, Javed Iqbal^{1,2}, Khurshid Ayub³

¹Department of Chemistry, University of Agriculture, Faisalabad-38000, Pakistan.

²Department of Chemistry, COMSAT University, Abbottabad Campus, KPK-22060, Pakistan

³Punjab Bio-energy Institute, University of Agriculture, Faisalabad-38040, Pakistan

E-mail of the Corresponding Author: raoaqil.shehzad@uaf.edu.pk

In this study, we probed the TIPSTAP molecule, which is highly appropriate for developing organic photovoltaic cells, but its use was hampered due to crystal brittleness and limpidity. As an alternate to TIPSTAP, we disclosed four molecules derived from the TIPSTAP thanks to the alteration with the acceptor groups at the hub and ter. butyl group to substitute phenylic hydrogen atoms. All the molecular structures have been analyzed with a DFT approach, and obtained results are compared with TIPSTAP. The bandgap curtails up to 24% in engineered molecules, enhancing the charge transfer properties. These molecules showed improved photophysical properties at the longer wavelength relevant for photovoltaic cells. To enhance the open-circuit voltage, designed acceptors molecules are aligned with the P3HT donor, improving photovoltaic performance. The power conversion efficiency of TIPSTAP, TAPTA1, TAPTA2, TAPTA3, and TAPTA4 with short circuit current density of 9, 12, and 15 mAcm⁻² ranges from 20-35% at a constant molecular open-circuit voltage that is better than pristine TIPSTAP or P3HT.

Design of Benzothiazole-Based Non-Fullerene Acceptor Molecules for High-Efficiency Organic Solar Cells

RaoAqil Shehzad¹, Javed Iqbal^{1,2}

¹Department of Chemistry, University of Agriculture, Faisalabad-38000, Pakistan.

²Punjab Bio-energy Institute, University of Agriculture, Faisalabad-38040, Pakistan

E-mail: raoaqil.shehzad@uaf.edu.pk

To enhance the efficiency of organic solar cells (OSCs), five non-fullerene π -conjugated acceptor molecules namely BTM1, BTM2, BTM3, BTM4 and BTM5 are designed from recently reported 16.5% efficient acceptor molecule BTP-Cl. The molecules in the present quantum chemical investigation consist of benzothiazole (BT) core with different chemical species on the terminal side. The optoelectronic study of BTM1-BTM5 reveals that BTM3 and BTM4 molecules are superior with respect to absorption range found at the wavelengths of 780 and 791 nm as compared to 746 nm of reference molecule BTP-Cl. Frontier molecular orbital (FMO) and transition density matrix (TDM) analysis are performed that give basic information about the distribution of charges among investigated molecules. All investigated molecules exhibit charge density spread over the entire molecules. The BTM4 and BTM5 molecules efficiently transfer their electron densities from highest occupied molecular orbital (HOMO) to lowest unoccupied molecular orbital (LUMO) with narrow bandgaps of 1.86 eV and 2.14 eV respectively. The electron mobility for BTM3 (0.00527), BTM4 (0.005820) and BTM5 (0.00539) are found less than BTP-Cl (0.00643). Similarly, BTM5 gives the least value of whole mobility (0.00558) as compared to BTP-Cl (0.00803). The binding energies of these molecules are also observed less (0.28 eV, 0.29 eV and 0.33 eV for BTM3, BTM4 and BTM5) in gas phase than BTP-Cl (0.35 eV). Also, BTM5 is tested with donor polymer PTB7-Th that provides further evidence for their interactions. It turned out that the structural tailoring at terminals can tune effectively the frontier molecular orbital energy levels, band gap, absorption spectra, open-circuit voltage, reorganization energy and binding energy value in investigated molecules. Our results suggest that the investigated

molecules can serve as fine acceptor materials. Additionally, some investigated molecules can also be used as a hole and/or electron transport materials for OSCs.

Quantum Chemical Study of Structural and Optical Properties of Pure Silver Clusters (Ag_n, n = 2-10): Linear and Nonlinear Optical Response

Rao Aqil Shehzad¹, Riaz Hussain², Javed Iqbal^{1,3}, Khurshid Ayub⁴

¹Department of Chemistry, University of Agriculture, Faisalabad-38000, Pakistan.

²Department of Chemistry, University of Okara, Okara-56300, Pakistan.

³Punjab Bio-energy Institute, University of Agriculture, Faisalabad-38040, Pakistan.

⁴Department of chemistry, COMSAT University, Abbottabad Campus, KPK-22060, Pakistan.

E-mail: raoaqil.shehzad@uaf.edu.pk

In this study, pure silver clusters Ag_n (n= 2-10) through a density functional method is explored to analyze the structure-property relationship with the linear and nonlinear optical response. The total density of state (TDOS), photoelectron spectra (PES) and non-covalent interaction (NCI) analyses are also performed to get structural information regarding the bonding environment. New energy levels developed as the silver atoms in higher clusters which are indicated by lowering the HOMO energy level. Among these clusters, Ag₅ and Ag₉ showed unusual behaviour with higher first hyperpolarizability values (1076 and 2223 au, respectively). The results of hyperpolarizability are compared with the external reference molecule para-nitroaniline (p-NA). Additionally, a two-level model has been applied to rationalize the first hyperpolarizability. The primary outcomes of this study enable the scientist to use silver clusters for photovoltaic applications or as a dopant to enhance the nonlinear optical response.

Synthesis, Crystal Growth, Structural Characterization, and Theoretical Calculations of Methylenium Salts of Benzenesulfonates: Insights into Supramolecular Chemistry

Ijaz Ullah¹, Rao Aqil Shehzad², Javed Iqbal³

¹Fujian Provincial Key Laboratory of Polymer Materials, College of Chemistry and Materials Science, Fujian Normal University, Fuzhou 350007, China

²Department of Chemistry, University of Agriculture, Faisalabad, 38000, Pakistan

³Department of Chemistry, College of Science, University of Bahrain, Main campus Sakhir, 32038, Manama Kingdom of Bahrain

E-mail: raoaqil.shehzad@uaf.edu.pk

The current investigation describes the synthesis of four novel methylene blue (MB) salts of benzene sulfonate derivatives, featuring bulky anionic groups. The process involves treating chloride salt of MB with sodium salts of 4-aminobenzene sulfonate, 4-styrenebenzene sulfonate, 3,7-naphthalene disulfonate, and anthraquinone-1,5-naphthalene disulfonate to substitute the chloride ion with benzoate sulfonate anion in MB-chloride. The synthesis includes quaternizing MB-chloride with the corresponding benzene sulfonate in minimal aqueous solvent to promote precipitation. The resultant precipitates were subsequently dissolved in an appropriate solvent to enable the crystallization of the ultimate product. The dissolution occurs either at ambient temperature or with heat. The crystals of the resultant salts were characterized using various analytical techniques like UV-visible, and FT-IR spectroscopy, TGA, single crystal X-ray diffraction

and powder X-ray diffraction analysis. The UV-visible spectroscopic results, frontier molecular orbital, density of states, molecular electrostatic potentials, and HOMO-LUMO energy gaps were estimated by DFT. Structural analysis revealed that supramolecular structure of compounds achieved stabilization through electrostatic interactions, a diverse range of both conventional and non-conventional hydrogen bonds, π - π stacking interactions, and other short-range interactions. The investigation delves into intricate details and offers a thorough discussion of the fundamental principles that contribute to the formation and stabilization of supramolecular structures.

Evaluating feasibility, limitations and methods of sprinkler irrigation

Husnain Ghaffoor, Muhammad Nouman Arshad

Department of Agronomy, University of Agriculture Faisalabad Constituent College Depalpure Okara

E-mail: husnainghafoor00@gmail.com

Global agricultural water security is critically threatened by the convergence of rising food demand, population growth and climate change. Addressing this challenge necessitates the adoption of efficient irrigation techniques. One such technique is sprinkler irrigation, a high efficiency method that can improve water productivity (WP) by 20-50%. This study aimed to evaluate the feasibility of different sprinkler irrigation systems, with a specific focus on their limitations and field applicability. A review of literature indicates that sprinkle system, when appropriately designed and managed, can enhance water use efficiency, minimize deep percolation losses, and improve uniformity of water distribution compared to conventional flood irrigation. Conventional flooding uses 30-50% and furrow irrigation uses 10 to 25% more water than sprinkle irrigation. Switching from flood irrigation to a center pivot for wheat can lead to water savings of 20-30% for the same yield. Adopting sprinkler irrigation for potatoes can result in water savings of 25-35% compared to furrow irrigation. In some cases, yields can even increase at critical growth stages due to more precise water application, further improving water productivity. Despite its potential to enhance water productivity by 20-50%, the adoption of sprinkler irrigation in developing regions is constrained by significant technical, economic, and agronomic limitations. Key constraints include high initial investment, operational energy costs, and water losses from wind drift and evaporation. Irrigation system selection is dictated by agronomic and infrastructural parameters to maximize water productivity. Portable systems $WP \approx (0.8-1.2 \text{ kg/m}^3)$ suit small-scale field crops, while solid set configurations $WP \approx (1.3-1.7 \text{ kg/m}^3)$ benefit high-value horticulture and turf. For broad-acre agriculture, mechanized systems (center pivot, linear move) achieve peak water productivity $WP \approx (1.5-1.9 \text{ kg/m}^3)$. Optimal water resource allocation therefore requires matching system hydraulic efficiency with crop requirements and field geometry. The literature concludes that while precision methodologies like Variable Rate Irrigation (VRI) can mitigate these inefficiencies, overall feasibility heavily depends on the actual field condition. It mainly relies on whether the system is affordable, if farmers have the technical skills to use it, and if regular maintenance can be done for long-term use.

AWD-A SWOT analysis as a Resource Conservation Technology

Muhammad Nouman Arshad, Husnain Ghafoor*

Department of Agronomy, University of Agriculture Faisalabad, Constituent College Depalpur, Okara

Email: mnoumanarshad312@gmail.com

The traditional flooded rice production is proving to be less sustainable because there is devastating shortage of water, excessive levels of greenhouse gas emissions, and accumulation of toxic heavy metal such as arsenic in the grains. Alternate Wetting and Drying (AWD) is an irrigation technique of saving water designed to control this dual crisis in order to sustain production using less water and less damage on the environment. In different studies, AWD was evaluated against conventional flooding in replicated field plots. The methodology was monitoring of the irrigation quantities, measurement of the quantity of grain at the time of maturity, and then calculation of the productivity of water. The recommended AWD installation depth is usually 15 cm but in Punjab regions like Okara, Sahiwal, and Pakpattan, AWD depth below 15 cm is being studied as deeper levels cause soil cracking. Moreover, the greenhouse gas fluxes were measured, to determine the level of environmental impact. Studies demonstrated that AWD could save 27-70% of irrigation water, reduce CH₄ emissions (11-95%), grain arsenic (13-90%) and mercury (5-90%) without yield loss and prevent from logging. The technique improved grain quality by lowering chalkiness (40%) and increasing head rice recovery (6%), though it increased weed infestation and associated weeding costs. Although having economic and environmental advantages, socioeconomic restrictions and the absence of institutional support limit the widespread usage of AWD. To have successful implementation, farmers should be assured of time when to plant, and issues on how to control weeds. Thus, extensive distribution requires institutional support, in terms of farmer training and confidence-building programs.

Evaluating feasibility and limitation of solar-powered drip irrigation for improved water and nutrient use efficiency

Ghulam Muhayudin, Huzaifa Nadeem

Department of Agronomy, University of Agriculture Faisalabad Constituent College Depalpure, Okara

Email: ghulammuhayudin019@gmail.com

Water scarcity and nutrient and energy inefficiency are critical challenges in agriculture, practically in arid and semi-arid regions. Conventional irrigation methods are inefficient because they waste both water and fertilizers along with electricity provided by expensive and unreliable sources. For water conservation, better water and nutrient use efficiency solar-powered drip irrigation systems play one of the important roles, coupled with better renewable electricity sources than conventional irrigation systems and non-renewable, unreliable electricity sources. After reviewing some of the studies, including both the field trials and the system evaluation of solar-powered drip irrigation and fertigation systems, we found that it saves water up to 30-50% while applying deficit irrigation, i.e., supplying 70-90% of the full crop water requirement. It also improves yield up to 10-25% under stress conditions. It also improves nutrient uptake to 20-35% more than conventional surface irrigation. The evaluation highlights its reliability along with low

operating cost and adaptation to off-grid rural environments. The socioeconomic assessments of recent studies show that it improves the farms' profitability, saves labor, and reduces dependence on conventional energy resources. However, adoption of this system remains limited due to high initial investment, lack of knowledge, and expertise. Still, with the adoption of solar-powered drip irrigation systems, farmers are tempted to over exploit groundwater, which lowers water productivity. This review shows that this type of irrigation combined with fertigation and better water management techniques than normal conventional techniques opens a better pathway to climate-smart agriculture, which also includes efficient use of resources in regions with low water and energy. Future work should focus on localized field trials to quantify long-term effects on soil fertility, energy economics, and system scalability in South Asian cropping systems.

Conservation tillage for combating climate change under resource constraints

Huzaifa Nadeem, Ghulam Muhayudin

Department of Agronomy, University of Agriculture, Faisalabad Constituent College Depalpur, Okara

Email: huzaifanadeem582@gmail.com

Climate change in combination with the deteriorating resources and expanding human population presents a formidable food security challenge: How will we feed a world population that is expected to grow by an additional 2.4 Billion people by 2050? According to World Bank, climate change may cut Pakistan's GDP by 18 to 20% by 2050. This will also exacerbate other issues such as desertification, deforestation, erosion, degradation of water quality and depleting water resources, further complicating the challenge of food security. The aim of this study is to show how conservation tillage can help in combating climate change. By desktop study, I found that conventional tillage have 1.3 to 2.1 t CO₂-eq/hectare/year while conservation tillage farming have 0.8 to 1.3 t CO₂-eq/hectare/year greenhouse gas emission. Conservation tillage also reduces CO₂ emission from soils by up to 47% compared to conventional tillage. Conservation tillage fields can store 14 to 30 % more carbon in soil. The average net reduction in carbon sequestration rate is 0.85 mg CO₂-eq/hectare/year from reduced tillage. So we can resist climate change by conservational tillage techniques because it can cause carbon sequestration in soil, reduce fossil fuel consumption, lower nitrous oxide emission, enhance water infiltration and retention, improve soil health and structure and can also buffer temperature. The critical challenge includes financial constraints, knowledge and labor constraints, technological and mechanical constraints, biophysical constraints, environmental constraints, and socio-economic constraints. There are certain ways to overcome these constraints. Hence, conservation tillage can prove to be an excellent technique for combating climate change after addressing the constraints.

Farm level composting for improving soil health and crop productivity

M.Talha Zubair, Ahmad Raza

Department of Agronomy, University Of Agriculture Faisalabad Constituent College Depalpur, Okara

Email: talhazubair78690@gmail.com

Agriculture is the economic backbone of Pakistan, as it contributes 23% to 24% of Pakistan GDP. Pakistani soils are poor in organic matter (often below 1%) and the fertility level is not sufficient to support increased crop yield. The objective of this study was to recognize composting as an alternate solution to this problem, which serves as a sustainable agriculture practice that improves soil fertility and reduces reliance on synthetic fertilizers. Several composting methods can be implemented, such as windrow, aerated static piles, in-vessel, and vermi-composting. Selection of method depends on many factors, like farm scale and available resources. A recent study testing different compost mixes confirmed the effectiveness of this approach and showed that a layered stack of equal parts of rice/wheat straw and animal waste delivers a good outcome. This recipe kept an ideal processing temperature (42%-45%) and a stable pH (6.1-8.3), resulting in high-quality compost rich in nitrogen (up to 2175 ppm), phosphorus (up to 13.98 ppm), and potassium (up to 640 ppm). The key benefits of composting include enhanced soil structure and nutrient cycling. However, its success depends on maintaining critical parameters like the C: N ratio (25:1-30:1), moisture (40%-60%), temperature (for the mesophilic state = 40-45°C; for the thermophilic state = 45-71°C), and aeration. Development of low cost and real time sensors represent a promising future direction for precision management in order to overcome the practical challenges of monitoring above parameters

Exploring option of drainage system for flood affected areas

M.Ahmad Mia, Ahmad Raza, M.Talha Zubair

Department of Soil Science, University Of Agriculture Faisalabad Constituent College Depalpur, Okara

E-mail: ar091459@gmail.com

Areas affected by flooding have particular challenges that seriously harm homes and landscapes. Construction problems, soil erosion, and the loss of important plants and trees can all result from severe flooding. This study goal are to reduce the danger of flooding, protect people, property, climate-resilient infrastructure, and sustainable resource management. Common methods include land drainage for surface runoff, pipelines to drain excess water, gutter, detection ponds, permeable pavement, and afforestation. In Sindh and southern Punjab projects like the Left Bank Outfall Drain (LBOD) and Right Bank Outfall Drain (RBOD) have been created to control waste irrigation water and saline water. Recent study in China focus on improving urban drainage systems through integrated & sponge city & initiatives and advanced techniques to reduce increasing flood risk by climate change and urbanization. Improved drainage systems are expected to yield significant agricultural, economic, social, environmental benefits, reduced water logging, salinity, mitigating urban and rural flooding, mitigate the infrastructural damage. Limitations are outdated infrastructure, inadequate Capacity, poor management, unplanned urban growth, and environmental challenges like climate change. We concluded that we also use different drainage methods, like permeable pavements, green roofs, and gutter systems, to control runoff water, stored surface water, and ground water.

Use of artificial intelligence in terrace farming

Ismail Khan, Abdul Rehman
UAF Constituent college Depalpur okara
E-mail: Ayankhan3023333@gmail.com

Terrace farming in mountainous regions faces challenges such as soil erosion, unstable slopes, and uneven water distribution. Traditional terrace design often struggles to maintain uniform platform width, optimal slope angles, and efficient water flow, affecting soil and water conservation. This study explores how Artificial Intelligence (AI) can optimize terrace structures by determining ideal platform height, width, length, and step-like slopes, enhancing stability and water retention. The methodology integrates AI algorithms with terrain mapping, soil and rainfall data, and slope-gradient modeling to generate optimal terrace layouts. AI predicts terrace dimensions and simulates runoff and water retention patterns. Results indicate that AI-assisted designs significantly reduce soil loss and improve water conservation compared to conventional layouts (Debnath et al., 2024; Tubog et al., 2025). Advantages include precise terrace planning, sustainable soil and water management, and faster implementation in difficult terrains. Limitations involve the need for high-quality data, access to AI tools, trained personnel, and initial costs. In conclusion, integrating AI into terrace farming offers a practical and sustainable solution for mountainous agriculture, provided adequate data, training, and infrastructure are available.

Exploring option of drainage system for flood affected areas

Ahmad Raza, M.Ahmad Mian, M.Talha Zubair
Department of Agronomy, University Of Agriculture Faisalabad Constituent College Depalpur, Okara
E-mail: ar091459@gmail.com

Flood-prone areas face substantial challenges that severely damage human settlements, agricultural lands, and natural landscapes. Recurrent flooding leads to construction failures, accelerated soil erosion, and the loss of valuable vegetation, including trees and native plant species. The primary objective of this study is to reduce flood risk and enhance the protection of human life and property through climate-resilient infrastructure and sustainable resource management. Common flood-mitigation and drainage strategies include surface runoff management, subsurface drainage pipelines, gutter systems, detention ponds, permeable pavements, and afforestation. In Sindh and southern Punjab, large-scale projects such as the Left Bank Outfall Drain (LBOD) and Right Bank Outfall Drain (RBOD) have been implemented to manage excess irrigation and saline drainage water. Recent studies from China highlight integrated “sponge city” approaches and advanced urban drainage technologies aimed at reducing flood risks exacerbated by climate change and rapid urbanization. Improved drainage systems offer significant agricultural, economic, social, and environmental benefits, including reduced waterlogging and salinity, mitigation of urban and rural flooding, and minimized damage to infrastructure. However, major limitations persist, such as outdated infrastructure, inadequate system capacity, poor management, unplanned urban expansion, and increasing climate-related pressures. This study concludes that a combination of conventional and nature-based drainage

solutions such as permeable pavements, green roofs, gutter networks, and managed surface and groundwater storage is essential for effective flood control and long-term resilience.

Phosphorus Source Management for Enhanced Productivity of Spring-Planted Maize

Saifullah, Wasi-ud-Din, Abdul Jabbar, Masood I Awan
Department of Agronomy, UAF Constituent College Depalpur, Okara
E-mail: saifullah96102@gmail.com

Phosphorus (P) is an essential macronutrient for maize production; however, its availability in calcareous soils is severely constrained by fixation and low solubility. This study was conducted during the spring 2025 season at the University of Agriculture Faisalabad, Constituent College Depalpur (Okara), to evaluate the effects of different phosphorus sources and their combinations—diammonium phosphate (DAP) and liquid phosphorus—on the growth, yield, and phosphorus use efficiency of spring-planted maize (*Zea mays* L., hybrid Pioneer 1429). The experiment was arranged in a randomized complete block design (RCBD) with seven treatments and three replications, including sole applications of DAP and liquid phosphorus, split DAP application, and integrated DAP–liquid phosphorus combinations at varying ratios. Growth attributes (germination percentage, plant height, and leaf area index), yield components (cobs per plant, cob length, grains per cob, and 1000-grain weight), and final outputs (biological yield, grain yield, harvest index, phosphorus uptake, and phosphorus use efficiency) were recorded. Phosphorus treatments exerted a highly significant effect ($P < 0.01$) on all measured parameters. The integrated application of 50% DAP + 50% liquid phosphorus (T_4) consistently outperformed all other treatments, producing the highest grain yield, phosphorus uptake, and phosphorus use efficiency. This treatment also resulted in superior growth performance, including greater plant height, cob length, and leaf area index. In contrast, the lowest values were observed under 50% DAP (T_2), reflecting the inefficiency of reduced and poorly managed phosphorus application commonly practiced by farmers. It is concluded that a balanced and integrated phosphorus fertilization strategy, particularly combining liquid and granular P sources, can substantially enhance maize productivity, nutrient uptake, and phosphorus use efficiency in calcareous soils of Pakistan. Adoption of such practices may support sustainable phosphorus management and contribute to improved food security.

Evaluating the Performance of a Novel Maize–Cover Crop System under Varying Planting Geometry

Mirza Muhammad Ahmad Saleem, Abdul Jabbar, Wasi-ud-Din and Masood Iqbal Awan*
Department of Agronomy, UAF Constituent College Depalpur, Okara
E-mail: realmirza.9i@gmail.com

Maize (*Zea mays* L.) is a major cereal crop worldwide, serving as a key source of food, feed, and raw material for agro-based industries. In Pakistan, maize plays a critical role in food security and livestock production; however, its productivity is constrained by declining soil fertility, intense weed pressure, and competition for essential resources. The integration of cover crops,

particularly leguminous species, is increasingly recognized as a sustainable strategy to enhance resource-use efficiency, improve soil health, and suppress weeds. This study evaluated the effects of different maize–cover crop intercropping arrangements on growth, yield, and related agronomic parameters during the spring 2025 season at the research farm of the UAF Constituent College, Depalpur, Okara. The experiment was laid out in a randomized complete block design (RCBD) with four treatments and three replications: T₁ (one row maize + one row cover crop), T₂ (two rows maize + two rows cover crop), T₃ (four rows maize + four rows cover crop), and T₄ (maize planted on one side of the ridge with cover crops on the opposite side). Red kidney bean (*Phaseolus vulgaris* L.) was used as the leguminous cover crop. Data were recorded on germination percentage, plant height, leaf area index, cover crop density, fresh and dry biomass, weed biomass, yield components, grain yield, biological yield, and harvest index. Results showed that germination percentage, plant height, cob length, and harvest index were not significantly affected by intercropping treatments, indicating stability of these traits under comparable management conditions. In contrast, intercropping arrangements significantly influenced leaf area index, cover crop biomass, weed biomass, number of grains per cob, and 1000-grain weight. Treatment T₄ produced the highest maize grain yield (5,400 kg ha⁻¹) and superior yield components, whereas T₃ resulted in the maximum cover crop biomass (8,736 kg ha⁻¹ fresh and 2,621 kg ha⁻¹ dry). Weed biomass was markedly reduced in T₃ and T₄, reflecting the suppressive effect of dense cover crop canopies. Overall, maize–cover crop intercropping enhanced crop productivity and ecological sustainability under semi-arid conditions. Ridge-based spatial separation (T₄) is recommended for maximizing maize yield, while wider intercropping arrangements (T₃) are more suitable for increasing cover crop biomass and improving soil fertility. Such diversified intercropping systems offer a viable pathway for sustainably intensifying maize-based production systems in Pakistan.

Modifying Boll–Leaf Balance through Early Square Removal: Yield Responses of Contrasting Cotton Genotypes

Yawar Abbas, Masood Iqbal Awan, Moez Khalid, Abdul Jabbar, Wasi-ud-Din
Department of Agronomy, UAF Constituent College Depalpur, Okara
E-mail: yarikhani@gmail.com

A field experiment was conducted in 2024 at the research farm of the UAF Constituent College, Depalpur, RenalaKhurd (30.85° N, 73.53° E), Okara, located in a semi-arid, subtropical region with silt loam soil, to evaluate the effects of modifying the boll-to-leaf ratio on cotton performance. Two cotton cultivars—UAF-1, a single-gene line (G1), and PB-131, a triple-gene line (G3)—were subjected to three square removal (SR) intensities: no removal (control), 10% removal (SR₁), and 20% removal (SR₂). In SR₁, 10% of squares were removed from the first and second fruiting nodes, whereas SR₂ involved the removal of 20% from the first to third fruiting nodes. Treatments were arranged in a factorial randomized complete block design with three replications, and data were analyzed using a two-way analysis of variance. Overall, neither genotype nor SR treatment alone had a significant effect on seed cotton yield; however, significant block effects indicated

environmental heterogeneity across experimental plots. Leaf area decreased progressively with increasing SR intensity, with the greatest reductions observed in PB-131. A highly significant genotype $\times$ SR interaction ($p < 0.001$) was observed for boll number: PB-131 achieved its highest boll count under the control treatment (46) and the lowest under SR₁ (36), whereas UAF-1 maintained higher boll numbers under SR₁ but declined markedly under SR₂. Seed size and boll weight were largely unaffected by SR treatments, indicating that yield variation was primarily driven by changes in boll number rather than individual boll mass. Trends in total biomass and harvest index closely mirrored yield responses, with PB-131 sustaining relatively high productivity under SR₂, while UAF-1 showed greater sensitivity to moderate SR but partially recovered at higher removal levels. These findings suggest that cotton can tolerate early square losses of up to approximately 20% without significant yield penalties when late-season growing conditions are favorable. The contrasting cultivar responses indicate greater tolerance of PB-131 to early fruit removal, whereas UAF-1 appears to benefit from management practices that minimize mid-season stress. Overall, this study advances understanding of source–sink dynamics in cotton and provides valuable insights for genotype-specific breeding and management strategies aimed at maintaining yield stability under variable early-season fruit retention.

Source-Sink Regulation in Cotton as Affected by Partial Defoliation

Moez Khalid, Masood Iqbal Awan, Yawar Abbas, Abdul Jabbar, Wasi-ud-Din

Department of Agronomy, UAF Constituent College Depalpur, Okara

E-mail: malikmoiz03@gmail.com

Cotton is a globally important fiber and cash crop; however, its productivity is often constrained by physiological limitations related to source–sink imbalances. To evaluate management strategies for improving these relationships, a field experiment was conducted at the UAF Constituent College, Depalpur, University of Agriculture Faisalabad. The study aimed to optimize the boll-to-leaf ratio through partial defoliation. The experiment was laid out in a factorial randomized complete block design with three replications, comprising two cotton genotypes (UAF-1 and PB-131) and three leaf-cutting levels (0%, 25%, and 50%). Growth, yield, and physiological traits were recorded, and treatment effects were analyzed using analysis of variance, with mean comparisons performed by LSD at the 5% probability level. Significant genotypic differences were observed for plant height, with PB-131 attaining greater height than UAF-1, while leaf-cutting treatments had no significant effect on this trait. Leaf area index declined progressively with increasing defoliation intensity but remained consistently higher in UAF-1 across treatments. Boll number per plant was significantly influenced by the genotype $\times$ defoliation interaction, with UAF-1 under 25% leaf removal producing the highest boll count. Seed number per boll remained stable across defoliation levels but was significantly higher in UAF-1 than in PB-131. Likewise, UAF-1 exhibited superior 100-seed weight (exceeding 11 g) compared with PB-131 (approximately 9.5g). Seed cotton yield was higher in UAF-1 and was not significantly affected by defoliation intensity; however, lint yield peaked (1,878 kg ha⁻¹) under 25% leaf removal in UAF-1 and declined sharply (1,233 kg ha⁻¹) under 50% defoliation. Harvest

index and biological yield were not significantly altered by treatments. Overall, the results indicate that moderate defoliation (25%) helps maintain a favorable source–sink balance and enhances yield-related attributes, whereas excessive defoliation (50%) adversely affects productivity. The superior resilience and performance of UAF-1 highlight its suitability for source–sink-oriented management strategies aimed at improving cotton yield stability.

Development of Novel active system for packaging of food materials

Faiza Ishtiaq¹, Sanam Saleem², Asma Maryam¹, Hira Kokab Maher¹

¹Department of Chemistry, University of Agriculture Faisalabad, Pakistan

²Department of Physics, University of Agriculture Faisalabad, Pakistan

E-mail: faizaishtiaq23@gmail.com

Packaging is an important step in the processing of food items that maintains the quality, freshness of ingredients and increase the shelf life without being leached into the food. Hazardous Chemicals such as terephthalates, polyethylene and polystyrene etc impose a serious threat to the consumer health and a root cause of pollution in the environment when dispose off. This challenge has drawn the attention of researchers to the use of biodegradable, and active materials for the packaging of food items. Active packaging includes those materials that enhance the shelf life, improve sensory attributes and safety of food materials by interaction with the ingredients and environment. Chemicals used in active packaging includes carbon dioxide, moisture absorber, ethylene or oxygen scavengers and use of antimicrobes. Growth of microbes and spoilage of food item can be reduced to a large extent by the mixing of antimicrobial agents in packaging materials. This step not only reduce the use of preservative, processing of food but also ensure the availability of natural and chemical free food to the consumer. These systems play a very important role to save the perishable food and to meet the sustainability goal by protecting food from spoilage and waste for a long period of time.

Efficient and cost effective method for the treatment of leather and textile industry effluents

Faiza Ishtiaq¹, Hira Ashfaq², Sanam Saleem³, Asma Maryam¹

¹Department of Chemistry, University of Agriculture Faisalabad, Pakistan

²Department of Management Sciences, UAF Constituent College Depalpur Okara, Pakistan

³Department of Physics, University of Agriculture Faisalabad, Pakistan

E-mail: faizaishtiaq23@gmail.com

Leather and textile industry effluents contain high percentage of heavy metals and dyes e.g. arsenic (As) cadmium (Cd), lead (Pd), crystal violet, methylene blue and malachite green along with other hazardous pollutants. If this waste water is mixed with fresh water systems without any pretreatment than toxicity caused by these pollutants disrupt the aquatic life by contaminating the fishes and aquatic plants. Moreover, when this contaminated water is used for irrigation purposes then these heavy metals and other POPs are ultimately incorporate in human body causing severe health issues e.g. liver diseases, renal disorders, dermatological issues and even gene mutations. For the reduction of toxicity caused by heavy metals and POPs it is mandatory to focus on the development of sustainable wastewater treatment methods.

There are several treatments for the extraction of these toxic metals from water e.g. osmosis, coagulation, ultrafiltration and adsorption. Out of all of the above mentioned techniques adsorption is one of the suitable method because of its simplicity, less operational charges and eco friendliness. Use of natural materials as adsorbent (e.g. rice husk, peanut husk, eucalyptus bark and mango peel) is a green and sustainable method for the removal of various toxic pollutants. Adsorption efficiency of these biosorbents can be increased to a large extent by applying various pretreatments e.g. formation of polymer that can provide mechanical support to biosorbent and enhance the removal efficiency. Researchers are working for the discovery of novel biosorbents that make this process economically more feasible and efficient.

Utilization of biosorbents for the removal of Crystal Violet dye from aqueous solution

Faiza Ishtiaq¹, Hira Ashfaq², Sanam Saleem³, Asma Maryam¹

¹*Department of Chemistry, University of Agriculture Faisalabad, Pakistan*

²*Department of Management Sciences, UAF Constituent College Depalpur Okara, Pakistan*

³*Department of Physics, University of Agriculture Faisalabad, Pakistan*

E-mail: faizaishtiaq23@gmail.com

Major sources of water pollution are drugs heavy metals, pesticides and dyes etc. Effluents from textile industries contain large amount of dyes. Mixing of this industrial waste with fresh water reservoir without any pretreatment poses a serious threat to aquatic life and also for humans. Therefore, treatment of this waste water is essential. Biosorption is one of the efficient and inexpensive methods for the removal of these toxic contaminants. Bio and geo waste material served as green adsorbent for treatment of water. Different composites were prepared by the combination of these adsorbents with other materials that increase their adsorption power by increasing mechanical strength and surface area. Different biomasses were treated with dye solution e.g. peanut husk, rice husk, saw dust, sugar cane, baggas and eucalyptus bark to check which biomass has high sorption power. Among all of the above mentioned bio wastes saw dust was selected due to its greater sorption capacity. Different composites were prepared by combining sawdust with other polymers like poly aniline coated with saw dust (PAN/SD), polypyrrol (Ppy/SD) and sodium alginate (Na-alginate/SD). Different parameters were studied and following conditions were found optimized for removal of Crystal violet like 0.05 g of adsorbent dose, temperature 30 °C, shaking time 120 minutes and pH 6, 7 and 8. Kinetic study was done by different kinetic models like pseudo first order, pseudo second order and intra-particle diffusion model. Thermodynamic parameter like Gibbs free energy change (ΔG), enthalpy (ΔH) and entropy changes (ΔS) were also calculated. From equilibrium study it was found that Langmuir model was best for SD, PAN/SD and Ppy/SD biosorbents and Freundlich model was fitted best for Na-Alginate/SD biosorbents than other equilibrium models. Characterization of biocomposites were done by FTIR and SEM techniques.

Utilization of noval composites for the remediation of Methylene Blue

Faiza Ishtiaq¹, Sanam Saleem², Asma Maryam¹

¹*Department of Chemistry, University of Agriculture Faisalabad, Pakistan*

Water contamination by dyes is a major issue and a serious threat for human health and for water bodies. Methylene blue (MB) is a cationic dye extensively used for coloring paper cotton, wools, as a biological stain and for leather processing. Removal of MB from water is the need of time because it can cause severe health issues in human's e.g. respiratory illness, skin discomfort and neurotoxicity. A number of methods are available for the removal of these contaminants from waste water e.g. membrane filtration, coagulation-flocculation, ion exchange, chemical oxidation and microbial degradation. But all of these processes face limitations of high cost and also generate secondary by-products. That's why there is a need of eco-friendly and sustainable alternative for the treatment of textile industry effluents and adsorption is one of such method. This method is noticeable because of its simplicity and high removal efficiency. MB can be removed by using different novel composites e.g. geo and biocomposites by combining simple and easily available adsorbents e.g. saw dust, rice husk and peanut husk etc. These adsorbents are prepared and characterized by different techniques e.g. FTIR, XRD and SEM. In batch adsorption experiment, red mud based geo-composites have 6.59mg/g adsorption capacity and fly-ash based geo-polymers have 30.1mg/g. Orange peels and peanut husk based composites showed 250mg/g and 118mg/g removal efficiency respectively. Therefore, biomass-based composites are more effective as compared to geo-polymers for the removal of MB from wastewater.

Studies on Symptomology of Bacterial Blight of Cotton In Field and Its Biological Management

Zobia¹, Nasir Ahmed Rajput², Khalid Naveed¹

¹*Department of Plant Pathology, University of Agriculture Faisalabad, Constituent College Depalpur, Okara*

²*Department of Plant Pathology, University of Agriculture, Faisalabad.*

E-mail: khalid.naveed@uf.edu.pk

The bacteria *Xanthomonas axonopodis pv malvacearum*, which causes angular leaf spot, or bacterial blight of cotton, poses a major danger to cotton crops. Cotton seed, acid-delinted seed, and sick plant detritus can all support the bacteria survival for several months. The intensity of the bacterial blight on cotton is greatly influenced by environmental conditions. This study assessed the resistance capability of six cotton types to bacterial blight in field. Based on the way that different varieties responded to different diseases, they were divided into susceptible and resistant categories. Every week, the bacterial blight progression was monitored, and a disease sign was noted. Regression analysis was used to evaluate how closely environmental factors—such as wind speed, relative humidity, rainfall, and maximum and minimum temperatures—interacted with the development of disease. The effectiveness of various plant extracts against bacterial blight was assessed. Data on the progression of diseases was statistically examined. Garlic and neem extracts, each containing 2.5 and 5%, were sprayed. In the experiment, randomized complete block designs (RCBDs) were employed with three replications. Row-to-row distance (75 cm) and plant-to-plant distance (30 cm) were maintained between plants. Data that

had been recorded was analyzed using statistical approaches. Treatment means were compared using the least significant difference (LSD) test at a 5% probability level. The study findings demonstrated that three cultivars, three are relatively resistant. Temperature and relative humidity had a major impact on the incidence of disease. When the relative humidity is high, the pathogen has a higher chance of proliferation. Temperatures between 30-to-40°C, along with a relative humidity of over 85% and an ideal soil temperature of 28°C, are ideal for the growth of bacterial blight in cotton. Plant extract is a management strategy for cotton bacterial blight control, and research found that 5% neem extract was more effective.

Incidence of Blackleg Of Potato Caused By *PectobacteriumAtrosepticum* in Punjab And Its Management

Saqlain Mushtaq¹, Nasir Ahmed Rajput², Khalid Naveed¹

¹Department of Plant Pathology, University of Agriculture Faisalabad, Constituent College Depalpur, Okara

²Department of Plant Pathology, University of Agriculture, Faisalabad.

Email Address: khalid.naveed@uaf.edu.pk

Potato is an important food crop grown worldwide and is used as staple food. Blackleg is a bacterial disease of potato caused by the soil-borne bacterium. Different *Pectobacterium*spp. and *Erwinia* spp. are associated with blackleg disease worldwide. The disease results in significant yield losses in potato in severe infections. This study investigated the resistance potential of six potato genotypes against *Pectobacteriumatrosepticum* under field conditions. Sante, Kuroda, Mosika, Lady Rosetta, Isme and Desiree were evaluated for their resistance potential against blackleg disease in field. All potato varieties behaved differently to blackleg infection under field conditions. Symptoms of disease on infected plants included yellowing of leaves, blackening of stem sear soil and reduced tuber size on infected plants. Results of the study showed that different varieties reacted differently to blackleg disease however, no variety showed resistance response. Environmental factors like temperature, humidity, wind speed, and rainfall significantly influenced blackleg disease. The data showed that temperature in the range of 15-25 °C is highly conducive for blackleg disease development. Effect environmental factors on blackleg disease development will be studied through correlation analysis. Chemical treatments for blackleg can be harmful, and biocontrol agents can reduce contamination. Different species of biocontrol bacteria and fungi will be investigated for their biocontrol efficacy against *P.atrosepticum* in vitro conditions. All the collected data was statistically analyzed.

A Smart Crop Insurance Framework Using Blockchain in Precision Agriculture

Syed Mushhad M. Gilani, Faheem Tariq

Department of Computer Science, Faculty of Sciences, University of Agriculture, Faisalabad

E-mail: mushhad@uaf.edu.pk, faheem.tariq@uaf.edu.pk

The integration of blockchain technology with precision agriculture marks a significant advancement in crop insurance systems by enabling higher levels of transparency, secure data management, and automated processes, thereby enhancing the efficiency and reliability of

agricultural risk management. However, farmers still suffer from considerable risks coming from uncertain weather patterns, pest infestation, and market volatility, which conventional crop insurance schemes frequently do not respond to effectively because of transparency problems, delayed payment of claims, and high administrative expenses. We proposed a framework to address fundamental shortcomings of traditional crop insurance by using various innovations. The proposed framework is structured into three layers, in first layer agriculture and weather-related data is gathered using IoT sensors, and weather stations. Machine learning models process data to estimate yield and categorize possible threats like drought, flood, rainfall and temperature fluctuations. In second layer authenticated farm data is stored safely on a blockchain, which makes it immutable and transparent. Smart contract-based automated claim minimizes settlement periods from weeks to minutes, and proof-of-concept implementations show end-to-end processing delay. Immutable blockchain records provide high transparency and auditability with low fraudulent claims through consensus ledgers that avoid duplicate claims across insurers. At third layer, Farmers, insurers, and stakeholders engage in a decentralized environment. When predetermined conditions are fulfilled, smart contracts automatically settle claims, allowing speedy and equitable payment. Set rules for insurance and validate claims automatically, saving time and eliminating middlemen end-to-end settlement latency. The proposed solution shows important potential advantages such as lower administrative expenses, accelerated settlement of claims, better farmer access to insurance, and better risk assessment accuracy using precision agriculture data.

An AI-Driven Framework for Optimizing Risk in Crop Insurance Systems

Faheem Tariq, Syed Mushhad M. Gilani

Department of Computer Science, Faculty of Sciences, University of Agriculture, Faisalabad

E-mail: faheem.tariq@uaf.edu.pk, mushhad@uaf.edu.pk

Accurate crop monitoring and forecasting are critical to ensuring food security and sustainable agriculture. As a result of climate change, agricultural landscapes are especially susceptible to extreme weather events like heat waves, prolonged droughts, and floods. Crop insurance is a crucial financial safety net that farmers rely on to guard against losses caused by erratic weather or natural disasters. Conventional crop insurance plans often fail to provide accurate risk estimates because they rely primarily on manual evaluations and historical data. This research use big data gathered from weather stations, field sensors, IoT devices, drones, and Earth observation satellites using artificial intelligence (AI) techniques. Artificial Intelligence (AI) has the potential to improve risk assessment accuracy by utilizing machine learning and deep learning models, and predictive analytics. These tools can integrate real-time data, including weather patterns, soil properties, and crop health indicators. These cutting-edge methods seek to increase the precision of premium pricing, decrease the uncertainty near insurance claims, and give farmers more particular coverage. AI integration with crop insurance programs may speed up decision-making, which will ultimately lead to more sustainable farming practices and stable income for farmers. This study provides an extensive framework for crop insurance optimization

going forward by assessing different AI models and their accuracy in forecasting risks related to crops.

Laboratory assessment of hydrogel and nano-formulations of some selected synthetic insecticides against fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

Umar Farooq¹, Muhammad Zeeshan Majeed¹, Muhammad Luqman², Muhammad Irfan Ullah¹, Muhammad Asam Raiz¹, Abu Bakar Muhammad Raza¹

¹Department of Entomology, College of Agriculture, University of Sargodha, 40100 Sargodha, Pakistan

²Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha, 40100 Sargodha, Pakistan

E-mail: zeeshan.majeed@uos.edu.pk

The fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) has been a challenging pest of maize crop worldwide. Novel, effective, eco-friendly, and target-oriented approaches are needed to mitigate the damage of *S. frugiperda*. Farmers rely predominantly on extensive and repetitive use of synthetic insecticides, but they have unsatisfactory control because of the cryptic feeding style of the pest's larvae and rapid decomposition of the applied insecticides. This study aimed to screen out available synthetic insecticides being used against different lepidopterans pests including *S. frugiperda* under field conditions and then the two most effective insecticides were further formulated with silver nanoparticles and with sodium alginate hydrogel beads and were bio assayed against the third larval instar of *S. frugiperda* under laboratory conditions using the standard leaf-dip method. Treatments included the following: T 1 = emamectin benzoate and chlorantraniliprole formulation at recommended dose (90 mL/acre), T 2 = nanoformulated emamectin benzoate and chlorantraniliprole formulation, T 3 = nano formulated emamectin benzoate and chlorantraniliprole at the recommended dose (90 mL/acre), T 4 = emamectin benzoate and lufenuron formulation at the recommended dose (400 mL/acre), T 5 = nano formulated emamectin benzoate and lufenuron formulation, T 6 = nano formulated emamectin benzoate and lufenuron formulation at the recommended dose (400 mL/acre), T 7 = nanoparticles alone (control) and T 8 = water (control). According to the results, the nano formulated recommended dose of the emamectin benzoate and lufenuron formulation manifested the highest mortality (100%) at 24 h, followed by the nano formulated recommended dose of the emamectin benzoate and chlorantraniliprole formulation (100%) at 48 h post-treatment. In another bioassay, alginate beads loaded with the recommended dose of emamectin benzoate and lufenuron formulations caused up to 50% more larval mortality compared to beads loaded with emamectin benzoate and chlorantraniliprole formulations, which resulted in 40% higher larval mortality than the control treatments. The findings suggest that nanoparticle-based and hydrogel bead formulations can be viable and eco-friendly alternatives to the conventional administration of insecticides, offering improved larval mortality, controlled-release of insecticidal compounds, and reduced environmental impact. Future research should focus on upscaling these formulations for practical implications and for assessing their compatibility with other integrated pest management (IPM) strategies under diverse agro-climatic conditions.

Harmful Effects of Pesticides on Human Health and Environment: Case Study of Punjab, Pakistan

Liaqat Ali, Muhammad Luqman, Muhammad Yaseen

*Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha, 40100
Sargodha, Pakistan*

E-mail: liaqat.ali786786@gmail.com

Pesticides are chemical compounds that are used to kill pests. Since many decades there is a debate regarding beneficial and harmful use of pesticides in Agriculture and its impact on human health and environment. The study was conducted in randomly selected three districts of Punjab province. For the purpose, the questionnaire was used as a research instrument containing various study related factors. Total sample consisted of 384 respondents from three selected districts. Total sample size was equally distributed among three districts resulting in 128 respondents per district. Findings of the study revealed that majority (108) of the respondents was in age group of 26-40 years (28.1%) and 89 were in the age group of 41-45 years (23.2%). Out of 384 people 17.2% were illiterate with no formal education. Matriculation was the most common educational level among the respondents as majority (43.0%) of respondents belongs to this group. The largest percentage, 63% depend solely on farming as their principal source of income supporting the fact that the community is mostly engaged in farming activities. However, 37% combine farming with other off-farm income sources, though the level of diversification is low. All the respondents (100.0%) used to apply pesticides in order to increase their farm production and to control pests. It was found that decision of the farmers generally in the Punjab province and particularly in the targeted research areas is mainly influenced by socio-economic, agronomic and institutional factors. There exists a complex interaction of these factors particularly for the farmers of targeted research area. In the research area pesticides' application was most common on wheat and cotton as reported by 94.01% and 92.19% of respondents, respectively. A wide variety of insects, weeds and diseases widely present in the research area that damage the crops. This is fact that farmers in the Punjab (Pakistan) mostly rely on pesticides for gaining maximum production and this is due to the availability of insufficient knowledge and expertise regarding safe use of pesticides. Other than the synthetic pesticides, some farmers were also using plant-based pesticides, but the ratio of these farmers is very few mainly due to the non-availability of these pesticides at market competitive rate. Awareness about advantages of naturally occurring and plant-based pesticides over synthetic pesticides among farming community was also identified as the major reason. Pesticide application disturbs the pH of soil. High effect of pesticides on bio-diversity and environment is through contamination of soil and water. Use of oil and sun glasses by the farmers were very common precautionary measure adopted. The ill-Health Symptoms after Pesticide Application table classify the minor health complaints made by farmers. The studies presented here show health effects from pesticide exposure, both current and future, should pesticide use persist. Safe application training for farmers should also be provided and adequate medical treatment for farmers exposed to these threats should also be made available. The results of correlation analysis showed a significant

association between adoption levels of protected measures and occurrence of different ill-health symptoms reported by the respondents. A negative correlation was found between the uses of mask/respirator and the incidence of cough ($p=-0.42 \leq 0.01$). Before buying a pesticide, identify the pest correctly was the best tip for minimizing pesticide risk for environment and health.

Dynamics of Solitary Wave Solution of Kraenkel-Manna-Merle System and its Applications

Sana Fatima, Malaika Shakoor, Mubashra Ghafoor, Muhammad Arshad

*Department of Mathematics and Statistics, Constituent College Depalpur, University of Agriculture Faisalabad
Pakistan*

Emails: sanafatimaa356@gmail.com, malaikashakoor5577@gmail.com, dr.marshad@uaf.edu.pk

In this paper, several new exact analytical solutions of the Kraenkel–Manna–Merle (KMM) system are derived using the Modified Sardar Sub-equation Method. This method is shown to be an efficient and systematic approach for constructing exact travelling-wave solutions of nonlinear partial differential equations. By applying a suitable wave transformation, the KMM system is reduced to an ordinary differential equation, which is then solved using the proposed method. Consequently, a variety of distinct wave structures are obtained for different values of physical parameters, both in the presence and absence of the damping factor. The resulting solutions include bright and dark solitons, kink and anti-kink waves, periodic and grey-type periodic waves, as well as evolving wave profiles. To illustrate the physical behavior and dynamical characteristics of these solutions, graphical representations are provided. These wave phenomena play an important role in describing the dynamics of magnetic materials under various physical conditions. Overall, the results confirm that the Modified Sardar Sub-equation Method is a robust and reliable tool for analyzing nonlinear evolution equations in applied mathematics and mathematical physics.

AI-Driven Food Design and Formulation: Current Advances and Future Potential

Muhammad Mursaleen¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

Artificial intelligence (AI) is transforming modern food design by shifting product development from traditional trial-and-error methods to efficient, data-driven formulation strategies. This review summarizes recent advances in AI applications, particularly machine learning, deep learning, and generative models, for optimizing flavor, texture, nutrition, safety, and sustainability in food systems. Tools such as Taste PepAI support the design of novel taste peptides for sweet, salty, and umami sensations, while platforms like Flavor Diffusion predict innovative ingredient combinations based on chemical interactions and sensory compatibility. AI-driven formulation frameworks also enable substitution of functional or health-enhancing ingredients without compromising sensory attributes, consumer acceptance, or processing performance. Explainable AI (XAI) increases model interpretability, enhances transparency, and builds scientific and regulatory trust in AI-supported decisions. AI technologies can significantly

reduce prototype development cycles, often by 70–90%, facilitate personalized nutrition tailored to individual dietary needs, and support more sustainable food supply chains by reducing waste and improving resource efficiency. Despite these advantages, several challenges remain, including limited availability of high-quality datasets, dependency on black-box model behavior, regulatory uncertainties, and restricted access to advanced computational tools for small and medium enterprises. Future research priorities include developing robust and interpretable AI models, establishing standardized data-sharing frameworks, and defining clear regulatory pathways to ensure safety, accountability, and consumer confidence. The integration of AI with food science holds strong potential to accelerate innovation, enhance product quality, and contribute to a more sustainable and intelligent global food system.

Sustainable and Smart Packaging for Food Innovations Challenges and Future Perspectives

Khadija¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

E-mail: adnan.mukhtar@uaf.edu.pk

The modern food industry faces increasing pressure to ensure food safety, preserve quality, extend shelf life, reduce environmental impact, and meet consumer expectations for convenience and transparency. In this context, sustainable and smart packaging has emerged as a key solution that integrates eco-friendly materials with advanced technological features to enhance protection, monitoring, and traceability. Sustainable packaging focuses on reducing the ecological footprint through the use of biodegradable, compostable, recyclable, and renewable materials, while promoting energy efficiency and minimizing waste across the supply chain. Smart packaging, by contrast, incorporates sensors, freshness indicators, intelligent labels, and active components capable of detecting spoilage, contamination, or fluctuations in storage conditions, thereby enabling real-time monitoring and improved quality management. This review summarizes recent advancements in sustainable and smart packaging technologies, highlighting their roles in extending shelf life, enhancing food safety, reducing postharvest losses, and supporting more efficient and transparent supply chains. The discussion also addresses key technological, economic, and regulatory barriers that hinder large-scale adoption, including high production costs, material performance limitations, and the need for standardized safety guidelines. Emerging trends, such as nanomaterials, bio-based polymers, antimicrobial and antioxidant systems, and digital traceability tools are examined for their potential to shape next-generation packaging solutions. By integrating sustainability with intelligent functionality, smart packaging offers a promising pathway toward a safer, more resilient, and environmentally responsible food system, delivering substantial benefits for producers, retailers, and consumers.

Alternative Proteins and Cultivated Meat Innovations Challenges and Future Perspectives

Aila Shahzadi¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

Global demand for protein is rising rapidly due to population growth, urbanization, and shifting dietary preferences, placing increasing pressure on conventional livestock systems that contribute to environmental degradation, greenhouse gas emissions, and inefficient resource use. Alternative proteins and cultivated meat have emerged as forward-looking solutions that offer sustainable, nutritious, and ethically aligned sources of protein. Alternative proteins encompass plant-based, insect-derived, algae-based, and microbial proteins, whereas cultivated meat is produced through the controlled growth of animal cells without the need for raising or slaughtering animals. This review provides a comprehensive overview of recent advancements in alternative protein technologies and cultivated meat production, emphasizing innovations in processing, cell culture techniques, nutritional quality, sensory attributes, and industrial scalability. Key challenges, such as high production costs, uncertain regulatory pathways, consumer acceptance, and safety validation are critically examined alongside environmental and economic considerations. Emerging approaches, including precision fermentation, metabolic engineering, and hybrid protein systems that combine plant and cultured components, are explored as promising strategies to enhance functionality, reduce costs, and improve market adoption. By integrating sustainability principles with cutting-edge biotechnology, alternative proteins and cultivated meat represent transformative pathways for reshaping global food systems. These innovations hold significant potential to reduce carbon footprints, increase food security, diversify protein sources, and meet future nutritional demands in a responsible and scalable manner.

Upcycling Food Waste into Functional Ingredients Innovations Challenges and Future Perspectives

Maham Tariq¹, Sana Mukhtar¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

The growing concern over food waste and its environmental, economic, and social impacts has driven the search for innovative strategies to valorize by-products and surplus food. Upcycling food waste into functional ingredients represents a sustainable approach that not only reduces waste but also generates value-added products with health-promoting properties. Functional ingredients derived from food waste include dietary fibers, antioxidants, proteins, bioactive compounds, and natural colorants, which can be incorporated into foods, beverages, and nutraceuticals to enhance nutritional quality and functionality. This review provides a comprehensive overview of recent advancements in the upcycling of food waste, highlighting extraction techniques, processing methods, and applications of functional ingredients in various food systems. Key challenges, including technological limitations, safety concerns, regulatory frameworks, and consumer acceptance, are critically discussed. Emerging trends such as

enzymatic treatments, fermentation, and novel drying technologies are explored as strategies to improve the yield, bioavailability, and stability of functional components. By transforming food waste into valuable ingredients, this approach contributes to circular economy principles, promotes sustainability, and offers opportunities for innovation in the food industry. The integration of upcycled functional ingredients into commercial products has the potential to enhance food quality, support environmental conservation, and provide economic benefits for producers and stakeholders, paving the way for a more resilient and resource-efficient food system.

Food Safety Rapid Testing and Predictive Microbiology Innovations Challenges and Future Perspectives

Itrat Zahra¹, Sana Mukhtar¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

Ensuring food safety is a critical global challenge, as contamination by pathogens, spoilage organisms, and chemical hazards can lead to significant public health risks and economic losses. Rapid testing and predictive microbiology have emerged as essential tools to enhance food safety management by enabling timely detection, risk assessment, and decision-making across the food supply chain. Rapid testing methods, including molecular assays, biosensors, immunoassays, and next-generation sequencing, allow fast, sensitive, and accurate detection of microbial contaminants, significantly reducing response time compared to traditional culture-based approaches. Predictive microbiology uses mathematical models and computational tools to estimate microbial growth, survival, and inactivation under various environmental and processing conditions, supporting risk assessment, process optimization, and shelf-life determination. This review provides a comprehensive overview of recent advancements in rapid testing techniques and predictive microbiology, highlights their applications in ensuring food quality and safety, and discusses technological, regulatory, and operational challenges associated with their implementation. Emerging trends such as integration with artificial intelligence, machine learning, and digital monitoring systems are explored as strategies to improve predictive accuracy and real-time decision-making. By combining rapid detection with predictive modeling, these approaches offer a proactive and science-based framework for controlling foodborne hazards, reducing food waste, and ensuring consumer safety, while supporting the development of resilient and sustainable food systems.

Non-Thermal Food Processing Technologies Innovations Challenges and Future Perspectives

Areeba Masood¹, Sana Mukhtar¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

Non-thermal food processing technologies have emerged as innovative alternatives to conventional thermal methods, aiming to preserve food quality while ensuring safety and extending shelf life. Unlike traditional heat-based processing, non-thermal techniques minimize nutrient loss, flavor degradation, and textural changes, making them highly suitable for fresh and minimally processed foods. Key technologies include high-pressure processing (HPP), pulsed electric fields (PEF), cold plasma, ultraviolet (UV) treatment, and ultrasound, which inactivate pathogens and spoilage microorganisms while maintaining sensory and nutritional properties. This review provides a comprehensive overview of recent advancements in non-thermal processing methods, highlighting their mechanisms, applications, and effectiveness across various food matrices. Critical challenges, such as equipment cost, scalability, regulatory approval, and consumer acceptance, are discussed alongside emerging strategies to overcome these barriers. The integration of non-thermal technologies with other processing methods, smart monitoring systems, and sustainable practices is explored as a pathway to enhance efficiency and product quality. By combining food safety, quality retention, and sustainability, non-thermal food processing technologies offer a promising approach to meet modern consumer demands, reduce postharvest losses, and support resilient and environmentally responsible food supply chains.

Gluten Free Biscuits Innovations Challenges and Future Perspectives

Urwa Asif¹, Sana Mukhtar¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

E-mail: adnan.mukhtar@uaf.edu.pk

The demand for gluten-free biscuits has grown significantly due to increasing awareness of celiac disease, gluten intolerance, and consumer preference for healthier alternatives. Gluten-free formulations present unique challenges because the absence of gluten affects dough structure, texture, and sensory properties. To overcome these limitations, various approaches including the use of alternative flours (rice, maize, sorghum, buckwheat), hydrocolloids, protein isolates, and novel processing techniques have been explored. This review provides a comprehensive overview of recent advancements in gluten-free biscuit development, focusing on ingredient selection, processing methods, and strategies to improve texture, taste, and nutritional quality. Challenges such as achieving consumer-acceptable sensory attributes, maintaining shelf life, and ensuring nutritional balance are critically discussed. Emerging trends including incorporation of functional ingredients, bioactive compounds, and fortification with fiber, protein, or micronutrients are also highlighted to enhance health benefits. By addressing both technological and nutritional aspects, the development of gluten-free biscuits offers opportunities to meet the growing market demand for safe, nutritious, and high-quality bakery products. This review emphasizes the importance of innovative formulations and processing strategies in creating gluten-free biscuits that satisfy both health and sensory expectations, contributing to functional and sustainable food solutions.

Organic Jam Innovations Challenges and Future Perspectives

Noor Fatima¹, Sana Mukhtar¹, Mazhar Iqbal², Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

The growing consumer demand for natural, minimally processed, and health-promoting foods has led to increased interest in organic jam production. Organic jams are prepared from fruits grown without synthetic pesticides, herbicides, or chemical fertilizers, and are processed using natural ingredients and methods that preserve bioactive compounds, flavor, and nutritional quality. Developing high-quality organic jams presents challenges such as maintaining shelf life, ensuring microbial safety, achieving desirable texture and consistency, and complying with organic certification standards. This review provides a comprehensive overview of recent advancements in organic jam production, focusing on fruit selection, formulation strategies, processing technologies, and preservation methods. Innovative approaches including the use of natural sweeteners, pectin alternatives, bioactive fortification, and minimal processing techniques are highlighted to enhance sensory, nutritional, and functional properties. Regulatory requirements, quality control, and consumer acceptance are also discussed as critical factors influencing product development. By integrating sustainability, health benefits, and innovation, organic jams offer a promising avenue for value addition in the fruit processing industry while meeting consumer expectations for safe, nutritious, and environmentally responsible products. This review emphasizes the potential of organic jam production to contribute to sustainable food systems, promote healthier diets, and support eco-friendly agricultural practices.

Toxins in Cereals Occurrence Health Risks Detection Methods and Mitigation Strategies

Bisma Sohail¹, Amina Sabir¹, Sana Mukhtar¹, Shoaib Ur Rehman², Amina Ayub³, Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

³Department of Zoology, University of Agriculture Faisalabad, Okara-Campus, Pakistan

Corresponding author: adnan.mukhtar@uaf.edu.pk

Cereals are essential staple foods worldwide, yet they are frequently contaminated with a range of natural and anthropogenic toxins that threaten food safety, public health, and economic stability. Among the most significant are mycotoxins, including aflatoxins, ochratoxin A, fumonisins, deoxynivalenol, and zearalenone, produced by fungal pathogens during pre-harvest, postharvest, and storage stages. In addition to mycotoxins, cereals may accumulate heavy metals, pesticide residues, and processing-related contaminants, all of which pose acute and chronic health risks such as carcinogenicity, immunosuppression, endocrine disruption, and neurotoxicity. This review presents a comprehensive overview of the occurrence of toxins in cereals, their sources, and associated health risks. It further discusses detection methods, including advanced chromatographic techniques, immunoassays, biosensors, and rapid field-deployable tools, highlighting their sensitivity, specificity, and applicability. The review also evaluates mitigation strategies, encompassing good agricultural practices, improved harvesting

and storage conditions, biological control, detoxification technologies, and regulatory interventions to minimize contamination. Emerging challenges, such as climate change-driven mycotoxin variability and global trade implications, emphasize the need for integrated and predictive approaches. Future research should focus on developing cost-effective monitoring systems, climate-resilient cereal production, and standardized regulatory frameworks to ensure toxin-free cereals. Implementing these strategies is critical for safeguarding public health, enhancing food security, and supporting sustainable cereal supply chains globally.

Poor Quality Food in Restaurants and Its Effects on Digestive and Gastrointestinal Health

Saba Shabbir¹, Saher Zahid¹, Sana Mukhtar¹, Mazhar Iqbal², Amina Ayub³, Tauhid Iqbal², Shoaib Ur Rehman², Adnan Mukhtar¹

¹Department of Food Science, University of Agriculture Faisalabad, Okara-Campus, Pakistan

²Department of Agriculture, University of Agriculture Faisalabad, Okara-Campus, Pakistan

³Department of Zoology, University of Agriculture Faisalabad, Okara-Campus, Pakistan

E-mail: adnan.mukhtar@uaf.edu.pk

The quality of food served in restaurants plays a critical role in public health, consumer confidence, and overall digestive well-being. Poor food quality, resulting from unhygienic preparation, improper storage, contaminated ingredients, and inadequate cooking practices can lead to a range of gastrointestinal disorders and foodborne illnesses. Pathogenic microorganisms such as *Salmonella*, *Escherichia coli*, and *Listeria*, along with chemical residues and toxins, are commonly implicated in digestive disturbances, causing symptoms such as nausea, vomiting, abdominal pain, diarrhea, and, in severe cases, long-term gastrointestinal complications. This review explores the prevalence and underlying causes of substandard food quality in restaurant settings, emphasizing its direct effects on digestive and gastrointestinal health. Factors such as lack of proper hygiene, cross-contamination, insufficient staff training, and failure to maintain appropriate storage and cooking conditions are highlighted. The physiological impacts of consuming contaminated or poorly prepared food, including disruption of gut microbiota, inflammation, and increased susceptibility to chronic digestive diseases are discussed in detail. Preventive strategies, including strict adherence to food safety regulations, regular inspections, proper food handling protocols, staff education, and consumer awareness, are essential for mitigating health risks. Ensuring high standards of food quality in restaurants is critical not only for protecting digestive health but also for fostering public trust and promoting overall food safety in the community.

Mitigating Salt Stress in Sunflower (*Helianthus annuus* L.) through Soil-Applied Bioactive Nutrient-Fortified Fertilizer (BNFF)

Naveed Ul Hassan¹, Muhammad Shahbaz², Farooq Ahmad², Ejaz Ahmad Waraich³

¹Department of Botany, University of Agriculture Faisalabad, Constituent College, Depalpur- Okara

²Department of Botany, University of Agriculture, Faisalabad

³Department of Agronomy, University of Agriculture, Faisalabad

E-mail: naveedulhassan@uaf.edu.pk

Salinity stress severely restricts sunflower growth and yield. A pot experiment conducted over two growing seasons evaluated the role of soil-applied bioactive nutrient-fortified fertilizer (BNFF) in the form of zinc-coated urea on two sunflower hybrids (FH-710 and FH-809) under saline conditions (0, 100, and 150 mMNaCl). Salinity significantly reduced growth, yield traits, and ion balance, while increasing oxidative stress. BNFF application improved chlorophyll content, enhanced antioxidant-related biochemical attributes, reduced Na⁺ accumulation, and improved K⁺ and Ca²⁺ uptake. Yield components were also significantly improved, particularly at the 0.01% BNFF level. Among the hybrids, FH-809 showed greater tolerance to salinity than FH-710. Overall, soil-applied BNFF at 0.01% effectively mitigated salinity stress and improved sunflower performance under saline conditions.

Sentiment Analysis for Mental Health Detection Using LLM

IfraMubarik, Syed Mushhad M. Gilani, Faheem Tariq

Department of Computer Science, Faculty of Science, University of Agriculture, Faisalabad.

E-mail: mushhad@uaf.edu.pk

The rapid growth of online communication has enabled individuals to express emotions, thoughts, and mental conditions through social media, creating opportunities for early mental health risk detection. This study aims to develop a multi-condition sentiment analysis system that classifies mental health states into seven categories: Normal, Depression, Suicidal, Anxiety, Stress, Bipolar, and Personality Disorder. Social media text, particularly Reddit data, is processed using advanced Natural Language Processing techniques, including text normalization, tokenization, stop word removal, and lemmatization. Transformer-based models-BERT, RoBERTa, and Distil BERT are employed to generate contextual text representations and perform multi-class classification. Model performance is evaluated using accuracy, precision, recall, and F1-score. Existing literature indicates that transformer-based approaches outperform traditional machine learning methods in detecting mental health conditions. The proposed framework offers a scalable and explainable AI-based solution for early mental health risk detection using social media text.

Addressing Limited Data Challenges: An Innovative Deep Learning Model for Accurate Skin Lesion Classification

Zargham Ali, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: shujanasqher@gmail.com

Skin cancer incidence is growing, it has a relatively high mortality, and the treatments are costly, all making it necessary for its symptoms to be detected at an early stage. The slow spread of skin cancer to the rest of the body increases its curable nature if detected early on, and much better treatment outcomes is why they say that “earlier diagnosis” would be best. The aim of this study

is to establish a novel machine- learning model to diagnose skin cancer. The models of Deep Neural Networks that are trained on a few images often fail because deep neural networks overfit. I saw that overfitting hurts the performance of networks. The study makes use of data enlargement, transfer learning and Generative Adversarial Networks (GANs). The convolutional neural networks and meta-learning can also help to identify skin cancer. The results show that a mix of networks and GAN models reduces class imbalance. I have seen that deep learning models are very accurate, at identifying skin lesions. The deep learning models can spot skin lesions with accuracy. I have seen that the deep learning models are very accurate, at telling skin lesions from skin lesions. I think the deep learning models can be placed in mobile health applications. Two consenting adults in any corner of the globe where people do not have access to check out for unusual markings on their skin can get Initial assessments using mobile health applications. I think that deep learning models may function as supportive tool of decision-making for dermatologists. I believe that deep learning models can allow intervention. The study says that early diagnosis is the key, to skin cancer treatment.

Where Living Neurons Touch Silicon: A Conceptual Framework for the First Bio-Digital Mind Interface

Muhammad Junaid Akbar, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: mja227666@gmail.com

Every technology begins by imitating nature, but this work begins by questioning it. What happens when a biological neuron, evolved to survive hunger, fear, pain, and memory, is asked to speak to a machine that knows none of these things? This study proposes a theoretical architecture for creating a hybrid intelligence system where stem-cell-derived human neurons, grown in controlled artificial environments, interface directly with silicon-based computational substrates. Not as sensors. Not as prosthetics. But as co-processors living, adapting, forgetting, remembering, and firing in ways no algorithm has ever captured. Instead of treating neurons as biological artifacts to be decoded, this framework treats them as computation itself. Their electrical spikes become data streams; their synaptic plasticity becomes self-modifying logic; their spontaneous firing becomes a non-deterministic search algorithm that no classical computer can emulate. The challenge is not how to read these signals, but how to create machines capable of understanding patterns shaped by life, evolution, and experience. A paradox emerges: silicon does not age, but neurons do. Silicon does not fear death, but neurons are born dying. Instead of seeing this as a flaw, the model turns it into a feature proposing dynamic regeneration cycles, organoid renewal loops, and modular biological clusters that allow a mortal tissue to contribute to an immortal architecture. In this system, decay itself becomes part of computation, introducing a temporal dimension no conventional chip possesses. By linking computational design with cellular behavior, this work suggests a new category of intelligence one that is neither artificial nor biological, but something created in the narrow, unexplored

space between them. This abstract does not describe a device; it describes a direction. A hypothesis. A question with enough depth to bend the reader inward: If a machine begins to think through living tissue, whose thoughts, are they? This framework aims not to answer that question, but to make it unavoidable.

Lightweight AI for Offline Crop Disease Detection on Low-Cost Android Phones

Muhammad Shaeel Ahmad, Haris Pervaiz

*Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara,
Pakistan*

Email Address: shaeelmian@gmail.com

This study presents a method for developing a lightweight Artificial Intelligence (AI) system capable of detecting plant diseases directly on low-cost Android smartphones without requiring internet connectivity. The work focuses on overcoming the hardware limitations of basic mobile devices commonly used by farmers, which typically have slow processors, limited memory, and no dedicated AI accelerators. These constraints prevent large models such as ResNet-152–based plant disease classifiers and YOLOv8x from running efficiently. During that the study looks at ways to make the model smaller and to cut the computation while keeping accuracy. The motivation comes from the 2025 study Leveraging Computer Vision and AI for Real-Time Crop Disease Detection in Smallholder Farming Systems, which points out that tools need to run on the device. The technical approach pulls design ideas from the 2024 study that compresses YOLOv8 using ShuffleNetv2, Ghost modules, and SE attention layers. The technical approach also uses insights from the 2025 paper focused on detecting leaf diseases in environments. Integrating these concepts, the research develops a compact version of YOLOv8 optimized for offline deployment. The main steps are to replace the backbone with layers that work on phones Cut-out channels shrink the model to make it smaller, and teach a model from a larger one to keep the performance. Then test the model on an Android phone. The model runs in time, uses memory, and works completely offline. Then the results show that AI can be practical and easy for farmers when we design the model for hardware. The results also prove that a disease detection system does not have to be big, expensive, or need the cloud.

Flood Severity Classification in Punjab Using Machine Learning and Deep Learning

Asad Shareef, Haris Pervaiz

*Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara,
Pakistan*

Email Address: asadasfprp2@gmail.com

Floods have always been a problem for Punjab, damaging not only the infrastructure, agriculture and economics of the province but also the daily life of a common citizen. Flooding weakens roads and bridges. Flooding puts families at risk. The province sees flood events again and again. The province cannot predict when flooding will strike. The province needs forecasts that show how bad flooding will be, in each district. Good forecasts help people get ready and act when

flooding comes. This study introduces a hybrid deep learning and machine learning framework for multi-class flood severity classification, designed to meet this need. The model combines the temporal learning strength of a Long Short-Term Memory (LSTM) network with the robust multi-class decision-making capability of XGBoost. LSTM looks at the time patterns, in the data that comes from water and weather factors. XGBoost then decides the flood level, such as no flood, flood or severe flood. The system uses inputs, such as satellite rainfall from TRMM or GPM river flow data from WAPDA or PMD glacier melt signs from MODIS, soil moisture data from SMAP, vegetation cover data from NDVI temperature data from NASA POWER and past district level flood impacts, from NDMA. This hybrid model combines pattern extraction, with -linear classification. The hybrid model aims to give accurate severity predictions. The resulting system enables warnings that support evacuations, better resource allocation and reduced socioeconomic losses across Punjab's most vulnerable districts.

How AI Threatens User Data and Privacy

Muhammad Haris Saleem, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: bhattiharis705@gmail.com

Artificial Intelligence (AI) and mobile apps have access to a considerable volume of personal information, which undermines user privacy. A majority of mobile apps require permission to access personal information such as a camera, microphone, location, and contacts without an individual understanding the implications. Research demonstrates that 87% of all mobile apps demand personal information permissions such as location and contacts, and more than 80% of smartphone users fear that apps misuse their personal information. Data Privacy Statistics Research further shows a misunderstanding among many users on how they can adequately secure their personal information. Nearly half a population feels that simple steps such as using the camera cover or incognito mode ensures complete privacy, which is not the case, but apps can easily access microphones and other information despite these safeguards. Digital privacy practices & misconceptions (Kaspersky) Moreover, very few people using digital technology have a complete understanding towards online safety in digital technology, with most people unaware of why apps require permissions from them despite not using such functions. Only 10 % aware of digital privacy concerns (The News) such results make it evident that personal information such as pictures, location, voice records, and other personal sensitive information remains not entirely protected, especially when people are not careful when designing different apps with permissions. The abstract emphasizes a need for education in terms of safety when it comes to personal information in order to avoid personal information misuse in the AI technology.

AI-Powered Farm Machinery and Seed Recommendation System

Muhammad Konain Qasim, Haris Pervaiz

Department of Computer Science, University of Agriculture, Faisalabad, Constituent College Depalpur-Okara, Pakistan

Email Address: konainqasim68@gmail.com

Small farmers often have trouble selecting the farm machinery and seed varieties. Small farmers have limited know how have money limits and work with soil and weather. Small farmers sometimes pick the equipment or seeds. Wrong equipment or seeds cause harvest, money loss and lower overall output. I have seen these problems, in farms. This study presents an AI-Powered Farm Machinery and Seed Recommendation System. The system helps small farmers pick the equipment and seeds based on data. I notice that the system uses machine learning to look at inputs such, as farm size, crop type, soil texture and budget. The system then recommends the machinery. The recommended machinery includes tractor horsepower, tiller type and harvester size. The system also finds seed varieties that're cost and good, for the farmer's resources. The system works well. The system's design is supported by existing research in agricultural decision support. Zhai et al. (2020) describe how agricultural DSS integrate soil, climate, and market data to enhance decision-making, while Yousaf et al. (2024/2025) discuss how AI, IoT, and Agriculture 4.0 tools can assist small farmers. For machinery recommendations, Sayed et al. (2024) demonstrate the value of combining machine learning with the Analytic Hierarchy Process (AHP) for tractor selection. For seed decisions, Senapaty et al. (2024) and Shams et al. (2024) show how ML and explainable AI improve crop and seed suitability assessment. By integrating these insights, the proposed system aims to reduce decision errors, improve productivity, and make smart farming more accessible to low-income farmers.

Colorimetric Detection Of Uric Acid By The Use Of Copper-Zinc Nanoparticles Deposited On Hydroxyapatite

*Sadia Mazhar, Amir Badshah, Umar Nishan
Department Of Chemistry Kohat University of Science and Technology
Email: abehayat356@gmail.com*

Uric acid (2,6,8-trihydroxypurine), the end product of purine breakdown in the human body, has been recognized as a significant biomarker with increasing applications other than those in gout and other related conditions. Its normal blood levels are generally considered to be 3.4–7.0mg/dL (200–420 μ M) in males and 2.4–6.0 mg/dL (140–360 μ M) in females, with the daily urinary excretion ranging from 250–750 mg (approximately 1.5–4.5 mmol depending on the volume of the urine). Higher levels of serum uric acid have also received considerable attention in recent times due to potential connections with hypertension, cardiovascular problems, leukemia, renal stones, and renal issues. Conventional analysis methods used for uric acid estimation, such as high-performance liquid chromatography, capillary electrophoresis, and electrochemical analysis, are highly accurate but are associated with drawbacks like high cost, needs for specialized knowledge and facilities, longer analysis time, and restricted availability. However, uric acid sensors based on nanoscale metal particles are on their way to gaining popularity because of their interesting electrical, optical, catalytic, and magnetic properties to create highly sensitive and selective uric acid assays that are also quick and inexpensive. Here we synthesized

Cu-ZnO@HAp nanoparticles for colorimetric detection of uric acid. The nanoparticles that we synthesized were characterized by spectroscopic techniques like FTIR spectra in the range of 4000-400cm⁻¹ that confirm the presence of some functional group (OH-, PO4-), the XRD pattern elucidate and confirm the material crystallinity and corresponding to the Cu-ZnO@HAp. The elemental composition and the chemical state of the constituents' elements, was confirmed by XPS analysis. Scanning electron microscope (SEM) and transmission electron microscope (TEM) shows the surface morphology of the synthesized Cu.ZnO@HAp that presents a successful doping of metal in hydroxyapatite. This biosensor exploits the intrinsic peroxidase-like catalytic activity of Cu-ZnO@HAp, which oxidizes 3,3',5,5'-tetramethylbenzidine in the presence of hydrogen peroxide to a distinct blue-green color. The uric acid reduces the oxidized TMB successfully, inducing a visible color fade from blue-green to colorless for naked-eye detection. Experimental parameters were systematically optimized, including pH, concentration of TMB, concentration of H₂O₂, amount of nanoparticles, and reaction time. Under the best conditions, pH 4.0, 8 mM TMB, 20mM H₂O₂, and 4 mg of nanoparticles shows maximum efficiency. Under optimal conditions, the proposed biosensor showed a linear detection concentration ranging from 50 µM to 400 µM with a limit of detection of 8.8 µM and limit of quantification of 26.5µM with good linearity ($R^2 = 0.9952$). The selectivity experiments showed good selectivity to uric acid over interferents like ascorbic acid, glucose, dopamine, tyrosine, oxalic acid, and glycine. The proposed colorimetric assay is a simple, fast, inexpensive, and visually readable biosensing strategy that can be used for point-of- care diagnostics as well as for real sample determination.

Economics From Cultivating Lemongrass To Distilling Essential Oil Under Steam Distillation Method In Punjab

Rashed Saeed¹, Arshed Bashir¹, Naveed Ahmad²

¹(PARC) Social Sciences Research Institute, AARI, Faisalabad.

²Horticultural Research Sub-Station for Floriculture and Landscaping, AARI, Faisalabad.

Corresponding Author: rashedkasuri@gmail.com

Essential oil production is an innovative and emerging profitable area in the country because of rising consumer demand for natural and herbal products in cosmetics, pharmaceutical, perfumery, aromatherapy and wellness sectors. But the limited awareness of our farmers and the processors about distillation methods and use of essential oils as well as poorly developed essential oil market are some of the challenges confronting the development of essential oil industry in Pakistan. In this background, present research study attempted to fill this gap by providing practical and comprehensive financial and technical knowledge about growing own lemongrass for extraction of essential oil from leaves using popular steam distillation method. The whole economic analyses from cultivating lemongrass crop to oil distillation was conducted based on market prices of inputs and output to comprehensively guide the potential investors in the business of essential oils. LPG fueled commercial distillation unit having 500 liter water holding capacity was hired to extract volatile oil at Ayub Agricultural Research Institute, Faisalabad during year 2025. The cost of production of lemongrass crop per acre reveals that

fresh lemongrass leaves cost to Rs.12 per Kg on average. Upon distillation of 100 Kg lemongrass leaves, 231 ml of pure essential oil was extracted in one round of distillation process taking around 4 hours while consuming 6 Kg LPG. Based on economic estimates of extracting essential oil, investors can earn a gross profit of Rs.122750 per month by producing and selling 11.5 liters essential oil in wholesale market (@ Rs.30/ml) with daily two rounds on distillation unit by incurring monthly operational expenses of Rs.223750/-. It can be inferred from whole analyses that a gross profit of 54% (without paying any taxes) is high enough to attract potential processors in the essential oil business that can be started even with initial small investment up to one million enjoying around 1 year payback period. Therefore, it is high time that government and private sectors should come forward to promote essential oil industry in the best interests at least of local farmers, unemployed youth and local consumers including practitioners of Unani system of medicine.

Keywords: Benefit-Cost Analysis, Cost of Production, Essential Oil, Lemongrass, Steam Distillation, Punjab

Synthesis and Characterization of Titania Nanocomposites of Triphenyl amine Based Polyimide for Fluorescent Antimicrobial Coating

Gul meenah

Department of Chemistry Kohat University of Science & Technology Kohat-26000 Khyber Pakhtunkhwa, Pakistan

Inorganic nanocomposites have received considerable interest due to their increased multifunctionalities and future applications in optoelectronics, sensing and protective coatings. The current study aimed at synthesizing and describing titania (TiO₂) nanocomposites with triphenylamine (TPA) based polyimide to use in the application as fluorescent antimicrobial coatings. Triphenylamine based polyimide was identified as a polymer backbone due to the high thermal stability, mechanical stability, chemical stability, and inherent fluorescence; at the same time, TiO₂ nanoparticles were added to improve the fluorescence, thermal stability, and antimicrobial properties. Titania nanoparticles were prepared using a more workable sol-gel procedure and subsequently incorporated into the polyimide matrix at moderate weight percentages (0.1, 0.3 & 0-0.5 wt %) to acquire uniform dispersion and improvement of aggregate induced emission behaviour. The nanocomposites thus obtained were characterized in a systematic manner using the spectroscopic, optical, thermal, and mechanical methodologies of analysis. UV- visible absorption and photoluminescence spectroscopy were used to study optical and fluorescence properties and the fluorescence quantum yields were measured. The thermal stability and mechanical properties were assessed by use of thermogravimetric analysis, differential scanning calorimetry and standardized mechanical testing procedures. The agar well diffusion method was used to determine antimicrobial efficacy against selected Gram-positive, Gram-negative, bacterial, and fungal strains. The data revealed that polyimide, titania nanocomposites could be used as multifunctional fluorescent and antimicrobial coating materials that can be applied in the high-technological process. These results add new knowledge on the

structure property relationships that control the behaviour of functional polymer nanocomposites.

Field Evaluation of Onion Genotypes for Susceptibility to Iris Yellow Spot Virus

Sabeeha Firdous, Saba Saeed

Department of Plant Pathology, University of Agriculture Faisalabad

Iris yellow spot virus (IYSV) adversely affect onion (*Allium cepa* L.) production worldwide, posing an economically important constraint. Therefore, systematic screening to identify resistant genotypes is essential. We evaluated fifteen onion varieties under natural field conditions to assess their resistance to IYSV. Disease severity, thrips populations, and leaf-age-specific incidence were recorded weekly from week 10 to 14 post-transplanting. Significant variation was observed among varieties in disease severity and incidence. Resistant varieties, including VR 10-9, GGAS-AC-64, and VR 10-3, maintained low disease ratings and limited lesion development despite moderate thrips activity, while susceptible varieties such as Desi Red and ICS-ON-2015 showed rapid symptom progression and nearly 100% infection in older and middle-aged leaves. Intermediate varieties exhibited moderate disease development, with older leaves more affected than younger leaves. This highlights the importance of varietal resistance in managing IYSV and provides practical guidance for selecting suitable cultivars. Furthermore, incorporating resistant varieties into breeding programs can enhance sustainable onion production and reduce dependence on chemical control of thrips.

Assessing The Impact Of Weather Variables On Cotton Sucking Pest Outbreaks Using Random Forest Models

Maria Bibi¹, Shouket Zaman Khan², Rana Muhammad Saleem³

¹Department of Information and Communications Engineering, Faculty of Computer Science, University of Murcia, 30100, Spain

²Department of Entomology, University of Agriculture, Faisalabad, Constituent College, Burewala 61010

³Department of Computer Science, University of Agriculture, Faisalabad, Constituent College, Burewala 61010

Corresponding Author: maria.bibi@um.es

Sucking pests pose a significant threat to cotton (*Gossypium hirsutum* L.) productivity in major cotton-growing regions worldwide. The dynamic interaction between environmental variables and pest population dynamics presents an opportunity for predictive modeling through machine learning techniques. This study aimed to assess the impact of key weather variables on outbreaks of major cotton sucking pests—including whitefly (*Bemisia tabaci*), jassid (*Amrasca biguttula biguttula*), and aphid (*Aphis gossypii*)—using a Random Forest (RF) model. The research was conducted over two consecutive kharif seasons (2023–2024) across three tehsils (Burewala, Vehari and Mailsi) of District Vehari in Punjab, Pakistan, employing a randomized complete block design (RCBD) with five standard cotton cultivars (CIM-496, FH-142, IUB-13, MNH-886, and BT-370) as treatments and three replications per site. Weekly data on pest population (number of insects per leaf) were collected through field scouting, while concurrent meteorological data

including average temperature, relative humidity, rainfall, wind speed, and sunshine hours—were obtained from automated weather stations installed at each experimental site. The RF model was trained using 70% of the collected dataset and validated with the remaining 30%. Model performance was evaluated using R^2 , Root Mean Square Error (RMSE), and Mean Absolute Error (MAE). The RF model showed strong predictive performance ($R^2 = 0.87$, RMSE = 1.98, MAE = 1.29), with temperature and relative humidity emerging as the most influential variables contributing to pest outbreaks. Whitefly populations were found to peak between 32–36°C and 55–65% relative humidity, while jassid outbreaks were positively correlated with lower rainfall and moderate temperature conditions. Sensitivity analysis and feature importance metrics confirmed that fluctuations in minimum temperature and relative humidity two weeks prior to observation were key predictors. These results validate the effectiveness of Random Forest models in identifying critical weather thresholds for pest development and support their integration into early warning systems for pest outbreaks. The outcomes offer a scalable solution for enhancing pest surveillance and timely management decisions in climate-sensitive cotton production systems.

Keywords: Pest scouting, monitoring systems, key predictors, pest outbreaks, production systems.

Computational Analysis of Sortilin Signaling and Gene Regulation in the Pathogenesis of Cardiac Ischemia

Areej Tahir, Muhammad Ishtiaq Jan, Saima Gul

Department of Chemistry, Kohat University of Science and Technology, Kohat, Pakistan

Email: areej.k2828@gmail.com

Cardiac ischemia is the leading cause of both morbidity and mortality among the non-communicable diseases in the world, with a prevalence estimated to be 17.0%. This pathological condition is driven by complex molecular pathways associated with oxidative stress, inflammation, and apoptosis. Latest researches highlight the importance of Sortilin (SORT1) from the Vps10p domain family, as the major regulator of cardiac ischemia. It works by connecting with the p75 NTR Neurotrophin Receptor in conjunction with proNGF to activate JNK, which promotes the mitochondrial dysfunction and caspase dependent cell death. This research focused on docking analysis of SORT1 and its regulated genes, including Bax, caspase 3/9, and Drp1, with different antioxidants to find the most suitable regulator of SORT1 and its signaling pathway. Molecular docking of SORT1 and its regulated genes with different antioxidants was performed to find interactions and binding affinity between them via PyRx. The docking score, binding affinity and hydrophobic interactions were analyzed with Discovery Studio Visualizer. Redocking of known co-crystallized ligands and ADME assessment was performed to validate the accuracy of the obtained docking results. The docking analysis presented the stable interactions and binding affinities of some specific antioxidants with SORT1, and its regulated apoptotic genes. Hydrogen bonding, hydrophobic contacts, and electrostatic forces were the characteristics of these interactions, which may have inhibited or modified SORT1-mediated

apoptotic signaling. Gaining an understanding of these molecular interactions could lead to the discovery of therapeutic modulators of SORT1-mediated signaling, providing new information on how to prevent and treat cardiac ischemia.

Keywords: Cardiac ischemia, sortilin signaling (SORT1), Gene regulated by sortilin (JNK signalling pathway), Molecular docking, Binding Affinity

Foraging Behaviour of Honeybees and Its Impact on Crop Pollination

Haseeb Ahmad

Department of Entomology, University of Agriculture Faisalabad Constituent College Depalpur, Okara

Correspondence: haseebimam393@icloud.com

Foraging behaviour is one of the most distinctive and ecologically important behaviours of honeybees, serving as a critical link between the colony and its surrounding environment. This behaviour is influenced by a wide range of in-colony factors (such as colony strength and nutritional status) and out-colony factors (including floral availability, habitat structure, and competition) and has therefore been extensively studied. Understanding and managing honeybee foraging behaviour is practically important, as it directly affects colony productivity and provides substantial agricultural benefits through pollination. Honeybees (*Apis mellifera*) are the most widely used managed pollinators in modern agriculture, and their behavioural ecology strongly determines how efficiently floral visits are translated into crop pollination and yield. Key foraging traits such as foraging distance and range, waggle-dance, visitation rate, and floral constancy play a central role in pollination efficiency across different crops. Honeybee foraging typically occurs within a 2000-3000 meters of the hive; however, habitat loss and increased competition can extend flight distances, raise energy costs, and reduce per-bee pollination efficiency. High visitation rates and strong floral constancy enhance conspecific pollen transfer, which is particularly important for hybrid seed production and outcrossing crops. Insects play a role in growing about three out of every four major food crops globally, yet wild pollinator populations are declining worldwide. Consequently, managed colonies of *Apis mellifera* are increasingly deployed in agricultural fields. Future research should focus on crop-specific relationships between hive density and pollination outcomes and integrate waggle-dance dynamics into field-scale pollen transfer models.

Keywords: *Apis mellifera*, foraging behaviour, crop pollination, floral constancy, pollination efficiency, waggle dance.

Antimicrobial And Antioxidants Evaluation Of Crude Extract And Derived Fractions Obtained From *Plocama Hymenostephana* (Jaub. & Spach) M.Backlund & Thulin

Farhat Ullah khan, Dr. Muhammad Adnan, Dr. Nisar Ahmad,

Department of Botany Kohat University of Science & Technology, Kohat-26000

Email: farhatkhanmsc810@gmail.com

Medicinal plants are an important source of natural compounds and have been used for centuries in traditional medicine to treat many diseases. Even today, they play a key role in modern drug

discovery because they contain bioactive substances such as phenolics and flavonoids, which show antimicrobial and antioxidant effects. However, many medicinal plants that are commonly used by local communities have not yet been scientifically studied. *Plocama hymenostephana* (Jaub. & Spach) M. Backlund & Thulin is a rare perennial shrub belonging to the family Rubiaceae and is distributed from Arabia to Pakistan through Iran and Afghanistan. In local traditional practices, this plant is used to kill harmful germs and to protect the body from damage caused by free radicals, but there is no scientific evidence available to support these claims. The present study aims to evaluate the antimicrobial and antioxidant activities of the crude methanolic extract and different solvent-based fractions of *P. hymenostephana*. Fresh aerial parts of the plant will be collected from the Suddak Hills, Kohat Division, Khyber Pakhtunkhwa, Pakistan, and their identity will be confirmed by a qualified botanist. The collected plant material will be shade-dried, powdered, and extracted using methanol. The crude extract will then be fractionated into n-hexane, chloroform, ethyl acetate, butanol, and aqueous fractions based on differences in solvent polarity to separate various bioactive compounds. Antimicrobial activity will be evaluated using the agar well diffusion method against selected pathogenic microorganisms, including *Escherichia coli* and *Candida albicans*. Antioxidant potential will be assessed using the DPPH free radical scavenging assay to determine the ability of the plant extracts to neutralize free radicals. The experimental data will be statistically analyzed using one-way analysis of variance (ANOVA) to determine significant differences among treatments. This study is expected to provide the first scientific validation of the traditional medicinal uses of *Plocama hymenostephana* and may highlight its potential as a natural source of antimicrobial and antioxidant agents, contributing to improved human health and supporting Sustainable Development Goal 3 (Good Health and Well-being).

Biological Control Strategies for Citrus Canker in Pakistan: Current Advances and Future Perspectives

Hania Younas

Department of Plant Pathology, University of Agriculture Faisalabad, Constituent College Depalpur, Okara

Correspondence: haniayounas20@gmail.com

Citrus canker, caused by *Xanthomonas citri* subsp. *citri*, is one of the most destructive bacterial diseases of citrus in Pakistan, particularly in Punjab, the major citrus-producing region. The disease spreads rapidly through wind-driven rain, contaminated tools, insects, and infected plant material, causing characteristic raised necrotic lesions on leaves, fruits, and twigs. Severe infections result in defoliation, premature fruit drop, reduced fruit quality, and significant economic losses. Conventional management strategies, including copper-based bactericides and sanitation practices, provide limited and short-term control and raise concerns regarding environmental safety and pathogen resistance. Biological control has emerged as a sustainable and eco-friendly alternative for citrus canker management. This review summarizes current advances in biological control strategies, focusing on the role of antagonistic microorganisms such as *Bacillus subtilis*, *Pseudomonas fluorescence*, and *Trichoderma* spp. These agents

suppress the pathogen through mechanisms including antibiosis, competition, and induction of host defense responses. Integration of biological control agents within an Integrated Pest Management (IPM) framework along with resistant cultivars, pruning of infected tissues, orchard sanitation, tool disinfection, and disease monitoring has shown considerable potential in reducing disease severity while minimizing chemical dependence. The review also highlights key challenges, research gaps, and future prospects for the wider adoption of biological control strategies in Pakistan, emphasizing the need for locally adapted formulations, improved delivery systems, and increased farmer awareness to ensure sustainable citrus production.

Keywords: Citrus canker, *Xanthomonas citri* subsp. *citri*, biological control, biocontrol agents, Integrated Pest Management (IPM), sustainable disease management, citrus production, Pakistan

Evaluation Of Antibacterial And Antibiofilm Potency Of Opuntia Ficus-Indica Extracts Against Multi-Drug-Resistant Bacteria

Ibrar Muhammad Khan, Muhammad Qasim, Abdul Rehman

Department of Microbiology, Kohat University of Science and Technology, Kohat, Pakistan

Email address: 313imkhan@gmail.com, qasim@kust.edu.pk

Background: Global health is seriously threatened by antimicrobial resistance, with multi-drug resistant (MDR) bacteria increasingly implicated in severe and life-threatening infections. Current antibiotics face several challenges, including narrow spectra of activity, adverse side effects, and a significant risk of resistance development. *Opuntia ficus-indica* (prickly pear cactus), traditionally recognized for medicinal applications, contains diverse phytochemicals with potential antibacterial activity but remains largely unexplored in Pakistan. The current study is to access the antibacterial and antibiofilm activities of *Opuntia ficus-indica* extracts against MDR bacteria, along with phytochemical and structural characterization.

Methods: Fresh cladodes were collected, shade-dried, and extracted using ethanol and distilled water. Preliminary phytochemical screening was performed to identify major bioactive groups, while extracellular polysaccharides (EPS) were isolated by ethanol precipitation. Antibacterial activity was assessed by agar well diffusion, and anti-biofilm activity was evaluated using a micro titer plate assay. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were determined through broth micro-dilution and sub-culturing methods. Functional groups in the extracts and EPS were analyzed using Fourier Transform Infrared (FTIR) spectroscopy.

Results: Both ethanol and aqueous extracts exhibited notable antibacterial activity, with ethanol extract showing stronger inhibition zones and lower MIC/MBC values against MDR strains. The extracts also significantly inhibited biofilm formation in a concentration-dependent manner. Phytochemical analysis confirmed the presence of phenolics, alkaloids, flavonoids, and steroids, while FTIR spectra highlighted functional groups associated with bioactive compounds.

Conclusion: In conclusion, *Opuntia.ficus-indica* demonstrates strong antibacterial and anti-biofilm potential, attributed to its rich phytochemical composition. These results suggest that this

underutilized cactus species may serve as a valuable natural source for developing novel antimicrobial agents to address the growing challenge of MDR infection.

Keywords: Antimicrobial resistance, multi-drug resistance bacteria, opuntia ficus-indica, anti-biofilm, minimum inhibitory concentration, minimum bactericidal concentration.

Valorization of Agro-Industrial By-Products for Functional Food Innovation and Sustainable Nutrition

Hafiza Madiha Jaffar

Institute of Diet and Nutritional Sciences, University of Lahore

Email: madiha.jaffar@dnsc.uol.edu.pk

The escalating demand for nutrient-dense foods and the concurrent need to reduce agro-industrial waste have converged into a transformative paradigm within modern food science. This study explores the valorization potential of agro-industrial by-products such as cereal bran, fruit pomace, and oilseed residues for their enrichment in polyphenols, dietary fibres, and bioactive compounds. Emphasis is placed on optimizing extraction techniques, enhancing bioavailability through encapsulation and fermentation, and integrating these bio-ingredients into functional food matrices. The research employs an interdisciplinary framework, combining analytical chemistry, food technology, and nutritional evaluation to assess antioxidant activity, physicochemical stability, and consumer acceptability. Findings underscore that the strategic re-utilization of agricultural residues not only advances circular bioeconomy models but also fortifies public health through the development of cost-effective, sustainable, and functional food products. The study advocates for strengthened academia-industry collaborations to scale these innovations within the agri-food sector, thereby contributing to food security, environmental preservation, and economic sustainability.

Keywords: Functional foods, agro-industrial by-products, bioactive compounds, circular bioeconomy, sustainable nutrition.

Maternal Dietary Fiber Intake During Pregnancy: Associations with Maternal Diet Quality, Pregnancy Health, and Infant Outcomes

Faiza Batool

Department of Human Nutrition and Dietetics, Riphah International University, Faisalabad

Dietary fiber intake during pregnancy has gained increasing interest due to its potential to modulate maternal metabolic health, gut microbiome composition, and early-life immune development. This integrative review synthesizes findings from observational human studies and experimental supplementation research to evaluate the role of maternal fiber intake in dietary patterns, pregnancy outcomes, and infant health. Evidence indicates that higher total dietary fiber consumption in late pregnancy is associated with improved maternal diet quality, particularly increased fruit and vegetable intake, and favorable sociodemographic correlates such as older maternal age and higher educational attainment. Despite these benefits, most pregnant women fail to meet recommended Adequate Intake levels for fiber, highlighting a

substantial nutritional gap that may be addressed through targeted antenatal nutrition education focused on increasing fruit and vegetable consumption. Emerging research examining fiber subtypes demonstrates distinct relationships with infant allergic disease, with resistant starch intake associated with reduced risk of infant wheeze but an increased risk of eczema, suggesting complex immune-modulatory effects mediated through maternal–infant microbiome interactions. Complementary experimental animal studies further support the biological relevance of fiber intake during gestation and lactation, showing that supplementation with complex dietary fibers enhances maternal antioxidant status, improves milk quality, increases microbial diversity, and promotes offspring growth performance while reducing inflammatory markers. Collectively, current evidence underscores the multifaceted impact of maternal dietary fiber on both maternal well-being and early-life health outcomes. Future research should prioritize large, well-designed human intervention trials to clarify optimal fiber types and intake levels, explore underlying mechanisms involving the gut microbiome and immune development, and inform evidence-based dietary recommendations to improve maternal and infant health.

Purple Leaf Spot Disease in Tomato (*Solanum lycopersicum*)

Abdul Rehman, Muhammad Ashiq Waseem

Department of Agriculture, University of Agriculture Faisalabad (UAF), Okara Campus

Purple Leaf Spot Disease in tomato (*Solanum lycopersicum*) is an emerging fungal problem caused by *Alternaria alternata*, mainly observed in warm and humid conditions. The disease starts as small purple or dark brown spots on older leaves, which slowly grow larger and develop light centers with dark edges. As the infection spreads, leaves turn yellow, dry up, and fall off early. This reduces photosynthesis, weakens plant growth, and results in small fruits and poor yield. The fungus survives in infected crop residues and spreads through wind, rain splash, contaminated seeds, and irrigation water, especially when fields have poor air movement and excess moisture. Purple Leaf Spot can reduce tomato yield by up to 30–40% in severely infected fields and also makes plants more sensitive to other diseases. Effective control requires good farm management practices such as crop rotation, removal of infected plant debris, and proper plant spacing. The use of disease-tolerant varieties is helpful where available. Early application of simple fungicides like copper-based sprays or mancozeb can reduce disease spread. Biological control using beneficial fungi such as *Trichoderma harzianum* is a safe and eco-friendly option. Early detection and integrated management are the best ways to protect tomato crops and ensure sustainable production.

Exploring The Effects Of Dietary Oyster Mushroom On Growth And Hematology Of Grass Carp (*Ctenopharyngodon Idella*)

Afaq Hussain¹, Muhammad Rauf¹, Farman Dawar²

¹Department of Zoology, Kohat University of Science and Technology, Kohat, Khyber Pakhtunkhwa, Pakistan.

²Department of Zoology, Kohat University of Science and Technology, Kohat, Khyber Pakhtunkhwa, Pakistan.

This study was designed to evaluate the effects of dietary supplementation of *Pleurotus ostreatus* powder on growth performance and haematological parameters of grass carp (*Ctenopharyngodon idella*). Following a two-week acclimatization period, fish were randomly allocated into four dietary groups: a control group (G0) fed a basal diet without mushroom supplementation, and three experimental groups receiving diets supplemented with *P. ostreatus* powder at inclusion levels of 5 g/kg (G1), 10 g/kg (G2), and 15 g/kg (G3) of feed for a feeding trial of 45 days. Growth performance was evaluated based on body weight changes, weight gain, and specific growth rate, while haematological indices including red blood cell count, white blood cell count, haemoglobin concentration, hematocrit, and platelet count were analyzed using standard laboratory techniques. The results demonstrated that dietary inclusion of *P. ostreatus* positively influenced both growth performance and haematological parameters in a dose-dependent manner. Fish fed mushroom-supplemented diets exhibited significantly improved growth indices and enhanced blood profiles compared to the control group, indicating improved physiological condition and immune stimulation. The observed findings are in agreement with earlier studies reporting the growth-promoting and immunomodulatory effects of oyster mushroom supplementation in aquaculture species. In conclusion, *P. ostreatus* powder can be considered an effective, natural, and eco-friendly functional feed additive for grass carp. Its dietary inclusion has the potential to improve growth performance and haematological health, thereby contributing to sustainable aquaculture practices and reducing reliance on synthetic growth promoters.

Keywords: Dietary supplementation, Growth performance, Haematological parameters, Functional feed additive, Sustainable aquaculture, Natural growth promoter

Pine Cone Derived Biochar And Its Application In Absorptive Removal Of Selected Heavy Metals From Aqueous Solutions: Kinetic And Thermodynamic Studies

Haseena Bibi

Department Of Environmental Sciences, Kohat University of Science & Technology

The adsorption effectiveness of biochar made from pine cones for the removal of Pb and Cd ions from aqueous solutions is examined in this work, with a focus on kinetic, isothermal, and thermodynamic behavior. By carefully pyrolyzing pine cones, (600 °C) biochar was created and its morphological and surface characteristics were assessed. Controlled pyrolysis with low oxygen levels was used to create pine cone biochar. Fourier Transform Infrared Spectroscopy (FTIR) was used to detect surface functional groups, Scanning Electron Microscopy (SEM) was used to study surface morphology and porosity, and X-ray diffraction (XRD) was used to analyze structural characteristics in order to characterize the physicochemical properties of the biochar. The effects of temperature, solution pH, initial metal ion concentration, and contact time on adsorption efficiency were assessed by batch adsorption studies. A very porous structure with well-developed channels and irregular cavities was shown by SEM examination, offering plenty of active sites for metal ion interaction. Following adsorption, surface smoothening and partial

Pore blockage were visible in SEM micrographs, indicating that Pb and Cd had successfully been deposited onto the surface of the biochar. Batch adsorption tests showed that pH, adsorbent dose, and beginning metal concentration all had a significant impact on metal removal. Adsorption peaked close to neutral pH. Chemisorption was identified as the primary rate-controlling mechanism by kinetic data that closely matched the pseudo-second-order model. The Langmuir isotherm fit the equilibrium data quite well, indicating monolayer adsorption on a homogeneous surface. According to thermodynamic analysis, both metals' adsorption was endothermic (positive ΔH°), spontaneous (negative ΔG°), and accompanied by an increase in randomness (positive ΔS°) at the solid-solution interface. Overall, the results show that biochar made from pine cones is an effective, affordable, and sustainable adsorbent for eliminating Pb and Cd from water, making it a material that shows promise for use in future environmental remediation applications.

Keywords: Pinecone, Pyrolysis, Biochar, Heavy Metals, Adsorption, Kinetics, Thermodynamics, Biochar Characterization, Langmuir Isotherm, Synthetic Water.

Comparative efficacy of entomocidal chemicals applied through drip chemigation against fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

Abdul Rehman Bilal¹, Tariq Mustafa¹, Hamza Rashid¹, Habib Ur Rehman²

¹Department of Entomology, University of Agriculture Faisalabad, Constituent College, Depalpur, Okara.

²Water Management Research Farm, Renala Khurd, Okara, Pakistan

Fall armyworm, *Spodoptera frugiperda* L. (J.E. Smith), is a notorious insect pest that causes qualitative and quantitative losses on a number of economically important crops especially maize (*Zea mays* (L.)). Maize is considered an important cereal and has great impact in the economy of Pakistan. The experiment was conducted to assess the effectiveness of different entomocidal chemicals (Emamectin Benzoate + Lufenuron, Chlorpyrifos + Lambda-cyhalothrin, and Neem extract) through two application methods, drip chemigation and foliar application. Furthermore, crop water productivity and population dynamics of fall armyworm was also observed. The trial was conducted using a randomized complete block design (RCBD) with three replications of each treatment. Mortality data of the fall armyworm was recorded after 1, 3, 5 and 7 days of applications. In first and second round of drip chemigation, the lowest infestations were recorded 3.34% and 1.67% against the treatment Emamectin Benzoate + Lufenuron and the highest infestations were recorded 43.43% and 36.67% against the treatment Neem extract respectively other than control. While in first and second round of foliar application, the lowest infestations were recorded 6.67% and 10.0% against the treatment Emamectin Benzoate + Lufenuron and the highest infestations were recorded 66.67% and 58.34% against the treatment Neem extract respectively other than control. The mean population incidence showed that highest population incidence (5.63 larvae/ 5 plants) was noted in the month of august trailed by July (3.57 larvae/ 5 plants) while the minimum (2.43 larvae/ 5 plants) was observed in month of September. The maximum crop water productivity (1.23 Kg/m³) was observed in drip irrigation while lower

(0.525 Kg/m³) in flood irrigation. In both rounds of insecticides application results revealed that the mixture of Emamectin Benzoate + Lufenuron was found effective against the larvae in both drip chemigation and foliar application but in drip chemigation found more effective.

Zygogramma bicolorata: A Safe Biological Control Agent for Parthenium hysterophorus Management

Abaid Ullah Naseem¹, Muhammad Faiq Ali¹, Muhammad Sannan Siddique¹, Tariq Mustafa¹, Habib Ur Rehman²

¹Department of Entomology, University of Agriculture Faisalabad, Constituent College, Depalpur, Okara.

²Water Management Research Farm, Renala Khurd, Okara, Pakistan

The invasive weed *Parthenium hysterophorus* L. (Asteraceae), has spread worldwide endangering agricultural, environmental, and public health. In Pakistan, *Parthenium* has spread aggressively, infesting crops, urban areas, and rangelands. Currently, *Parthenium* is managed manually, and with herbicides, which not only cause economic losses but also causes environmental and health issues. The current study investigated the developmental biology and host specificity of *Zygogramma bicolorata* on *Parthenium*, potato, and maize. The *Z. bicolorata* successfully completed its life cycle only on *Parthenium*. The mean pre-oviposition and egg incubation periods were 8.63 ± 0.39 and 3.30 ± 0.14 days, respectively on *Parthenium*. Larval developments ranged from 2.56 ± 0.13 to 2.95 ± 0.17 days in all four instars. The pre-pupal and pupal stages were 2.84 ± 0.16 and 9.56 ± 0.27 days, respectively. High fecundity (970 ± 12.29 eggs per female) and extended adult longevity further confirmed *Parthenium* as the optimal host. No oviposition was observed on potato, and maize compared to *parthenium*, where the *Z. bicolorata* have successfully laid eggs and completed its life cycle. No *Z. bicolorata* larvae survived beyond 2.1, and 3.4 days on potato, and maize respectively. The Leaf consumption was higher on *Parthenium* (99.43 leaves after 24 days), whereas no feeding symptoms were observed on potato and maize. Adult's longevity was also significantly higher on *Parthenium* (81.16 days) compared with potato (10.24 days) and maize (8.56 days) respectively. Overall, our findings demonstrate a strong host specificity of *Z. bicolorata* towards *P. hysterophorus*, supporting its suitability and safety as a biological control agent for the sustainable management of *Parthenium*.

Antiulcer Activities And Phytochemical Analysis Of Polyherbal Formulation Use To Treat Human Mouth Ulcers

Nazish Gulfam¹, Nisar Ahmad¹, Mubashir Hussain²

¹Department of Botany, Kohat University of science and technology, Kohat, Khyber Pakhtunkhwa, Pakistan

²Department of Microbiology, Kohat University of science and technology, Kohat Khyber Pakhtunkhwa, Pakistan

Corresponding Author: nisarahmad@kust.edu.pk

Oral ulcers are common inflammatory lesions of the oral mucosa that cause significant discomfort and negatively affect quality of life. In Khyber Pakhtunkhwa, Pakistan, polyherbal formulations are traditionally used for the treatment of mouth ulcers; however, most lack scientific validation. The present study aimed to evaluate the antiulcer activity and

phytochemical composition of a locally used polyherbal formulation intended for the management of human mouth ulcers. The polyherbal formulation was prepared using selected medicinal plants traditionally employed for oral ulcer treatment. Phytochemical screening was performed to identify major bioactive constituents. Phytochemical analysis revealed the presence of phenolics, flavonoids, tannins, alkaloids, and saponins. The antiulcer potential was determined using experimental oral ulcer/wound-healing models by measuring ulcer size reduction, healing time. Our polyherbal extract showed promising inhibition against ulcer causing agents. The findings provide scientific evidence supporting the traditional use of the polyherbal formulation for the treatment of mouth ulcers. The observed antiulcer activity may be attributed to the synergistic effects of its bioactive phytochemicals. This formulation may serve as a safe, effective, and economical therapeutic option for oral ulcer management.

Keywords: Polyherbal formulation, Mouth ulcers, Antiulcer activity, Phytochemical analysis, Oral wound healing, Traditional medicine

Characterization Of Probiotics From Raw Camel Milk And Their Antagonistic Activity Against Multidrug Resistant Enteropathogens

*Syed Haider Ali Shah Noorani, Baharullah Khattak, Saqib Malik, Hassan Naveed
Department of Microbiology kohat University of Sciences and Technology Kohat, Khyber
Pakhtunkhwa Pakistan*

Corresponding Author Email: baharkk75@gmail.com

Raw camel milk is a rich source of indigenous probiotic microorganisms with potential health benefits. In recent years, the emergence of multidrug-resistant (MDR) enteropathogens has intensified the search for alternative, natural antimicrobial agents. Probiotics isolated from camel milk may offer a promising biocontrol strategy due to their ability to inhibit pathogenic bacteria through competitive exclusion and antimicrobial metabolite production. Raw camel milk samples were collected aseptically and subjected to microbiological analysis for the isolation of probiotic bacteria using selective culture media. Isolates were characterized based on morphological, biochemical, and physiological properties, including Gram staining, catalase activity, and carbohydrate fermentation profiles. Molecular identification was performed using 16S rRNA gene sequencing. The antagonistic activity of the identified probiotic strains was evaluated against MDR enteropathogens (including *Escherichia coli*, *Salmonella* spp., and *Shigella* spp, *Klebsilla pneumonia.*, *pseudomonas aurginosa*) using agar well diffusion and co-culture assays. Several probiotic strains, predominantly belonging to the genera *Lactobacillus*, *Enterococcus*, and *Bifidobacterium*, were successfully isolated from raw camel milk. These isolates demonstrated high tolerance to acidic pH and bile salts, indicating their probiotic potential. Significant antagonistic activity was observed against all tested MDR enteropathogens, with clear inhibition zones ranging from moderate to strong. The antimicrobial effect was attributed to the production of organic acids, bacteriocins, and other inhibitory metabolites. Raw camel milk harbors diverse probiotic bacteria with strong antagonistic activity against multidrug-resistant enteropathogens. These findings highlight the potential application of camel milk-derived probiotics as natural

antimicrobial agents and functional food components to combat antibiotic-resistant gastrointestinal infections.

Keywords: Camel milk; Probiotics; Multidrug-resistant enteropathogens; Antagonistic activity; Lactobacillus; Functional foods

Phytochemical Analysis and Anti-Pharyngitic Activities of Polyherbal Formulation Used To Treat Pharyngitis in Humans

Nazish Ali, Dr Nisar Ahmad

Department of botany, Kohat University of science and technology

Corresponding authors: arhamkhattak102@gmail.com

One of the most widespread airways infections people contract all over the world is pharyngitis that is an inflammation of the throat lining commonly known as sore throat. The healthcare system today is being driven by the massive issue of antibiotics being rendered useless due to bacteria developing resistance mechanisms. This is why herbs can be used to provide help to people; they include a large number of various chemicals. There are many small chemical structures produced in plants, including alkaloids, flavonoid, tannin, saponin, terpenoid and other active components. They are able to combat germs and inflammation, prevent the occurrence of free radicals, alleviate pain, boost the immune system, repair cuts, assist in the regulation of blood sugar, prevent cancer and support the heart. In this study, a total of four medicinal plants samples were collected from the local market of District Kohat, and then used them to make extracts using methanol and test the extracts in a laboratory against the bacteria that cause pharyngitis. The well-diffusion method was used to determine the antibacterial activity. The bioactive constituents were identified using Phytochemical screening tests. Gas Chromatography-Mass Spectrometry (GC-MS) were also done to determine what active compounds were present in the extracts. The paper also explains the process of data collection by us and the statistics performed in order to investigate the combined effects of the herbs. The polyherbal throat infection formulation showed clear dose-dependent antibacterial and phytochemical activity. Against *Streptococcus pyogenes*, the lowest inhibition was observed at 25% concentration (10.2 mm), while the highest inhibition occurred at 100% concentration (20.9 mm), compared with the positive control ciprofloxacin (26.0 mm) and no inhibition by distilled water (0 mm). Similarly, against *Staphylococcus aureus*, the minimum zone of inhibition was recorded at 25% (8.2 mm) and the maximum at 100% (21.2 mm), whereas ciprofloxacin produced 25.4 mm inhibition. Phytochemical screening revealed that tannins and saponins were present in all plant extracts, while flavonoids were the least detected and observed only in fenugreek. GC-MS analysis identified 22 compounds, with eugenol as the most abundant constituent (36.57%) and β -sitosterol as the least abundant (0.53%). Overall, the highest antibacterial activity and dominant phytochemicals support the strong antimicrobial potential of the polyherbal formulation.

Keywords: Pharyngitis, Polyherbal formulation, Antibacterial activity, GC–MS analysis, Antibiotic Resistance

Green Synthesis Of Carbon Dots From Peanut Shell And Their Applications In Metal Ion Detection

Muhammad Awais, Muhammad Iqbal Khan, Saima Gul, Shahab Rauf

Chemistry Department, Kohat University of Science and Technology, Kohat 2600, Pakistan

Corresponding author Email: awais06062000@gmail.com

Carbon dots (CDs) have emerged as promising fluorescent nanomaterials due to their excellent photoluminescence, biocompatibility, and environmental friendliness. In this work, fluorescent carbon dots were successfully synthesized from peanut shell, an abundant agricultural waste, via a green hydrothermal carbonization route. The prepared CDs exhibited good water solubility and strong fluorescence, attributed to surface functional groups formed during biomass carbonization. The physicochemical properties of the CDs were characterized using UV–Vis spectroscopy, photoluminescence spectroscopy, FTIR, and XRD analyses. The sensing performance of the CDs was investigated for the detection of heavy metal ions in aqueous media. A significant fluorescence response was observed toward Pb^{2+} ions, demonstrating high sensitivity and selectivity. Optimization studies were carried out with respect to time, concentration, and material loading. The results highlight the potential of biomass-derived CDs as low-cost, eco-friendly fluorescent sensors for heavy metal detection in environmental and physiological samples.

Evaluation Of The Antibacterial Efficacy Of Various Green-Formulated Extracts Of Juglans Regia (Walnut) Green Husk Against Aeromonas Hydrophila

Sana Rauf, Shehzad Zareen, Muhammad Rauf

Department of Zoology, Kohat University of Science and Technology (KUST) 26000, Khyber Pakhtunkhwa, Pakistan

Email: sanarauf411@gmail.com, Zoologistonline@gmail.com

The extensive use of antibiotics in aquaculture has accelerated the development of antibiotic-resistant bacterial strains. Among the promising alternatives, plant-derived phytoextracts are gaining increasing attention as natural sources of bioactive antimicrobial compounds. The present study aimed to evaluate the antibacterial activity of ethanolic, methanolic, and acetonetic extracts of green walnut husk (*Juglans regia*) against *Aeromonas hydrophila* isolated from the aquaculture species *Labeo rohita*. Walnut husk extracts were prepared by macerating the husks in the respective solvents, then filtered and concentrated using a rotary evaporator. The antibacterial activity of each extract was assessed using the agar well diffusion method. Eight concentrations (2, 4, 6, 8, 10, 12, 14, and 16 mg/ml) were prepared for each extract. The results showed that the ethanolic extract exhibited the highest antibacterial activity at 10 mg/ml, producing a zone of inhibition (ZOI) of 21.4 mm. For the methanolic extract, the maximum antibacterial effect was observed at 14 mg/ml, with a ZOI of 21.5 mm. For the acetonetic extract, the highest activity was observed at 8 mg/ml, yielding a ZOI of 19.8 mm. Overall, the methanolic extract demonstrated the strongest antibacterial activity against *A. hydrophila*, with a mean ZOI

value of 19.15 mm, followed by the ethanolic (18.03 mm) and acetonetic (17.96 mm) extracts. These findings suggest that the green husk of walnuts contains potent antibacterial phytochemicals and may serve as a viable alternative to conventional antibiotics in aquaculture. Future studies may focus on nanoparticle-based formulations, alternative solvents, improved extraction techniques, and the isolation of individual bioactive compounds to further enhance antibacterial efficacy.

Keywords: Aquaculture, phytoextracts, *Juglans regia*, green walnut husk, *Aeromonas hydrophila*, antibacterial activity, ZOI.

Investigating The Synergistic Antimicrobial Activities Of Garlic, Onion And Honey Polyherbal Formulation Against Uropathogenic *Escherichia Coli*

Junaid Ahmad¹, Nisar Ahmad¹, Mubbashir Hussain²

¹*Department of Botany Kohat University of Science and Technology, Kohat-2600 Khyber Pakhtunkhwa, Pakistan*

²*Department of Microbiology Kohat University of Science and Technology, Kohat-2600 Khyber Pakhtunkhwa, Pakistan*

Corresponding Author Email: junaidk992@gmail.com

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide, with uropathogenic *Escherichia coli* (UPEC) being the leading causative agent. The increasing prevalence of antibiotic-resistant UPEC strains has become a major public health concern, necessitating the exploration of alternative antimicrobial strategies. Natural products and plant-derived formulations are gaining attention due to their antimicrobial efficacy, safety, and lower likelihood of resistance development. This study aimed to investigate the antimicrobial and synergistic effects of a polyherbal formulation containing garlic (*Allium sativum*), onion (*Allium cepa*), and honey against uropathogenic *E. coli*. Aqueous garlic and onion extracts and medical-grade honey were combined in equal proportions to formulate polyherbal preparation. Uropathogenic *Escherichia coli* isolates from urine samples were identified by standard methods, and antibacterial activity was assessed by agar well diffusion on Mueller Hinton agar after 24 h at 37 °C. Synergistic effects were determined by comparing the combined formulation with individual components. All individual components exhibited antibacterial activity against UPEC isolates, with garlic showing the highest inhibitory effect, followed by honey and onion. Notably, polyherbal formulation produced significantly larger zones of inhibition than any individual component. This enhanced antibacterial effect indicates a synergistic interaction among garlic, onion, and honey, likely due to the complementary mechanisms of action of their bioactive compounds. The findings demonstrate that the garlic onion honey polyherbal formulation possesses potent synergistic antimicrobial activity against uropathogenic *E. coli*. The combined formulation was more effective than individual components, highlighting the potential of polyherbal approaches as alternative or adjunct therapies for the management of UTIs. Further in vivo studies and mechanistic investigations are recommended to validate its clinical applicability.

Keywords: Uropathogenic *Escherichia coli*, Polyherbal formulation, Garlic, Onion, Honey, Synergistic antimicrobial activity, Urinary tract infections

In Vitro Antibacterial Screening Of A Polyherbal Formulation Used To Treat Lung And Gastrointestinal Infections Caused By *Escherichia coli*

Rashid Menhas¹, Nisar Ahmed¹, Mubashir Hussain²

¹Department of Botany, Kohat University of Science and Technology Kohat, Khyber Pakhtunkhwa, Pakistan

²Department of Microbiology, Kohat University of Science and Technology Kohat, Khyber Pakhtunkhwa, Pakistan

Corresponding Author Email: rashidminhas9385@gmail.com

The increasing incidence of antibiotic-resistant *Escherichia coli* has become a major global health concern, particularly in lung and gastrointestinal infections. The limitations of conventional antibiotics have encouraged the exploration of alternative therapies, including polyherbal formulations derived from medicinal plants with known antimicrobial properties. Polyherbal remedies are widely used in traditional medicine due to their synergistic effects, improved efficacy, and reduced side effects. In this study, a polyherbal formulation traditionally used for the treatment of lung and gastrointestinal infections was prepared using selected medicinal plants. The antibacterial activity of the formulation was evaluated in vitro against *Escherichia coli*. Standard microbiological techniques, including agar well diffusion and minimum inhibitory concentration (MIC) assays, were employed to assess antibacterial efficacy. Standard antibiotics served as positive controls, while the solvent was used as a negative control. The polyherbal formulation demonstrated appreciable antibacterial activity against *Escherichia coli*. A concentration-dependent increase in the zone of inhibition was observed, indicating effective suppression of bacterial growth. The MIC values confirmed the inhibitory potential of the formulation, though its activity was comparatively lower than that of standard antibiotics. The observed antibacterial effect suggests a synergistic action of bioactive phytochemicals present in the formulation. The findings of the present study indicate that the investigated polyherbal formulation possesses significant in vitro antibacterial activity against *Escherichia coli*. These results scientifically support its traditional use in the management of lung and gastrointestinal infections. Further studies involving phytochemical analysis, in vivo evaluation, and clinical trials are recommended to validate its therapeutic potential and mechanism of action.

Keywords: Polyherbal formulation, *Escherichia coli*, Antibacterial activity, Lung infections, gastrointestinal infections, In vitro study

Proposing a framework for identifying Strip Cropping Zones through Artificial Intelligence

Muzamal Hussain

Department of Agronomy, University of Agriculture Faisalabad Consituent College Depalpur Okara

Email: muzamals0786@gmail.com

Soil erosion and water depletion have become major constraints to sustainable agriculture. Pakistan loses nearly 1.4 billion tons of fertile soil annually with erosion rates up to 70 tons per hectare. About 28–30% of Punjab's cultivated area is prone to moderate to severe land degradation. Among the various soil conservation practices, one of the most effective approach

is strip cropping. It involves cultivating of different crops in alternating strips. Prediction of such areas which are suitable for strip cropping is essential to minimize soil loss and enhance water recharge in erosion prone areas. Traditional way of strip cropping is time consuming and lack precision. This study describes utilization of artificial intelligence integrated with geographic information system to identify the optimal strip cropping zones in agricultural landscape. This approach uses machine learning with geographical data, also included satellite images, digital models, soil characteristics and climatic variables. AI algorithm will be trained to detect land data according to erosion vulnerability across Punjab also including D.G Khan, Rajanpur, Chakwal, Attock and Potohar plateau. AI based zone is expected to improve accuracy by 15-25% and increase crop productivity by 10-20% over traditional methods. Effective implementation will require an interdisciplinary team of agronomists, soil scientists and data analysts to evaluate feasibility of proposed system by optimizing crop selection, crop rotation and water management practices. Applicability of study may be limited by data resolution, climatic variability, high initial setup costs and need for trained personnel to manage AI system effectively. In conclusion, AI serves as an efficient tool to manage strip cropping zones to ensure sustainability in agriculture and maintain long-term soil health.

In Vivo Evaluation Of The Synergistic Effects Of *Melia Azedarach* And *Nigella Sativa* Against *Varroa Destructor*

Hafsa Shahzad¹, Shehzad Zareen¹, Abdul Rehman²

¹*Department of Zoology, Kohat University of science and technology, Kohat*

²*Department of Microbiology, Kohat University of science and technology, Kohat*

Email: hafsashahzad85@gmail.com

The ectoparasitic mite *Varroa destructor* remains the principal biological threat to honey bees worldwide, largely due to its role in transmitting viral pathogens and weakening host immunity. Increasing resistance of *Varroa* populations to conventional acaricides has created an urgent need for alternative, eco-friendly control strategies. In this study, methanolic botanical extracts of *Melia azedarach* (MA) and *Nigella sativa* (NS) were evaluated individually and in combination for their acaricidal toxicity and safety to *Apis mellifera*. While distilled water and Amitraz (0.5%) were used as negative and positive control respectively. Treatments were tested at three concentrations (5%, 10%, and 20%) using a direct contact spray bioassay. All treatments showed dose-dependent acaricidal activity. MA was highly potent but toxic to bees: at 5%, 10%, and 20% concentrations, it caused 60%, 72%, and 100% mite mortality, and 21.3%, 41%, and 60% bee mortality, respectively. *Nigella sativa* was much safer to bees but less effective against mites, yielding 23%, 41%, and 49% mite mortality and 0%, 1.3%, and 5.3% bee mortality at the same concentrations. In contrast, the combination of both extracts demonstrated synergistic activity. Even at a low combined concentration (2.5% MA + 2.5% NS), mite mortality exceeded 50% with 0% bee mortality. At 10% combined concentration, the blend caused 80% mite mortality with 0% bee mortality. At 20% combined concentration, the blend caused 92% mite mortality with 20% bee mortality, and at the highest concentration (20%), it resulted in 92% mite mortality with

29.3% bee mortality. While Amitraz used as positive control at standard concentration of 0.5% showed 80% mites mortality and 10% bee mortality. Thus, the combination of MA and NS at low concentrations provides a significant synergistic acaricidal effect with an excellent safety profile for honey bees. This blend represents a promising candidate for botanical mite control, offering a high therapeutic index essential for sustainable apiculture.

Keywords: *Apis mellifera*, *Varroa destructor*, Botanical extracts, *Melia azedarach*, *Nigella sativa*, synergistic effects.

Green Synthesis Of Fluorescent Carbon Dots From Potato Peels Via Cold Carbonization For Selective Heavy Metal Ion (Fe³⁺) Detection In Aqueous Environment

Saad Ahmad, Iqbal khan, Saima Gul

Department of chemistry, Kohat University of science and technology (KUST)

Kohat 26000, Khyber Pakhtunkhwa, Pakistan,

Email: gorikhan@kust.edu.pk

A green and energy-efficient cold carbonization method was employed to synthesize fluorescent carbon dots (CDs) from potato peels under ambient conditions. The method avoids high-temperature processing and complex instrumentation while introducing surface oxygen- and sulfur-containing functional groups that enhance aqueous solubility and fluorescence properties. The CDs were characterized by FTIR, XRD, SEM, TGA/DSC, BET, and pHZPC analyses. Fluorescence sensing studies revealed selective responses toward Pb²⁺, Hg²⁺, Cu²⁺, and Fe³⁺ ions in water, with a strong quenching response observed for Fe³⁺ ions due to surface coordination interactions. The sensing system demonstrated concentration-dependent fluorescence behavior with micro molar detection limits and good reproducibility. These results demonstrate the potential of biomass-derived carbon dots as eco-friendly and low-cost fluorescent probes for heavy metal ion detection and water quality monitoring.

Keywords: Carbon dots, Cold carbonization, Green synthesis, Potato peel, Heavy metals detection, Fluorescence sensing, Water quality monitoring

Antibacterial Efficacy Of *Apis Mellifera*-Derived Royal Jelly Against Multidrug-Resistant *Staphylococcus Aureus*

Syeda Fatima Sughra, Syed Ishtiaq Anjum, Muhammad Rauf, Sidra Ishaque

Department of Zoology, Kohat University of science and technology, Kohat

Email: fatimasughrapk@gmail.com

Royal jelly is a natural beehive product, produced by the hypopharyngeal and mandibular glands of worker bees (*Apis mellifera*). It is widely recognized for its nutritional and medicinal value and is rich in bioactive compounds, including antimicrobial peptides, fatty acids such as 10-hydroxy-2-decenoic acid, and functional proteins, all of which contribute to its diverse pharmacological properties. Due to the increasing prevalence of antibiotic resistance, there is growing interest in evaluating natural products as alternative antimicrobial agents. This study evaluated the antibacterial efficacy of *A. mellifera*-derived royal jelly against multidrug-resistant (MDR)

Staphylococcus aureus. Royal jelly was collected from *A. mellifera* colonies maintained at the KUST Model Honey Bee Farm and extracted under sterile laboratory conditions to ensure sample integrity. Antibacterial activity was assessed using the agar well diffusion method at concentrations of 2, 4, 6, and 8 mg/mL. Royal jelly demonstrated a clear concentration-dependent inhibitory effect against MDR *S. aureus*. In the ciprofloxacin-based assay, royal jelly produced inhibition zones of 15.5 mm at 2 mg/mL, 16.67 mm at 4 mg/mL, 18.5 mm at 6 mg/mL, and 20.0 mm at 8 mg/mL. Ciprofloxacin used as positive control showed no inhibitory activity (0 mm), confirming resistance of the MDR *S. aureus* strain. These findings indicate that royal jelly possesses strong antibacterial activity against MDR *S. aureus*, even in cases where conventional antibiotics such as ciprofloxacin are ineffective. The results support the potential of royal jelly as a natural antimicrobial agent and highlight its promise as an alternative or adjunct therapeutic option for combating drug-resistant bacterial infections.

Keywords: Royal jelly, *Apis mellifera*, *Staphylococcus aureus*, Antibacterial activity, Multidrug-resistant *S. aureus*, Agar well diffusion assay, Antibiotic resistance.

Mitigating Salt Stress in Sunflower (*Helianthus annuus* L.) through Soil-Applied Bioactive Nutrient-Fortified Fertilizer (BNFF)

Naveed Ul Hassan¹, Muhammad Shahbaz², Farooq Ahmad², Ejaz Ahmad Waraich³

¹Department of Botany, University of Agriculture Faisalabad, Constituent College, Depalpur-Okara

²Department of Botany, University of Agriculture, Faisalabad

³Department of Agronomy, University of Agriculture, Faisalabad

Corresponding Author: naveedulhassan@uaf.edu.pk

Salinity stress is a major problem for agricultural crops. Sunflower is an important oilseed crop cultivated worldwide for its oil. Bioactive nutrient-fortified fertilizer in the form of zinc-coated urea can mitigate the adverse effects of abiotic stress, including salt stress. To explore the role of soil-applied bioactive nutrient-fortified fertilizer (BNFF) on sunflower (*Helianthus annuus* L.) under saline conditions, an experiment was conducted in plastic pots at the Old Botanical Garden, University of Agriculture, Faisalabad. Seeds of two sunflower hybrids (H1= FH-710 and H2= FH-809) were obtained from AARI (Ayub Agricultural Research Institute). Ten seeds per pot were sown, and thinning was carried out to maintain six seedlings per pot. Three salinity levels (0, 100 mM, and 150 mM) were imposed. Zinc-coated urea (ZU) was used as a source of bioactive nutrient-fortified fertilizer (BNFF). Four levels of BNFF (0, 0.005%, 0.01%, and 0.02%) in the form of ZU were applied. When the sunflower seedlings were 30 days old, the first treatment (salinity and BNFF) was applied via the rooting medium using Hoagland solution. Salinity stress significantly inhibited growth in both hybrids, as reflected in reduced shoot fresh and dry weight, root fresh and dry weight, shoot and root length, and plant height. However, BNFF enhanced chlorophyll a, chlorophyll b, and total chlorophyll content. Salinity stress triggered excessive production of reactive oxygen species (ROS). The application of BNFF likely improved the synthesis and activity of antioxidants, thereby reducing oxidative damage and maintaining cellular homeostasis. Biochemical responses to salinity stress were characterized by significant

increases in total soluble proteins (TSP), total soluble sugars (TSS), total free amino acids (TFAA), total free proline, total phenolic contents (TPC), and leaf ascorbic acid (AsA). Salinity stress disrupted ion homeostasis by increasing Na^+ accumulation while reducing K^+ and Ca^{2+} uptake. BNFF application mitigated the negative effects of salinity by reducing Na^+ accumulation and improving K^+ and Ca^{2+} uptake. Salinity stress significantly reduced yield-related traits, including capitulum diameter, capitulum weight, number of achenes per capitulum, and 100- achene weight. BNFF application, particularly at 0.01%, improved yield parameters by enhancing assimilate partitioning, reproductive growth, and oil biosynthesis. Salt stress at 150 mM NaCl caused more damage than at 100 mM NaCl. Hybrid FH-809 performed better than FH-710 under saline conditions, reflecting its better adaptation to stress. The soil-applied BNFF at 0.01% proved to be more effective in salt tolerance for the sunflower crop.

Keywords: Sunflower, salinity, Bioactive Nutrient Fortified Fertilizer, BNFF, ZU

Deep Eutectic Solvent Based Synthesis Of Silver Nanoflowers For Efficient Solid-Phase Extraction Of Methylene Blue From Water And Commercial Spices

Najeeb Ullah, Mansoor Khan, Muhammad Naseer Abbas

Department of Chemistry Kohat University of Science and Technology Kohat

Email: Khannajeebua12@gmail.com

The contamination of water and food products with synthetic dyes has become an increasing environmental and public health concern. In this study, a green extraction method was developed for the removal and quantification of methylene blue (MB), a model toxic dye. Silver nanoflowers (AgNFs) were synthesized using a deep eutectic solvent (DES) composed of choline chloride and decanoic acid (1:1) as the reaction medium. In this one-pot synthesis, AgNO_3 was co-reduced by ascorbic acid in the DES, yielding AgNFs. The resulting nanoparticles were characterized by UV–visible spectroscopy (showing a surface plasmon resonance near 425 nm), scanning electron microscopy (revealing flower-like morphologies), FTIR (confirming organic capping groups), and X-ray diffraction (indicating face-centered cubic Ag with ~20 nm crystallites). The AgNFs were employed in a dispersive solid-phase extraction (DSPE) procedure for MB. Key parameters were optimized: the best extraction was achieved at pH 8 using 50 mg of AgNF for 10 mL of sample, with a 4-minute vortex-assisted desorption step. Under these conditions, the method exhibited a linear calibration curve ($R^2 \approx 0.9999$) for MB over 0.10–5.00 mg/L, with a limit of detection of ~0.41 mg/L. A 10-fold enrichment (10 mL sample to 1 mL eluent) improved the detection sensitivity. The method was validated with real samples: spiked surface water and a commercial spice (Bannu Masala). Recoveries of MB were high (96.0–97.6%) with low relative standard deviations (<3%), demonstrating the accuracy and reproducibility of the approach. Overall, the combination of a benign DES synthesis and a simple extraction protocol provides a rapid, cost-effective, and eco-friendly method for monitoring methylene blue in environmental and food matrices. This approach could be extended to other dye pollutants, and its scalability and reusability warrant future investigation.

Toxic Effects Of Sublethal Concentrations Of Chlorpyrifos On Hematology And Histopathology Of Rohu (Labeo Rohita)

Bashir Ahmad, Kalim Ullah, Muhammad Rauf

Department of Zoology Kohat University of Science and Technology

Email: bashirahmadsp@gmail.com

Chlorpyrifos, a widely used organophosphate pesticide, often contaminates freshwater ecosystems, posing serious risks to aquatic organisms. This study evaluated the toxic effects of chlorpyrifos on hematological parameters and histopathology of Rohu (*Labeo rohita*), an important aquaculture species in Pakistan. Fish were exposed to sublethal concentrations of chlorpyrifos under controlled laboratory conditions. Hematological analysis included red blood cell (RBC) count, hemoglobin (Hb) concentration, hematocrit (Hct), white blood cell (WBC) count, and related indices. Histopathological changes were examined in gills, liver, and kidneys to assess tissue-level damage. The results showed a significant reduction in RBCs, Hb, and Hct, indicating anemia and impaired oxygen transport, while WBC counts increased, suggesting an immune response to chemical stress. Histopathological observations revealed lamellar fusion, epithelial lifting, and necrosis in gills; hepatocellular degeneration and vacuolization in liver; and tubular degeneration and glomerular shrinkage in kidneys, confirming organ-specific toxicity. These findings align with known chlorpyrifos toxicity mechanisms, including acetylcholinesterase inhibition, oxidative stress, and inflammatory responses. The study concludes that chlorpyrifos exposure negatively affects both blood physiology and organ integrity in Rohu, which may compromise fish health and aquaculture productivity. These results emphasize the need for careful management of pesticide use near freshwater habitats to prevent ecological and economic losses.

Keywords: Chlorpyrifos, Rohu (*Labeo rohita*), Hematology, Histopathology, Pesticide Toxicity, Aquaculture

Green Synthesis Of Zinc Oxide Nanoparticles Using *Withania Somnifera* Extract And Its Efficacy Against *Aeromonas Hydrophila* And *Streptococcus Iniae*

Sajid Ullah, Dr. Farman Ullah, Mr. Muhammad Rauf

Department of zoology, Kohat University of science and technology

Corresponding authors: usajid103@gmail.com

This study details a sustainable, single-step synthesis of Zinc Oxide nanoparticles (ZnO NPs) employing a *Withania somnifera* leaf extract as a multifunctional bio-agent for reduction, capping, and stabilization. The research comprehensively evaluates the antimicrobial potency of these biogenic nanoparticles against two virulent fish pathogens, *Aeromonas hydrophila* and *Streptococcus iniae*, which were isolated from diseased specimens and definitively identified through a battery of biochemical assays (triple sugar iron, indole, and motility tests). Rigorous physicochemical characterization confirmed the successful synthesis of high-quality ZnO NPs. A sharp plasmon resonance peak at 361 nm in UV-Vis spectroscopy indicated nanoparticle formation. XRD patterns established a pure wurtzite hexagonal crystalline phase with an average

crystallite size of 45-55 nm. SEM analysis revealed monodispersed, spherical to quasi-spherical nanoparticles, while EDX spectroscopy confirmed their elemental purity. The nanoparticles demonstrated exceptional colloidal stability in suspension, as evidenced by a high positive zeta potential of +73.2 mV, with DLS reporting a mean hydrodynamic diameter of 82.5 nm. Antibacterial assessment revealed significant, pathogen-specific efficacy. The ZnO NPs exhibited superior activity against *A. hydrophila*, with a minimum inhibitory concentration (MIC) of 25 µg/mL and a minimum bactericidal concentration (MBC) of 40 µg/mL. A strong inhibitory effect was also observed against *S. iniae*. These results underscore the successful green synthesis of stable, crystalline ZnO NPs and their promising potential as a potent, natural nanomaterial for combating bacterial infections in aquaculture, offering an eco-friendly alternative to conventional antimicrobials.

Keywords: Green Synthesis, Zinc Oxide Nanoparticles, *Withania somnifera*, Phytomedicine, *Aeromonas hydrophila*, *Streptococcus iniae*, Aquaculture Antibacterial Activity, Nanobiotechnology.

Green Synthesis and Characterization Of Silver Nanoparticles Using Combination Of *Terminalia Chebula* And *Foeniculum Vulgare* And Their Antibacterial Activity

Fayyaz mehmood, Ruqia Nazir, Muslim Khan

Department of Chemistry, Kohat University of Science & Technology, Kohat-26000
Khyber

This study explores the antibacterial properties of the plant-based combination employed to produce silver nanoparticles from silver nitrate in an environmentally friendly way. The resultant greenish silver nanoparticles were characterized by X-ray diffraction, scanning electron microscopy, ultraviolet-visible spectroscopy, and Fourier-transform infrared spectroscopy. Fourier-transform infrared spectroscopy is used to identify metals and biomolecules, including silver nanoparticles. Stretching revealed the alkene functional group at 1563 cm⁻¹. The stretching frequency at 1029 cm⁻¹ suggests the presence of a carbon-oxygen group, whereas the stretching frequency at 1287 cm⁻¹ implies C-H bending vibrations. The formation of nanoparticles was verified by the presence of peaks between 410 and 450 nm. The green-synthesized nanoparticles made from the plant mixture showed notable efficacy against *Vibrio cholera* and *Escherichia coli*. The plant extracts demonstrated significant inhibitory zones of 21 mm and 26 mm against *Vibrio cholera* and *Escherichia coli*, respectively. Overall, the results showed an easy, low-cost, secure, and practical way to create silver nanoparticles that might be employed as an antibacterial agent to treat bacterial and fungal diseases.

Keywords: Silver Nps, *foeniculum volguare*, *terminalia chebula*, and Antibacterial activity.

The Role Of Pharmacist In Administration And Monitoring Of Antenatal Corticosteroids To Optimize Outcomes In Premature Labor Cases

Aiman Ishfaq, Sajid Khan Sadozai, Bushra Rauf

Antenatal corticosteroids (ACS) are one of the most effective ways to help infants born to mothers at risk of premature delivery, which is a major problem in world health. A tertiary hospital in Peshawar, Pakistan, analyzed 110 pregnant women diagnosed with preterm labor (24-34 weeks gestation) to determine the effectiveness of structured pharmacist-led ACS therapy. The study was an observational one. The interventions that were administered to a group of patients by pharmacists consisted of showing them how to correctly administer ACS (betamethasone or dexamethasone), maintaining attention out for side effects, and helping them stick to their treatment plans. The second group did not have any pharmacist involvement and received standard treatment. The participation of pharmacists greatly improved adherence to treatment protocols, according to this study. There was a significant decrease in serious neonatal complications, including neonatal sepsis and necrotizing enterocolitis, as well as the timely administration of betamethasone (<0.001) and the absence of preterm births in the intervention group (<0.001). Pharmacists participation in ACS therapy enhances medication delivery efficacy, raises clinical results, and makes treatment safer for neonates overall. There is more evidence from this study that pharmacists should be formally included in obstetric care teams that handle cases of premature labor.

Keywords: Corticosteroid, Betamethasone, Dexamethasone

Copper Sulfate Induced Genotoxicity In The Erythrocytes Of Rohu (Labeo Rohita)

Atta Ullah, Farman Ullah Dawar, Muhammad Rauf

Department of Zoology, Kohat University of Science and Technology Kohat

Email: atta0119897@gmail.com

Copper sulfate (CuSO_4), widely used in agriculture, aquaculture, and industry, is a known environmental contaminant with potential genotoxic effects on aquatic organisms. This study aimed to evaluate the genotoxic impact of CuSO_4 exposure on *Labeo rohita* (rohu), a commercially important freshwater fish species. Juvenile fish were exposed to sublethal concentrations of CuSO_4 (0.0, 0.5, 1.0, and 1.5 mg/L) for 96 hours under controlled laboratory conditions. Peripheral blood samples were analyzed using the micronucleus (MN) assay and other nuclear abnormality tests to assess genotoxicity. Results revealed a statistically significant, concentration-dependent increase in micronuclei frequency ($p < 0.001$), along with other nuclear deformities such as binucleated cells, nuclear buds, and lobed nuclei in exposed groups compared to controls. These findings clearly demonstrate that CuSO_4 induces chromosomal damage and nuclear instability in *L. rohita* erythrocytes, raising concerns about its ecotoxicological implications. The study highlights the necessity of regulating copper-based compounds to minimize genotoxic risks in freshwater ecosystems.

Keywords: Copper sulfate, *Labeo rohita*, erythrocytes, genotoxicity, micronucleus assay, nuclear abnormalities, aquatic toxicology

Bactericidal Role Of Epidermal Mucus Of *Oreochromis Mossambicus* Against Human Disease Causing Bacterial Strains

Saima Afsheen, Farman Dawar

Department of Zoology, Kohat University of Science and Technology, 26000, Kohat,
Pakistan

Corresponding Author email: afsheensaima777@gmail.com

Bacterial infections caused by human pathogenic microorganisms remain a major global health challenge, particularly due to the rapid emergence of antimicrobial resistance. The discovery of alternative natural antimicrobial agents has therefore become a critical research priority. Fish epidermal mucus, a key component of innate immunity, contains a variety of bioactive compounds with potential antimicrobial properties. The present study was designed to evaluate the bactericidal role of epidermal mucus of *Oreochromis mossambicus* against selected human disease-causing bacterial strains. Healthy specimens of *O. mossambicus* were collected and acclimatized in the laboratory. Epidermal mucus was collected by non-invasive scraping and processed to yield crude and acidic extracts. The antibacterial activity of both extracts was evaluated against *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, and *Escherichia coli* using the agar well diffusion method. The minimum inhibitory concentration (MIC) of each extract was determined using a graded concentration series. Both crude and acidic mucus extracts exhibited clear antibacterial activity against all tested bacterial strains. The acidic extract consistently produced larger zones of inhibition than the crude extract, indicating superior bactericidal efficacy. A concentration-dependent increase in antibacterial activity was observed for all bacterial strains. The MIC for both crude and acidic extracts was 10%, confirming that bacterial growth was inhibited even at the lowest tested concentration. Among the tested pathogens, *Aeromonas hydrophila* showed the highest susceptibility, followed by *Escherichia coli*, whereas *Pseudomonas aeruginosa* exhibited greater resistance. The findings of this study confirm that the epidermal mucus of *O. mossambicus* possesses significant broad-spectrum bactericidal activity. The enhanced performance of acidic extracts highlights the importance of extraction methodology in maximizing antimicrobial efficacy.

Antibacterial activity of *Silybum marianum* against *Aeromonas hydrophila* isolated from *Cyprinus carpio*

Irum Ayaz, Kaleem Ullah

Department of Zoology, Kohat University of science and technology

Aquaculture provides a vital source of protein, but bacterial infections can significantly impact fish health and productivity. The excessive use of antibiotics has led to the development of resistant bacterial strains, emphasizing the need for safe and natural alternatives. *Silybum marianum*, a medicinal plant known for its therapeutic properties, is being explored for its potential antibacterial effects. This study aimed to investigate the antibacterial activity of ethanolic and methanolic extracts of *Silybum marianum* against *Aeromonas hydrophila* isolated from *Cyprinus carpio* (common carp). The antibacterial effects of the extracts were evaluated

using the well diffusion method at four different concentrations: 100 mg/mL, 75 mg/mL, 50 mg/mL, and 25 mg/mL. Among the ethanolic extracts, E100 exhibited the largest zone of inhibition (18 ± 0.58 mm), followed by E75 (17 ± 0.5 mm), E50 (16 ± 0.58 mm), and E25 (15 ± 0.58 mm). The methanolic extracts showed a similar pattern, with M100 (17 ± 0.5 mm), M75 (16 ± 0.58 mm), M50 (15 ± 0.5 mm), and M25 (14 ± 0.58 mm). These results indicate that the antibacterial activity of both extract types increased with concentration, demonstrating a dose-dependent effect. Overall, the findings suggest that *Silybum marianum* possesses notable antibacterial activity against *Aeromonas hydrophila*, particularly at higher concentrations. The ethanolic extract showed stronger inhibition compared to the methanolic extract, highlighting its potential as a plant-based alternative to antibiotics. These results support the use of *Silybum marianum* in reducing bacterial infections and promoting sustainable carp farming practices.

Plant-Mediated Fabrication of Magnesium Oxide Nanoparticles and Their Role in Countering Antimicrobial Resistance

Maqsood Qaisar, Abdul Rehman, Baharullah Khattak, Muhammad Qasim

Department of Microbiology, Kohat University of Science and Technology (KUST), Kohat, 26000, Khyber Pakhtunkhwa, Pakistan.

Corresponding email: maqsoodmicro@gmail.com

The global rise of antimicrobial resistance has diminished the clinical utility of several frontline and last-resort antibiotics, necessitating alternative therapeutic strategies. In this work, magnesium oxide nanoparticles (MgO-NPs) were produced via a plant-assisted synthesis route employing extracts of *Citrullus colocynthis*, a medicinal species known to contain diverse bioactive phytochemicals. The formation and physicochemical features of the nanomaterial were confirmed using ultraviolet–visible spectroscopy, Fourier-transform infrared analysis, scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy, and X-ray diffraction, revealing nanoscale crystalline MgO with characteristic optical and structural signatures. The biosynthesized MgO-NPs demonstrated marked antimicrobial activity against multidrug-resistant *Staphylococcus aureus* and *Escherichia coli*, displaying a concentration-dependent bactericidal response. Notably, when combined with selected β -lactam antibiotics, the nanoparticles enhanced antibacterial performance against resistant isolates, indicating a synergistic interaction that partially improved antibiotic responsiveness. Antifungal potential was also observed against *Candida albicans* and *Aspergillus Niger*. Phytochemical screening of *C. colocynthis* extracts indicated solvent-dependent profiles of phenolic, flavonoid, and terpenoid constituents, which may contribute to nanoparticle stabilization and bioactivity. Overall, the findings highlight the promise of plant-derived MgO-NPs as an eco-friendly nanomaterial with dual antimicrobial and antibiotic-potentiating properties, supporting their potential integration into future strategies aimed at mitigating drug-resistant infections.

Keywords: Antimicrobial resistance, Green nanotechnology, Magnesium oxide nanoparticles, *Citrullus colocynthis*, Antibiotic potentiation

Molecular Identification Of *Echinococcus Granulosus* Using 18s Rrna Gene In Large Ruminants Of District Kohat

Muhammad Safdar¹, Ameen Ullah¹, Abid Umar¹, Abdullah Muslim¹, Noor ul Akbar¹, Farman Ullah², Shahid Niaz Khan¹

¹Department of Zoology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

²Department of Pharmacy, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

Corresponding Author: shahid@kust.edu.pk

Hydatidosis (echinococcosis) is a significant zoonotic disease caused by the larval cysts of *Echinococcus* tapeworms. In livestock, these slow-growing, fluid-filled cysts develop in internal organs, typically without visible symptoms. The infection often remains undetected until slaughter, resulting in substantial economic losses from organ condemnation, reduced carcass value, and diminished productivity, including lower yields of milk, wool, and hides. Molecular characterization of *E. granulosus* uses mitochondrial genes (e.g., *cox1*, *nad1*) for fine-scale strain differentiation due to their high mutation rate. In contrast, the nuclear 18S rRNA gene is highly conserved and is primarily used for genus-level identification, diagnostics, and broad phylogenetic analysis, though it can still reveal some regional population structure. In the present investigation, 87 hydatid cyst samples were obtained from infected organs of large ruminants slaughtered at multiple abattoirs in District Kohat. Samples were collected under sterile conditions by aspiration or excision. Genomic DNA was isolated from cyst fluid using a phenol-chloroform extraction protocol involving cell lysis and sequential purification to remove proteins and contaminants. The purified DNA was subjected to PCR amplification targeting the 18S rRNA gene. Amplified fragments were resolved on 2% agarose gel stained with ethidium bromide, with a 100 bp plus ladder used for size estimation. Sequence identity was confirmed through NCBI BLAST comparison with reference database entries. Sequence and phylogenetic analyses indicated that most isolates belonged to *Echinococcus granulosus* and showed close similarity to strains reported from neighboring countries including China, Iran and India, suggesting cross-border circulation. These results provide baseline molecular evidence for Kohat and support the need for ongoing molecular monitoring and coordinated control programs.

Keywords: *Echinococcus granulosus*, Genetic Diversity, Hydatidosis, Phylogenetic Analysis.

Biochemical And Hematological Analysis Of Humans Infected With Cystic Echinococcosis

Vinee Asif¹, Elisha Sakhawat¹, Alisha Khan¹, Ameen Ullah¹, Noor ul Akbar¹, Farman Ullah², Shahid Niaz Khan¹

¹Department of Zoology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

²Department of Pharmacy, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

Corresponding Author: shahid@kust.edu.pk

Background: Cystic echinococcosis (CE) is a zoonotic parasitic infection caused by *Echinococcus granulosus*, predominantly affecting the liver and leading to systemic physiological disturbances. Despite its clinical significance, comprehensive haematological and biochemical profiling across demographic subgroups remains limited. This study aimed to compare haematological and biochemical parameters between CE patients and healthy controls, stratified by age and gender.

Methods: A total of 113 participants were included, comprising 62 CE patients and 51 age- and gender-matched healthy controls. Venous blood samples were collected and analysed using automated haematology and biochemistry analysers. Parameters evaluated included complete blood count (haemoglobin, RBC indices, WBC differential), platelet count, liver function tests (ALP, AST, ALT), renal function markers (BUN, creatinine), lipid profile, fasting blood glucose, and electrolytes. Data are presented as mean $\pm$ standard deviation. Subgroup analyses were performed by gender and age group (young adults: 18–39, middle-aged: 40–59, older adults: $\geq$ 60 years). Results: CE patients showed mild anaemia, with significantly lower haemoglobin, haematocrit, and RBC counts compared to controls. Eosinophil levels were elevated ($6.10 \pm 3.1\%$ vs. $2.52 \pm 1.63\%$), consistent with parasitic infection. Liver enzymes were markedly increased, particularly ALP (208.37 ± 8.33 U/L vs. 85.34 ± 3.41 U/L). Lipid profiles indicated reduced HDL and cholesterol levels. Electrolyte imbalances, including lower sodium, were also observed. Gender-based analysis revealed higher eosinophilia in males, while age-based comparisons demonstrated progressive declines in RBC parameters and renal function with advancing age. Platelet counts were elevated in CE patients across all subgroups.

Conclusion: CE infection is associated with significant haematological and biochemical alterations, including anaemia, eosinophilia, hepatic impairment, dyslipidaemia, and electrolyte disturbances. These changes are influenced by demographic factors, highlighting the need for tailored clinical monitoring and management in affected individuals.

Keywords: Cystic echinococcosis, Haematological profile, Biochemical profile, Eosinophilia, Hepatic impairment, Dyslipidaemia

Identification And Genotypic Analysis Of *Echinococcus Granulosus* From Human Isolates Using Cox-1 Gene

Elisha Sakhawat¹, Alisha Khan¹, Vinee Asif¹, Ameen Ullah¹, Noor ul Akbar¹, Farman Ullah², Shahid Niaz Khan¹

¹Department of Zoology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

²Department of Pharmacy, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

Corresponding Author: shahid@kust.edu.pk

Echinococcus granulosus is an endoparasite tapeworm belonging to family Taeniidae that causes “echinococcosis” disease in both humans and animals. More than a million people have been reported to be diagnosed with echinococcosis which extends over cystic (CE), alveolar (AE), and neotropical (NE) echinococcosis. Cystic Echinococcosis infection is the most common *Echinococcus* species infection worldwide, contributing in considerable morbidity and relative mortality in human populations. *E. granulosus* causes an accidental human infection and is transmitted to human occurs via the fecal-oral route. The study was designed as a cross-sectional molecular investigation carried out at selected municipal and private laboratories in Khyber Pakhtunkhwa, Pakistan. Over the study period, a total of 56 samples were systematically examined during routine. The study followed a standardized molecular workflow in which 3 cysts were isolated from fertile cysts, and genomic DNA was extracted for the amplification of the mitochondrial Cox-1 gene using PCR. Purified PCR products were sequenced, and the resulting

sequences were analyzed through BLAST comparison and phylogenetic tree construction to determine circulating species and evaluate their genetic relatedness to isolates reported from other regions of the world. The PCR amplification yielded a 446 bp fragment specific to *E. granulosus*, and sequencing results confirmed the predominance of the exact *E. granulosus* species in the study area. Ongoing molecular surveillance is recommended to monitor genetic shifts and inform targeted control strategies.

Keywords: *Echinococcus granulosus*, Phylogenetic analysis, PCR; Cox-1

Molecular Characterization Of *Echinococcus Granulosus* Using Its2 Gene In Small And Large Ruminants Of District Kohat

Rizwan Azam¹, Muhammad Safdar¹, Ameen Ullah¹, Abid Umar¹, Abdullah Muslim¹, Noor ul Akbar¹, Alisha Khan¹, Farman Ullah², Shahid Niaz Khan

¹Department of Zoology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

²Department of Pharmacy, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

Corresponding Author: shahid@kust.edu.pk

Echinococcus granulosus exhibits significant genetic diversity, with different genotypes influencing host range, transmission, and disease severity. Accurate identification of circulating strains is therefore critical for informing surveillance, optimizing diagnostic tools, and guiding the development of targeted vaccines and therapeutics. Molecular markers are essential for characterizing *E. granulosus*. Mitochondrial genes (cox1, cytb, nad1) are widely used for phylogenetic studies due to sequence variability and conservation. Nuclear ITS2 provides high-resolution differentiation of species and genotypes. The present study aimed to characterize the genetic diversity and phylogenetic relationships of *E. granulosus* isolates obtained from Small and Large Ruminants in District Kohat, Pakistan. A total of 200 slaughtered animals, including cattle, buffaloes, sheep, and goats, were examined during routine meat inspection. Protoscolices from fertile hydatid cysts were collected, and genomic DNA was extracted using a commercial kit. The ITS2 gene was amplified by PCR, followed by sequencing and comparative analysis using BLAST and phylogenetic tree construction via Mega 11. Sequencing results confirmed the predominance of *E. granulosus* in the study area. Phylogenetic analysis demonstrated a high degree of genetic similarity between the local isolates and those documented in neighboring endemic countries, including India and China, indicating possible cross-border dissemination of related strains. These findings provide baseline molecular data for Kohat and emphasize the importance of continuous molecular surveillance and integrated control strategies to reduce the burden of CE in both animals and humans.

Keywords: *Echinococcus granulosus*, PCR, ITS2, Phylogenetic Tree, DNA

Green Synthesis and Characterization of Royal Jelly Mediated Zinc Oxide Nanoparticles and Their Antibacterial Potential Against Fish Bacteria

Shabir Ahmad¹, Syed Ishtiaq Anjum¹, Niamat Khan²

¹Department of Zoology, Kohat University of Science and Technology, Kohat, Khyber Pakhtunkhwa, Pakistan

²Department of Biotechnology and Genetic Engineering, Kohat University of Science and Technology, Kohat, Khyber Pakhtunkhwa, Pakistan

Bacterial infections caused by opportunistic aquatic pathogens are a major constraint to fish health and sustainable aquaculture worldwide. Conventional antibiotic treatments are increasingly limited due to antimicrobial resistance, environmental persistence and residue accumulation, emphasizing the need for eco-friendly alternatives. Nanotechnology offers a promising strategy, with zinc oxide nanoparticles (ZnO NPs) exhibiting broad spectrum antibacterial activity. In this study, royal jelly (RJ) a honeybee derived secretion rich in proteins, fatty acids, phenolics and antioxidants was employed as a natural reducing and stabilizing agent for the green synthesis of ZnO nanoparticles. The biosynthesized royal jelly mediated ZnO NPs were characterized using UV visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM) confirming their crystalline hexagonal wurtzite structure, nanoscale size, surface functionalization by royal jelly biomolecules and uniform morphology. The antibacterial activity of the royal jelly (RJ) mediated ZnO nanoparticles was evaluated against *Klebsiella pneumoniae* using the agar well diffusion method. The results demonstrated a clear dose dependent antibacterial response with the highest tested concentration producing a prominent inhibition zone (39.0 ± 1.0 mm; $p < 0.0001$) comparable to the standard antibiotic control. Even at lower concentrations royal jelly mediated ZnO NPs retained substantial antibacterial efficacy, highlighting their strong bioactivity. Overall, this study establishes royal jelly as an efficient and sustainable biogenic source for ZnO nanoparticle synthesis and demonstrates their potent antibacterial potential. These findings support the prospective use of royal jelly mediated ZnO NPs as environmentally friendly and cost effective antimicrobial agents in aquaculture. Future work should focus on in vivo validation, toxicity assessment and scalability to enable practical implementation in sustainable fish farming systems.

Keywords: Green synthesis, Zinc oxide nanoparticles, Royal jelly, *Klebsiella pneumoniae*, Aquaculture, Antibacterial activity

Seroprevalence And Molecular Identification Of *Toxoplasma Gondii* In Pregnant Females Of District Tank

Amna Khalid¹, Naila Gul¹, Abdulrehman²

¹Department of Zoology Kohat University of science and technology

²Department of Microbiology, Kohat University of science and technology

Corresponding Authors: amna62616@gmail.com

This cross-sectional study conducted from February to September 2025 investigated the seroprevalence, molecular identification, and risk factors associated with *Toxoplasma gondii* infection among 158 pregnant women attending antenatal care clinics in District Tank, Khyber Pakhtunkhwa, Pakistan, revealing an overall seroprevalence of 35.4% (55/158) through Onsite Toxo IgG/IgM rapid testing, with tehsil-wise distribution showing higher positivity in Tank (38.1%) compared to Jandola (27.0%), while age-specific analysis demonstrated the highest seroprevalence (38.2%) among women aged 26–30 years and the lowest (14.3%) in those aged

36–40 years, with trimester-wise distribution indicating increasing prevalence with advancing gestational age from 36% in the first trimester to 31.4% in the second and 37.3% in the third trimester; significant risk factors identified through structured questionnaires and statistical analysis included rural residence (45.1% seropositivity vs. 24.0% in urban areas; $p<0.05$), housing conditions with 64.0% positivity among women living in mud houses compared to 26.2% in concrete houses ($p<0.001$), consumption of undercooked meat (44.4%), presence of free-roaming cats (46.3%), direct animal contact (44.4%), and inadequate hand hygiene following raw meat handling (39.5%), while obstetric history revealed strong associations between seropositivity and previous abortion (70.0% vs. 23.0%; $p<0.001$) as well as stillbirth (53.3% vs. 33.0%; $p<0.001$); molecular confirmation through conventional polymerase chain reaction targeting the highly repetitive 529 bp fragment of the B1 gene successfully amplified *T. gondii* DNA in all seropositive samples, confirming active or latent infection; these findings demonstrate a moderate to high burden of toxoplasmosis among pregnant women in this underserved Pakistani district, with rural residence, poor structural conditions, specific food-related behaviors, and animal contact serving as significant transmission determinants, while the strong correlation between seropositivity and adverse pregnancy outcomes underscores the critical need for implementing targeted public health interventions including routine antenatal screening programs, context-specific health education emphasizing proper food handling, hand hygiene, and avoidance of contaminated soil and cat feces, thereby enabling early detection and management to reduce the risk of congenital transmission and associated maternal-neonatal morbidity, with the molecular epidemiological data providing essential evidence for regional disease surveillance and control strategies in resource-limited settings.

Keywords: *Toxoplasma gondii*, Toxoplasmosis, Seroprevalence, Pregnant women, PCR, B1 gene, District Tank, Pakistan, Congenital toxoplasmosis, Risk factors, Zoonotic disease.

Comparative Assessment of Heavy Metals In The Muscles Of Fish Collected From The Market Of Districts Kohat And Peshawar

Moeen Ullah¹, Farman Ullah¹, Ameen Ullah¹, Noor ul Akbar¹, Fardous²

¹Department of Zoology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

²Department of Medical Lab Technology, Kohat University of Science & Technology, Kohat-26000, Khyber Pakhtunkhwa Pakistan

Corresponding Author: farmandawar@kust.edu.pk

Fish is a major source of high-quality protein and essential nutrients, but contamination with heavy metals in aquatic environments has raised increasing food safety and public health concerns. Because heavy metals are persistent and bioaccumulative, they can concentrate in fish muscle and enter the human food chain through regular consumption. The present study was conducted to comparatively assess heavy metal accumulation in the muscle tissues of commonly consumed fish collected from retail markets of District Kohat and District Peshawar, and to evaluate spatial variation and potential health risk in relation to recommended permissible limits. A total of 30 market fish samples were collected from both districts, representing major edible species. Muscle tissues were excised, washed, homogenized, oven-dried, and acid digested using

a nitric acid and perchloric acid mixture. Concentrations of zinc (Zn), nickel (Ni), chromium (Cr), lead (Pb), cadmium (Cd), arsenic (As), and copper (Cu) were determined using atomic absorption / ICP-based analytical techniques under calibrated and quality-controlled conditions. Data were expressed as mean $\pm$ standard deviation on a dry weight basis and statistically analyzed to compare inter-species and inter-district variation. Results showed measurable but generally low concentrations of all analyzed metals in fish muscles from both districts. In Kohat samples, Zn ranged approximately from 0.01 to 0.06 mg/kg, Ni from 0.04 to 0.06 mg/kg, Pb around 0.03–0.04 mg/kg, and As about 0.04–0.05 mg/kg, while Cr and Cd were absent in some species. In Peshawar samples, relatively higher mean values were observed for Ni (up to about 0.11 mg/kg), Zn (up to about 0.08 mg/kg), As (up to about 0.08 mg/kg), and Cu in certain species, indicating spatial variation in bioaccumulation. Across species, Mahseer frequently showed comparatively higher metal uptake than others. When compared with recommended permissible limits for metals in fish, all measured mean concentrations were far below maximum allowable levels. In conclusion, market fish from both Kohat and Peshawar were within acceptable safety limits for the studied metals, indicating low immediate risk for consumers. However, observable spatial and species-wise differences confirm variable bioaccumulation patterns and highlight the importance of continuous monitoring of market fish to support food safety management and public health protection.

Keywords: heavy metals, fish muscle, bioaccumulation, comparative assessment, food safety