ABSTRACT BOOK

8th INTERNATIONAL HORTICULTURE CONFERENCE & EXPO (IHCE-2024)

Theme Innovations in Sustainable Horticulture

FEBRUARY 26 – 28, 2024

ABSTRACT BOOK

8th International Horticulture Conference and Horti-Expo South Punjab (IHCE-2024)
February 26-28, 2024

Theme: Innovations in Sustainable Horticulture

Editors

Muhammad Nafees

Muhammad Azher Nawaz

Muhammad Wasim Haider

Muhammad Amin

Organized By

Department of Horticultural Sciences,
The Islamia University of Bahawalpur, Pakistan &
Pakistan Society for Horticultural Science

DEDICATION

The organizing team of the 8th International Horticulture Conference and Expo (IHCE-2024), and Pakistan Society for Horticultural Science (PSHS) dedicate IHCE-2024 and this Abstract Book to

Dr. Basharat Ali Saleem (Late)

Dr. Basharat Ali Saleem left this world on August 05, 2024. He was an active member of PSHS, and serving as the Vice President of PSHS and Associate Editor of HortiMag. He was working as the Deputy Director Horticulture Extension, Agriculture Department, Government of Punjab, Pakistan. He was a very good researcher and an excellent extension worker. His presence was a blessing for the citrus growers of Pakistan, and his departure has created a void. His significant contributions for the horticulture sector of Pakistan will always be remembered. We pray to ALLAH SUBHANAHOO WA T'ALA to bless eternal peace and high rank in paradise to the departed soul and grant patience to the grieved family to bear this irreparable loss, Aameen.

Memories of Dr. Basharat Ali Saleem (Late) during participation in IHCE-2024 at DHS, FA&E, IUB

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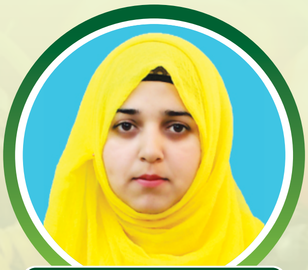

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Message of the Patron-in-Chief IHCE-2024
Prof. Dr. Naveed Akhtar, Vice Chancellor, IUB

Horticulture is an important subsector of agriculture that has great potential to solve food security challenges in changing climatic conditions. The horticulture sector holds great importance for the country's economic development and can play a major role in generating employment. I congratulate Prof. Dr. Muhammad Nafees, Chairman Department of Horticultural Sciences, Prof. Dr. Tanveer Hussain, Dean Faculty of Agriculture and Environment, and Pakistan Society of Horticultural Sciences for organizing this important and wonderful event at The Islamia University of Bahawalpur (IUB). The Department of Horticultural Sciences is one of the vibrant departments at the IUB; it has a vast research area and is fully equipped with the labs and infrastructure required for quality teaching and research. The Department has a fully functional nursery that provides quality nursery plants to the farmers and gardeners of this region. The outreach activities of the Department of Horticultural Sciences are important for increasing the economic situation of the farmers in this area.

I hope this Conference and Expo will provide an opportunity for participants from different walks of life to share issues and possible solutions. Indeed, there is a great opportunity for academia, researchers, and industry representatives to work together to strengthen the horticulture sector in Pakistan. It is a great opportunity to learn from the experience of international delegates from different countries. I am thankful to the sponsoring organizations, particularly the Punjab Higher Education Commission, Pakistan Science Foundation, Australian Centre for International Agriculture Research, Engro Fertilizers, Croplands Chemicals & Seed Services, ECS, Nutricels, Mobi Paints, Shamim Ghee Industries Pvt Ltd. Bahawalpur, and Vital Tea, Pakistan, for providing support in organizing this auspicious conference and Expo. I hope your stay will be comfortable at The Islamia University of Bahawalpur during the conference days. Thank you all for your participation.

Message of the Patron IHCE-2024
Prof. Dr. Tanveer Hussain Dean FA & E, IUB

Horticulture is an important sector of agriculture that contributes to fulfilling food requirements and helps increase the economic status of growers. At Islamia University of Bahawalpur, the University College of Agriculture and Environment was established in 2005, and different departments, such as Entomology, Horticulture and Soil Sciences, were subsequently established at the College. Now we have four different institutes that are part of the Faculty of Agriculture. The Department of Horticultural Sciences is a vibrant department that is imparting education and training to stduents and providing outreach services to farmers in this area. The Department of Horticulture has arranged this 8th International Horticulture Conference and Expo, and I am thankful to the participating national and international organizations and scientists who presented their research work in the form of oral or poster presentations. I am also thankful to the Australian Centre for International Agricultural Research (ACIAR), Australia; Engro Fertilizers Limited, Pakistan; Punjab Higher Education Commission (PHEC), Lahore; Pakistan Science Foundation (PSF), Islamabad; Shamim Ghee Industries Pvt Ltd. Bahawalpur; Croplands Chemicals & Seed Services, Bahawalpur; Nutricles, Pakistan; MOBI Paints; ECS; and Vital Tea for their financial support to organize this international conference and expo. Finally, I am again thankful to all the participants who have traveled a long way to participate in this conference, and we apologize if you face any difficulty during travel or stay at the Islamia University of Bahawalpur.

Welcome Note of President PSHS/Focal Person IHCE-2024
Prof. Dr. Muhammad Nafees, Chairman, Department of Horticultural Sciences, FA & E, IUB

Welcome to the 8th International Horticulture Conference and Expo (IHCE-2024). This conference is being organized by the Department of Horticultural Sciences, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur, Pakistan, in collaboration with the Pakistan Society for Horticultural Science (PSHS). The horticulture industry is rapidly changing worldwide. New crop-growing techniques are becoming popular, and the horticulture industry is facing new challenges. In this conference, scientists, academics, industry leaders, students, growers, and other people linked with the horticulture industry share their knowledge and experience and learn the latest advances in the field of horticulture. We are thankful to the participating scientists and researchers, who presented and discussed their work, and to the national and international companies, who displayed their stalls in the expo. We hope that new aspects of research will arise from this discussion and that researchers can work on those ideas to contribute to the development of the horticulture industry in the country. We are thankful to the administration of The Islamia University of Bahawalpur for providing support to organize this conference. We are also highly grateful to the sponsors for their valuable financial support in organizing this conference successfully.

CONFERENCE PROGRAM

February 26, 2024 (Monday)

Inaugural Session (10:00 am–1:00 pm)

Venue: **Khawaja Farid Auditorium, BJ Campus, IUB (Main Hall)**
Arrival of Guests and Registration: **8:00--10:00 am**
Recitation of the Holy Quran **10:00 am**
Welcome Address: **Prof. Dr. Muhammad Nafees, Chairman Department of Horticultural Sciences, IUB/President PSHS**
Inaugural Address: **Prof. Dr. Naveed Akhtar, Vice Chancellor The Islamia University of Bahawalpur**
Keynote Address: **Prof. Dr. Aman Ullah Malik, The University of Faisalabad, Pakistan**
(Pakistan Horticulture Industry at the Crossroad: Status, Challenges and Ways forward)
Plenary Lecture: **Professor Dr. Taki Demir**, Dean Faculty of Agriculture, Sakarya University of Applied Science, Türkiye (Horticultural Plant Production in Turkey: Future Risks and Opportunities)
Address Guest of Honor Mr. Saqib Ali Ateel, Secretary Agriculture South Punjab
Address Guest of Honor Mr. Athar Hussain Khokhar, Chief Executive Officer, PHDEC
Address of Chief Guest: Prof. Dr. Ishtiaq Ahmed Rajwana, Vice Chancellor MNS-University of Agriculture, Multan
Vote of Thanks: **Dr. Tanveer Hussain, Dean Faculty of Agriculture, IUB**
Expo Stall Visit: **12:15-1:00 pm**
Lunch and Prayer Break **1:00–2:00 pm**

Technical Sessions

TECHNICAL SESSION 1 2:00 – 3: 30 pm

Venue: **Main Hall (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Prof Dr. Aman Ullah Malik, University of Faisalabad**
Co-chair: **Dr. Iftikhar Ahmed, IHS, UAF**
Moderators: **Dr. Muhammad Amin, IUB/Dr. Muhammad Azher Nawaz, IUB**
Theme: **General Horticulture (Invited Talks)**

Sr. #	Titles and Authors	Time	Page No.
1	**Multiplication of Some Wild Pear Rootstocks by Tissue Culture Technique** Omayma M. Ismail*, Farid M. Rohim, Amira A. Fouad, Chunqing Ou, Yanjie Zhang, Fei Wang and Shuling Jiang	2:00–2:15 pm	29
2	**Improvement of Horticultural Crops through Tissue Culture** Muhammad Jafar Jaskani	2:15–2:30 pm	30
3	**Status, Opportunities and Challenges of Citriculture in South Punjab** Basharat Ali Saleem*, Aman Ullah Malik, Muhammad Akbar Saggu, Muhammad Azher Nawaz, Fareeha Shireen and Ishtiaq Ahmed Rajwana	2:30–2:45 pm	31
4	**Potential of Horticulture Sector for Women Empowerment in South Punjab** Ms. Kaynat Raza*, Fareeha Shireen, Muhammad Azher Nawaz	2:45–3:00 pm	32
5	**Citrus Decline: Causes, Effects and Remedies in Pakistan** Muhammad Ashraf*, Muhammad Usman Ghazanfar, and Sher Muhammad Shahzad, Muhammad Azher Nawaz	3:00–3:15 pm	32

6	**Urban Food Gardening: A Concise Approach to Environmental Sustainability and Food Security** Muhammad Azam Khan* and Umer Habib	3:15–3:30 pm	33

TECHNICAL SESSION 2 2:00 – 3: 30 pm

Venue: Video **Audio Video Conference Room (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Dr. Ahmed Sattar Khan IHS, UAF**
Co-chair: **Dr. Raheel Anwar IHS, UAF**
Moderator: **Dr. Rashid Hussain, IUB/Dr. Muhammad Wasim Haider, IUB**
Theme: **Virtual Session**
Zoom Link: **https://us02web.zoom.us/j/84166157483?pwd=VXRvOUtEQ0w4WTJhM3VpQnF3aE5zZz09**

Sr. #	Titles and Authors	Time	Page No.
1	**Cuticular Wax Effects on Fruit Storage Quality Indices of Passion Fruit and Its Industrial Status in China** Prof. Dr. Faxing Chen, College of Horticulture, Fujian Agriculture and Forest University, Fujian Province	2:00–2:10 pm	36
2	**Progress in Smart Vegetable Seedling Production** Dr. Yuan Huang College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan 430070, Hubei Province, China	2:10–2:20 pm	36
3	**Use of Cover Crops for Sustainable Vegetable Cropping Systems: 10-Year Experiment in Mediterranean Environment** Dr. Emanuele Radicetti, Department of Chemical, Pharmaceutical and Agricultural Sciences (DOCPAS), University of Ferrara, Ferrara, Italy	2:20–2:30 pm	37
4	**Genome-Wide Analysis and Expression Profiling of Pseudo-Response Regulator (PRR) Genes in Cabbage (*Brassica oleracea* L.) Under Abiotic Stress Conditions** Yunyun Xing, Yujie Jiang, Muhammad Adnan Raza* and Jianghua Song College of Horticulture, Anhui Agricultural University, Hefei, Anhui, China	2:30–2:40 pm	38
5	**Genome Editing using CRISPR/CAS9 System: A Productive Tool to Accelerate Genetic Improvement in Commercial Palms** Faiza Shafique Khan*, Zhiying Li, Peng Shi, Dapeng Zhang, Yin Min Htwe, Qun Yu, Fareeha Shireen, Muhammad Azher Nawaz and Yong Wang Hainan Yazhou Bay Seed Laboratory/Sanya Research Institute of Chinese Academy of Tropical Agricultural Sciences, Sanya, China	2:40–2:50 pm	38
6	**Fruit Hollowness and Browning in Huangguanli Plum and Associated Lignin Accumulation** Dr. Honghong Deng, College of Horticulture and Forestry Sciences, Huazhong Agricultural University, Wuhan 430070, Hubei Province, China	2:50–3:00 pm	39
7	**Flower and Fruit Management of Table Grape in China** Dr. Yanshuai Xu, Hunan Agricultural University, Changsha, Hunan Province, China	3:00–3:10 pm	40
8	**The Terpene Synthase (TPS) Gene Family in Kiwifruit Shows High Functional Redundancy and A Subset of TPS Likely Fulfill Overlapping Functions in Fruit Flavor, Floral Bouquet and Defense** Prof. Dr. Wu Wang, Jiangsu Key Laboratory for the Research and Utilization of Plant Resources, Institute of Botany, Nanjing China	3:10–3:20 pm	40

9	**Rice Straw as an Alternative Growing Media for Vegetable Production in Egypt** Dr. Shaban Abou-Hussein, Vegetable Research Department, Agricultural and Biological Research Institute, National Research Centre, Giza, Egypt	3:20–3:30 pm	41
10	**Effect of Foliar Spray of Yeast Extract and Potassium Nitrate on Yield and Fruit Quality on "*Ziziphus jujuba* L." Trees** Mahmoud Abdel-Aziz Ahmed*, Abdullah Alebidi, Rashid Al-Obeed and Alaa Omar, Department of Horticultural Crops Technology, National Research Centre, Dokki, Egypt	3:30–3:40 pm	42

Tea Break: **3: 30 – 3:45 pm**

TECHNICAL SESSION 3 3:45 – 6:00 pm

Venue: **Main Hall (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Dr. Muhammad Jafar Jaskani, IHS, UAF**
Co-chair: **Dr. Muhammad Usman, IHS, UAF**
Moderator: **Dr Rashid Shaheen, IUB/Dr. Muhammad Ahsan, IUB**
Theme: **Ornamental Horticulture and Landscaping**

Sr. #	Titles and Authors	Time	Page No.
1	**Global Floriculture Trends and Opportunities for Pakistan** Iftikhar Ahmad	3:45–4:00 pm	44
2	**Innovative Technologies for Sustainable Urban landscape** Aamir Nawaz	4:00–4:15 pm	44
3	**Urban Horticulture: A Sustainable Approach after Devastating Floods in Pakistan Caused Food Security Crisis** Adnan Younis	4:15–4:30 pm	45
4	**Exogenous Application of Biofoliar on Bells of Ireland (*Moluccella laevis* L.) for Production Optimization** Tahreem Anwar, Umer Habib*, Ismara Naseem and Tanveer Hussain	4:30–4:45 pm	45
5	**Biostimulants for Sustainable Petunia Production: A Comparative Study on Growth, Flowering, and Environmental Impact** Rashid Iqbal Khan, Syed Muhammad Faheem, Saba Shakeel, Mazhar Abbas* and Iftikhar Ahmad	4:45–5:00 pm	46
6	**Optimal Indigenous Soilless Substrate for High Quality Cut Flower Production of *Matthiola incana L.* in Punjab, Pakistan** Syed Munib Hussain*, Iftikhar Ahmad, Muhammad Asif, Rimsha Rafique and Tazkia Hussain	5:00–5:15 pm	47
7	**Evaluating the Growth and Production of Cut Stock (*Matthiola incana* L.) using Macro and Micronutrients along with Biostimulants** Ayesha Jabeen*, Iftikhar Ahmad, Muhammad Qasim and Hifza Safdar	5:15–5:30 pm	48
8	**Changes in Antioxidant Enzyme Activities, Hormone Levels and Growth Traits of Rose Induced by Three Native Strains of *Trichoderma harzianum*** Abdul Majeed Baloch*, Rui Miao, Dan Sui, Abdul Wahid Baloch, Yuan Chang, Junjie Deng, Xueyue Hou, Muharam Ali and Rongshu Zhang	5:30–5:40 pm	49

TECHNICAL SESSION 4 3:45 – 6:00 pm

Venue: Video **Audio Video Conference Room (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Prof. Dr. Muhammad Ashraf, COA, UOS**
Co-chair: **Dr. Tanveer Ahmed, MNSUA, Multan**
Moderator: **Dr. Ishtiaq Ahmed, IUB/Dr. Hera Gul, IUB**
Theme: **Abiotic Stresses**

9	**Strigolactone (Gr24) Ameliorates the Adverse Cadmium Impact on *Gladiolus grandifloras* via Modulating the Photosynthetic Apparatus and Antioxidative Defense Mechanism** Muhammad Ahsan*, Hera Zulfiqar, Adnan Younis and Emanuele Radicetti	5:45–6:00 pm	59

Posters Evaluation

Time: **4:00 - 5:00 pm**
Coordinators: Dr. Muhammad Sarwar Yaqub and Mr. Faisal Zulfiqar

Business Meeting of PSHS

Business Meeting of Pakistan Society for Horticultural Sciences (PSHS) 6:00–7:00 pm
Venue: Audio Video Conference Room (Khawaja Farid Auditorium, BJ Campus, IUB)

February 27, 2024 (Tuesday)

TECHNICAL SESSION 5 9:15 – 11: 15 am

Venue: **Main Hall (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Prof. Dr. Muhammad Azam Khan, PMAS UAAR**
Co-chair: **Dr. Atiq Ahmad Alizai, Gomal University, DI Khan**
Moderator: **Dr. Muhammad Amin/Dr. Muhammad Sarwar Yaqub, IUB**
Theme: **Postharvest Science and Technology**

Sr. #	Titles and Authors	Time	Page No.
1	**Recent Trends in Preharvest Management Strategies to Preserve Postharvest Quality of Fruits: An Overview** Ahmad Sattar Khan*, Saqib Ayyub, Raheel Anwar and Sajid Ali	9:15–9:30 am	62
2	**Harvest Maturity Affects Postharvest Quality of Fresh and Dry 'Santa Rosa' and 'Black Amber' Plum Fruit Quality** Sami Ullah*, Ishtiaq A. Rajwana, Kashif Razzaq, Ambreen Naz, Shafa Nayab and Khalid Ahmad	9:30–9:45 am	62
3	**Nano-Emulsion Coating Maintains the Quality of Harvested Guavas under Ambient Storage** Shaghef Ejaz*, Laraib Amjad, Sajid Ali, Fareeha Saeed and Muhammad Shahzad Saleem	9:45–10:00 am	63
4	**Valorizing Citrus Peel Waste through Nanoparticle Development for Enhanced Shelf Life and Food Safety** Muhammad Qambar Raza, Muhammad Ammar Khan* and Tahir Mehmood	10:00–10:15 am	64
5	**Production and Supply Chain Management of Strawberry in Pakistan** Raheel Anwar*, Ahmad Sattar Khan, Ishtiaq Ahmad Rajwana, Kashif Razzaq, Khurram Ziaf, Zahoor Hussain, Muhammad Moaaz Ali and Ayesha Maryam	10:15–10:30 am	64
6	**Comparative Evaluation of Eco-Friendly Edible Coatings on Pears: Sodium Benzoate, Olive Oil, Bee's Wax, and Corn Starch as Sustainable Preservation Strategies** Moazzam Anees*, Mehr Un Nisa and Muhammad Rizwan Tariq	10:30–10:45 am	65

7	**Exploring the Nutritional and Physiochemical Attributes of Cucumber-Ginger Drink During Storage** Muhammad Rizwan Tariq*, Maryam Muhammad Ali Mubarak, Shinawar Waseem Ali and Moazzam Anees	10:45–10:55 am	66
8	**Screening and Quantification of Pesticide Residues in Marketed Mango in Punjab, Pakistan** Muhammad Asif Farooq*, Muhammad Usman Khan, Farrukh Baig, Muhammad Nadir Naqqash and Bilal Atta	10:55–11:05 am	67
9	**Morpho-nutritional and Anatomical Characterization of Rubus Species from Muzaffarabad Division of Azad Jammu And Kashmir** Mehdi Maqbool	11:05–11:15 am	68
10	**Carboxymethyl Cellulose Coating Delays Quality Deterioration in Harvested Table Grapes during Postharvest Cold and Ambient Storage** Muhammad Hassan, Sajid Ali*, Ahmad Sattar Khan, Shaghef Ejaz and Sami Ullah	11:05–11:15 am	68

TECHNICAL SESSION 6 9:15 – 11: 15 am

Venue: Video **Audio Video Conference Room (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Prof. Dr. Amir Nawaz, BZU, Multan**
Co-chair: **Dr. Rana Mazhar Abbas, University of Karachi**
Moderator: **Dr. Khalil Ur Rehman, IUB/Dr. Hera Gul, IUB**
Theme: **Breeding and Biotechnology and other Horticulture-related aspects**

Sr. #	Titles and Authors	Time	Page No.
1	**Exploration and Identification of the NPR1 Gene Family Member Mediated Defense in Chili against Gemini-Virus Infection** Muhammad Shafiq	9:15–9:30 am	71
2	**Exploring Ploidy Manipulation in Potato for Improved Yield and Quality** Syeda Anum Masood Bokhari*, Tanveer Ahmad, Sawera Rehman, Alishba Shahid, Muhammad Usman, Bilquees Fatima, Fareeha Shireen and Asia Bibi	9:30–9:45 am	71
3	**Role of Ornamental Plants in Phytoremediation of Nickel Contaminated Soils** Amir Hameed, Gulzar Akhtar*, Kashif Razzaq and Amjad Farooq	9:45–10:00 am	72
4	**Studies on Identification of Phenological Stages in Two Varieties of Date Palm (P*hoenix dactylifera* L.) and Relationship of Growth Patterns with Various Climatic Factors** Muhammad Arif, Atiq Ahmad Alizai*, Abdul Qayum and Umar Khitab	10:00–10:15 am	73
5	**Effective Air Temperature Accumulated as Crop Heat Units is a Robust Representative of Grapevine Phenology** Rizwan Rafique*, Touqeer Ahmad, Muhammad Azam Khan and Mukhtar Ahmed	10:15–10:30 am	74
6	**Cultivar-Specific Responses of Strawberry (*Fragaria × ananassa* Duch.) to Climatic Variability in Azad Jammu and Kashmir: A Runner Health Evaluation** Noosheen Zahid* and Mehdi Maqbool	10:30–10:45 am	75

7	**New Exotic Vegetable for Pakistan: Malabar Spinach (*Basella rubra* L.)** Muhammad Mazhar Hussain*, Hidaytullah, Ghulam Jellani, Nousherwan Nobel Nawab, Sultan Mehmood, Muhammad Salman and Muhammad Qamar Uz Zaman	10:45–10:55 am	75
8	**Future Strategy of Date Palm Production and Its Issues in South Punjab** Muhammad Azhar Bashir*, Muhammad Ikhlaq, Kashif Shabir, Ammara Noreen, Bilal Akram, Muhammad Faraz Ayoub Khan, Aqib Nawaz Mughal, Ahmar Jaleel, Lubna Altaf, Waqar Jaleel, Naheed Akhtar, Faheem Altaf and Muhammad Akmal Rana	10:55–11:05 am	76
9	**Comparative Analysis of Capsicum Cultivars for Cultivation Systems, Productivity and Quality under Partially Controlled Greenhouse** Ali Asad Bahar, Hafiz Nazar Faried*, Sami Ullah, Gulzar Akhtar, Kashif Razzaq, Tanveer Ahmad, Syeda Anum Masoud Bokhari, Abid Hussain, Mohsin Bashir, Rashid Shaheen and Tanveer Hussain	11:05–11:15 am	77

Tea Break: **11: 15 – 11:30 am**

TECHNICAL SESSION 7 11:30 am – 1: 15 pm

Venue: **Main Hall (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Prof. Dr. Muhammad Akbar Anjum, BZU, Multan**
Co-chair: **Dr. Maryam, Govt. Sadiq College Women University, Bahawalpur**
Moderator: **Dr. Muhammad Amin, IUB/Dr. Muhammad Azher Nawaz, IUB**
Theme: **Nutrient and Water Management**

Sr. #	Titles and Authors	Time	Page No.
1	**Quantifying Impact of High-Efficiency Irrigation Systems on Yield, Quality and Health of Horticultural Crops with Judicious Use of Inputs** Muhammad Irfan Nawaz*, Fareeha Shireen, Majid Nawaz and Muhammad Azher Nawaz	11:30–11:45 am	79
2	**Physiological and Transcriptional Responses of Watermelon Genotypes to Low Boron Conditions** Fareeha Shireen*, Muhammad Azher Nawaz, Syeda Anum Masood Bokhari, Faiza Shafique Khan, Khurram Ziaf, Muhammad Awais Ghani, Yuan Huang, Bie Zhilong	11:45–12:00 pm	79
3	**Optimization of Yield, Fruit Quality and Nutritional Status of Strawberry by Using Various Sources of NPK Fertilizers** Muhammad Waqas Azam, Khalid Mehmood Qureshi and Umer Habib*	12:00–12:15 pm	80
4	**Planting Date and Nitrogen Management Interactions in Sweet Pepper** Muhammad Saqib* and Muhammad Akbar Anjum	12:15–12:25 pm	81
5	**Role of Potassium Humate and Vermicompost on Nutrient Availability, Growth, and Yield Attributes of Soybean** Hadia Kaleem, Muhammad Ameen*, Maqshoof Ahmad, Ghulam Hassan Abbasi, Muhammad Ali, Muhammad Adnan Bukhari, Muhammad Usman Bashir, Qasim Ali, Ashar Ayub and Muhammad Nadeem	12:25–12:35 pm	82

6	**Vermi-Compost Use in Horticultural Crops** Muqarrab Ali*, Amar Matloob, Ahmad Mahmood, Muhammad Nazim, Kashif Razzaq, Ishtiaq Ahamd Rajwana, Sami Ullah, Nazar Fareed, Gulzar Akhter, Muhammad Amin, Saleem Ullah, Rehan Jameel, Rasheed Amin, Omer Farooq and Khurram Shahzad	12:35–12:45 pm	83
7	**Effect of Moringa Leaf Extract on Seed Germination, Seedling Growth and Yield in Cumin** Karim Yar Abbasi*, Haroon Arshad, Muhammad Usman, Bilquees Fatima, Muhammad Haroon and Khurram Ziaf	12:45–12:55 pm	83
8	**Enhancing the Quality of Grapes and Altering Bacterial Diversity with Biochar Inoculated Soil Bacterium** Aqib Nawaz Mughal*, Muhammad Ikhlaq, Waqar Jaleel, Ahmar Jaleel, Muhammad Azhar Bashir, Ammara Noreen, Kashif Shabir, Bilal Akram, Lubna Altaf and Muhammad Faraz Ayoub Khan	12:55–1:05 pm	84
9	**Optimization of Nutritional Regimes for Quality Flower and Seed Yield of Dahlia (*Dahlia pinnata* L.) and Celosia (*Celosia argentea* L.) in Punjab, Pakistan** Rimsha Rafique*, Iftikhar Ahmad, Khurram Zaif, Urwa Irshad and Tazkia Hussian	1:05–1:15 pm	85

TECHNICAL SESSION 8 11:15 am – 1: 15 pm

Venue: Video **Audio Video Conference Room (Khawaja Farid Auditorium, BJ Campus, IUB)**
Chair: **Dr. Basharat Ali Saleem, Horticulture Extension, Lahore**
Co-chair: **Mr. Muhammad Ikhlaq, HRS, RARI, Bahawalpur**
Moderator: **Dr. Muhammad Wasim Haider/Mr. Faisal Zulfiqar**
Theme: **Propagation and Nursery Management, and Biotic Stresses**

Sr. #	Titles and Authors	Time	Page No.
1	**Unveiling the Role of NAC Genes in Passion Fruit Resistance to Pathogenic Stress: Insights into Hormonal Dynamics and Antioxidant Activity** Xiaobo Hu* and Faxing Chen, College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, China	11:30–11:45 am	88
2	**Enhancing Growth and Development of Mango Nursery Plants through Nutritional Management** Muhammad Arshad, Kashif Razzaq*, Ishtiaq Ahmad Rajwana, Muhammad Umair, Sami Ullah, Gulzar Akhtar, H. Nazar Faried, Shafa Nayab and Abid Hussain	11:45–12:00 pm	88
3	**Metabolomic Characterization of Biochar Induced Biotic Stress Resistance in *Solanum lycopersicum*** Muhammad Ibraheem , Adnan Akhter , Muhammad Khurshid*	12:00–12:15 pm	89
4	**Sprouting and Growth Response of Dragon Fruit (*Hylocereus udantus*) to Various Cutting Lengths and Hormonal Application Methods** Ghulam Fatima Tunio, Noor-un-Nisa Memon, Muzamil Farooque Jamali*, Afifa Talpur and Hub e Ali Mangsi	12:15–12:25 pm	90
5	**Performance of Bitter Gourd Grafted onto Wild Bitter Gourd Genotypes**	12:25–12:35 pm	91

	Muhammad Qamar Uz Zaman*, Muhammad Azher Nawaz and Fareeha Shireen		
6	**Comparative Study of Enzymatic Responses in Leaves and Calli of Cholistan Desert's Medicinal Plants** Muhammad Samsam Raza*, Muhammad Nafees and Muhammad Wasim Haider	12:35–12:45 pm	91
7	**Tea Leaf Residue: A Potential Agriculture Based Waste Material as Substrate Mix for Nursery Production and Growth of *Anthirinum* (Snapdragon)** Irslan Ali*, Umar Habib, Iftikhar Ahmad, Shahid Nadeem, Fahad Muhibullah, and Mushtaq Ahmad	12:45–12:55 pm	92
8	**Mitigation of Early Blight in Tomato Plant: Evaluating *Trichoderma harzianum*, *Cassia fistula* and *Azadirachta indica* Leaves Powder** Ayesha Shafqat* and Sundus Akthar	12:55–1:05 pm	93
9	**Citrus Huanglongbing Pathogen Detection in Bahawalpur, Pakistan** Muhammad Sarwar Yaqub*, Rozina Aslam and Aqib Nawaz	1:05–1:15 pm	93
10	**Poisonousness of Three Different Essential Oils Against Red Palm Weevil (*Coleoptera*: Dryophthoridae)** Muhammad Ikhlaq, Waqar Jaleel*, Muhammad Azhar Bashir, Ammara Noreen, Ahmar Jaleel, Kashif Shabir, Bilal Akram, Lubna Altaf, Aqib Nawaz Mughal, Muhammad Faraz Ayoub Khan	1:15–1:30 pm	94

Lunch and Prayer Break 1:30 - 2:00 pm

Concluding Ceremony

Recitation of the Holy Quran 2:00 pm
Conference Recommendations: Prof. Dr. Muhammad Akbar Anjum, Department of Horticulture, BZU, Multan
Distribution of Shields: Guests, Sponsors and Organizers
Vote of Thanks: Prof. Dr. Tanveer Hussain, The Dean Faculty of Agriculture and Environment, The Islamia University of Bahawalpur
Tea Break 3:30 – 3:45 pm

February 28, 2024

Conference Tour and Departure of guests: 9:00 am – 3:30 pm

Conference Venue

Khawaja Ghulam Farid Auditorium, Baghdad-ul-Jadeed Campus, The Islamia University of Bahawalpur, Bahawalpur, Pakistan
For Information: Email: ihce@iub.edu.pk
Phone No. +92-3006853074, +92-300-6859364

Poster Presentations in IHCE-2024

Key Note Address & Invited Talks (General Horticulture)

Pakistan Horticulture Industry at the Crossroad: Status, Challenges and the Ways Forward

Aman Ullah Malik*
The University of Faisalabad, Faisalabad, Pakistan.
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Horticulture is an important sector of Pakistan. The traditional malpractices in domestic chains affect the volume commitments and value earnings of export chains. Inadequate postharvest handling (poor processing, improper grading, inappropriate packaging and lack of a cool chain) is among the key issues that results in poor fruit quality, limited shelf life and, ultimately, low value earnings in the domestic and export markets. Over the last decade, various interventions have been made in the horticulture industry of Pakistan because of the awareness, R&D, technical support and infrastructural developments made possible through various national and international projects. The progressive transformations in the case of domestic supply chains are slow compared with those in export chains. The harvest systems and basic consignment preparation practices in domestic and export chains are different from each other. A similar level of good preparation practices needs to be adopted to achieve uniformity in both chains and improve global competitiveness, trade volume and value earnings. This paper provides a detailed account of the current status and future directions for improving the horticulture sector through identification of the commercial needs of the sector; research, development and promotional activities; conservation of the history and cultural heritage of growing communities; promotion of postharvest processing; grading and packaging in the local industry; supporting the export industry; improving market competence and value; stimulating decency in the sector; enhancing profitability in value chains; and capacity building/development of well-trained technical human resources and skilled postharvest management labor and national and international promotions.

Horticultural Plant Production in Turkey: Future Risks and Opportunities

Taki DEMİR*
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Türkiye has a diverse and important horticultural sector. Horticultural production in Turkey covers a wide range of products, from fruits and vegetables to nuts and ornamental plants. The country's diverse climate and geographical features contribute to the cultivation of a wide range of products. Fruit growing, vegetable growing, hazelnut and nut production, grape production, greenhouse cultivation and floriculture are important horticultural activities in Turkey. Apples, cherries, apricots, peaches, and citrus fruits are the famous fruits produced in

Turkey. Vegetable production consists of tomatoes, peppers, cucumbers, onions and various green leafy vegetables. Turkey is also an important producer of nuts, especially hazelnuts. The country is one of the world's leading producers and exporters of hazelnuts. Other nuts produced in Turkey include walnuts and pistachios. Grape cultivation in Turkey has a long history. Various grape varieties are grown in different regions. Greenhouse farming is widely practiced in Turkey, allowing certain products to be produced throughout the year and protecting plants from adverse weather conditions. Tomatoes, cucumbers and peppers are particularly produced in greenhouses. The floriculture sector is producing ornamental plants and flowers for domestic use and export. Cut flowers, potted plants and landscape plants are grown in different parts of our country. Turkey exports a significant part of its horticultural products to various countries. Hazelnuts, fresh fruits and vegetables are among the main exported products. Like every agricultural sector, Turkish horticulture faces challenges such as water scarcity, climate variability and market fluctuations.

An overview of Horticultural Industry of Pakistan

Ishtiaq A. Rajwana*, Sami Ullah and Kashif Razzaq
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Agriculture is the backbone of Pakistan's economy, as it contributes 21% and 50% of the gross domestic product (GDP) and provision of the labor force, respectively. There are several indigenous fruits, vegetables and floricultural commodities produced in the country. The Horticulture sector contributes significantly to a country's GDP and employment generation. Globally, Pakistan's horticultural crops are in a prime position and are currently among the top ten producers of mango, date palm, mandarin, apricot and onion. Horticultural crops have strengthened Pakistan's economy; in addition, they play pivotal roles in ensuring human health through the provision of dietary constituents vital for balanced nutrition. Similarly, the Department of Horticulture, MNS, University of Agriculture, Multan, has been striving to promote horticulture in the region of South Punjab since 2012. Currently, 10 ongoing research projects of more than Rs. 35 million are worth addressing various problems of pomology, olericulture, floriculture and postharvest science funded by various public and private sector organizations, including HEC, PARB, ACIAR and the private sector industry. Moreover, it has completed 5 projects on minor fruit, strawberry, phalsa, chilies and insect repellent plants worth more than Rs 15 million. For infrastructure development, the department has developed two full-fled labs, one field lab, one soilless farming unit (hydroponic unit), five plant nursery units, and experimental orchard, vegetable and floriculture areas covering approximately 6 acres of land. The laboratories included a postharvest science and technology laboratory and a plant physiology and propagation laboratory. The department has also optimized hydroponic technology for fresh vegetable production. The department has also significantly contributed to the campus landscape, developing more than 20 lawns through campus avenue and path plantations. In addition to the main campus, the department has contributed to the development of its remote research area at the JalalPur Pirwala (JPP) farm. Currently, approximately 20% of the farm area is occupied by various horticultural crops, including citrus, olive, guava, date palm, phalsa and mango. Currently, a fruit plant nursery unit has been developed at JPP farm. With respect to outreach activities and farming community services, the department has been involved in organizing mango festivals, spring flower shows and chrysanthemum flower shows on a regular basis for the last 7 years. Moreover, it has organized three international conferences for the promotion of R&D in the horticulture sector. In summary, horticulture is an important sector that contributes significantly to the national economy, and the Department of Horticulture is striving to promote the capacity of the horticulture sector in the South Punjab region.

Multiplication of Some Wild Pear Rootstocks by Tissue Culture Technique

Omayma M. Ismail [1*], Farid M. Rohim[1], Amira A. Fouad[2], Chunqing Ou[3], Yanjie Zhang[3], Fei Wang[3] and Shuling Jiang[3]

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The rootstock is very important for the growth and development of the tree as a necessary part of a grafted fruit tree. Pear is a delicious fruit, and its propagation also requires rootstocks. This study was conducted over two successive years in the Tissue Culture Technique Laboratory, Central Laboratories Network - National Research Center - Dokki - Egypt. The purpose of this study was to propagate pear rootstocks via tissue culture, where Egypt needs to import pear seeds every year. In this study, seeds of several pear species were collected from China for tissue culture, and their germination, subculture and micropropagation abilities were investigated. The chilling requirements of different wild pear species were also compared to select rootstock strains that need low chilling requirements and are more suitable for use in Egypt. Three different media were tested for the multiplication of M_1: BA at 2 mg/L + Kin at 1 mg/L + NAA at 1 mg/L, M_2: 2ip at 1 mg/L + Kin at 0.5 mg/L + IBA at 0.5 mg/L, and M3: BAP at 4 mg/L + TDZ at 1 mg/L + IBA at 1 mg/L. The response of different rootstock genotypes differed in terms of the number of shoots and shoot length. *Pyrus betulifolia* and *P. calleryana* had the highest rooting percentages, and 1 mg/l IBA was the best medium. *In vitro* propagation of some wild pear rootstocks can be achieved, and different growth regulators of auxin and cytokinin affect the pear proliferation stage. During the rooting stage, a low concentration of IBA was

better than a high concentration of IBA or IAA. *P. betulifolia*, *P. calleryana* and *P. serrulata* have high survival percentages and are more suitable for *in vitro* propagation of pear rootstocks in Egypt; moreover, they have low chilling requirements.

Improvement of Horticultural Crops through Tissue Culture

Muhammad Jafar Jaskani[1*], Muhammad Nafees[2] and Muhammad Wasim Haider[2]
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The improvement of horticultural crops through tissue culture has revolutionized agricultural practices worldwide, offering robust solutions for enhancing crop quality, productivity, and resistance to diseases. Conventional tissue culture techniques such as micropropagation have pivotal importance in the cloning of elite plant varieties, ensuring genetic uniformity and rapid multiplication. This technique has been particularly effective in the propagation of fruits, vegetables, and ornamentals, allowing for the large-scale production of high-quality planting material. In Pakistan, the application of micropropagation has significantly increased the productivity of crops such as citrus, bananas, strawberries, and orchids, contributing to the growth of the agricultural sector. Furthermore, the conservation of medicinal plants through callogenesis and the quantitative and qualitative enhancement of extracted bioactive compounds of pharmaceutical value, such as antioxidants and phenolics, is possible. Modern advancements in tissue culture, such as somatic embryogenesis and protoplast fusion, have enabled the development of hybrid plants with superior traits, including enhanced disease resistance and stress tolerance. The use of molecular markers in conjunction with tissue culture has facilitated the selection of desirable traits at the cellular level, expediting the breeding process and ensuring the introduction of high-yielding and resilient varieties. Similarly, the ornamental plant industry has leveraged tissue culture to introduce novel varieties with improved aesthetic qualities and environmental adaptability. The tissue culture of potatoes has been instrumental in producing the first-generation seed tubers of both indigenous and exotic potato cultivars. The horticultural sector can achieve greater productivity, sustainability, and resilience by continuously refining these techniques and integrating new biotechnological advancements while ensuring environmental conservation.

Status, Opportunities and Challenges of Citriculture in South Punjab

Basharat Ali Saleem[1*], Aman Ullah Malik[2], Muhammad Akbar Saggu[3], Muhammad Azher Nawaz[4], Fareeha Shireen[2] and Ishtiaq Ahmed Rajwana

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Citrus is one of the most in-demand fruits in the world; therefore, its development continues simultaneously in advanced and developing countries. Pakistan ranks 11--13th in citrus production worldwide. Citrus cultivation in southern Punjab is still under development, and only 16% of the total Punjab citrus area lies there. There are some clusters of Kinnow mandarin, limes and sweet oranges in different areas of all three divisions of South Punjab. There is tremendous potential for citriculture in South Punjab, which has well-drained soils if the water sources are sufficient with good quality. There has been development of seedless lemon areas with excellent export potential. The reported average yield in Pakistan (11 tonnes/ha) is far less than the practically achievable potential yield (25−30 tonnes/ha). The main reasons for this low productivity are poor nursery plants; the uncontrolled size of citrus trees; low and imbalanced use of plant nutrients; intercropping; excessive and inappropriate irrigation; improper insects; pests; and disease incidence due to favorable weather conditions for disease proliferation. These major problems have become the main causes of stagnation in increasing yields and improving fruit quality. Efforts have been made through the introduction of different interventions by the Department of Agriculture in collaboration with extension and research wings. A lack of knowledge of modern techniques among common farmer communities is another barrier to citrus quality production. A complete package of technology for prevailing resources is available in Pakistan, and if farmers are convinced to adopt these practices, per acre yield and overall production and fruit quality can be enhanced, which will result in increased exports with prosperous growers and a glorious citrus industry. There is a dire need for disease-free healthy citrus nursery provisions to develop the citrus industry of South Punjab at the public and private sector levels, which will ensure good citrus plantations.

Potential of Horticulture Sector for Women Empowerment in South Punjab

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Horticulture is an important sector of agriculture, contributing 12% of the national agricultural GDP. Owing to the diverse climatic conditions of Pakistan, there is potential to produce the varieties of fruits and vegetables and their export, which can help reduce poverty and ensure food security. Compared with that of other developed countries, the performance of this sector in Pakistan is low. One of the possible reasons is that there are fewer opportunities for women in this sector than for men. Moreover, women, who are often crucial resources for enhancing the rural economy, face social constraints that reduce their productivity. Women face problems such as a lack of power and ownership, limited access to resources, gender-based discrimination, unfavorable working environments and a lack of education. There are many opportunities for women in the horticulture sector, but due to a lack of education, training and guidance, women are unable to explore this sector, and their involvement is limited to cultural practices such as sowing, weeding, harvesting and drying. Women can play their role in the horticulture industry as entrepreneurs, growers, researchers, marketers, and employees at all levels. There are several opportunities for women as entrepreneurs in horticultural business, such as nursery raising, kitchen gardening, tunnel farming of vegetables, flower production, flower shops, flower arrangements, seed production and value addition of horticultural crops. Moreover, the role of women in the marketing and supply chain of horticultural products can be strengthened by empowering them.

Citrus Decline: Causes, Effects and Remedies in Pakistan

Muhammad Ashraf[1*], Muhammad Usman Ghazanfar[2], Sher Muhammad Shahzad[1] and Muhammad Azher Nawaz[3]
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More than 30 types of fruits are being produced in Pakistan, among which citrus stands in the leading position, accounting for more than 30% of total fruit production. In Pakistan, it is primarily adaptable and grows in Punjab, which shares approximately 95% of the crop area and 80% of the citrus growing area. The soil and climatic conditions of Punjab have added a distinctive flavor and taste to citrus to make it a trademark. Despite the use of modern agricultural techniques and methods, the average per hectare fruit yield of citrus in Pakistan is only 9.076 tons, whereas it is 26.73 tons in Turkey, 25.98 tons in the USA and 21.64 tons in Brazil. Several interventions have been introduced by the government over the past few years to increase citrus productivity. However, these interventions did not result in a significant increase in citrus fruit yield or quality. There are several reasons for the failure of such interventions, ranging from problems in the provision of certified nursery plants to specialized extension services, the availability of quality inputs, mechanization, packaging, storage, transport, harvest, postharvest management, and marketing facilities. However, inadequate and imbalanced supplies of plant nutrients, poor planting material, improper plant protection strategies and poor cultural management are the major factors responsible for the rapid decline in the productivity of citrus orchards in Pakistan. The fruit yield and quality of citrus in Pakistan can be improved by the adoption of appropriate management strategies, such as adequate regulation of plant nutrients, suitable plant protection measures, provision of certified nursery plants, appropriate intercropping, manuring, adequate water management, appropriate cultural management practices and weed management. There is a dire need for the capacity building of extension workers and farming communities for site-specific management of citrus orchards in accordance with the prevailing agroclimatic conditions. Furthermore, the government needs to focus on adding citrus value and exploring the global market for exporting a sizeable portion of citrus and citrus products.

Urban Food Gardening: A Concise Approach to Environmental Sustainability and Food Security

Muhammad Azam Khan* and Umer Habib
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The world’s urban population is increasing at an enormous rate and is estimated to double in the next 30 years, which will result in poor urban areas. According to the United Nation Report, the migration trend toward cities is at the highest rate in developing countries in search of security, employment and food. To meet the ever-increasing food requirements of urban areas, urban and peri-urban horticulture must be considered as integral parts of agricultural production systems, with a focus on generating employment, providing food security and generating income for urban people. The current study focused on urban horticulture, which uses edible crops (fruits, vegetables, and herbs) as a single emerging solution to mitigate the risks of food safety, food security and ecosystem degradation in urban areas. A pilot project funded by EFS-UAF focused on the sustainable provision of fresh vegetables to urban communities was initiated by the Department of Horticulture to introduce urban food gardening in twin cities on sustainable grounds. An impact assessment of the needs and perceptions of urban dwellers was carried out across both cities through a comprehensive survey. Production technology and substrate were standardized specifically for the needs of home gardeners. The project has been a great success until today, and more than 500 people were trained in its first year, with the dissemination of over 1000 seed kits, 15000 vegetable seedlings and 50 vegetable production demonstration units in twin cities. Studies regarding the economic uplift, quality and impact of food gardening were also considered and executed. The outcomes are clearly designed to contribute to improvements in food safety and security in urban areas on sustainable grounds, economic subsistence to deprived dwellers and women's empowerment.

Virtual Session

Cuticular Wax Effects on Fruit Storage Quality Indexes of Passion Fruit and Its Industrial Status in China

Faxing Chen*, Honghong Deng†, Xi Liang†, Qiang Yang†, Ziyang Zhang, Mingkang Wei, Chao Peng, Muhammad Moaaz Ali, Viola Kayima, Hafiz Muhammad Rizwan, Xiaobo Hu and Binqi Li
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† These authors contributed equally to this work.

Compared with purple passion fruit, yellow passion fruit is highly susceptible to postharvest decay and has a shorter shelf life. Here, a comprehensive study of yellow and purple passion fruit was conducted from the perspectives of structural morphology, chemical composition and key gene expression in cuticular wax. SEM analysis revealed that the purple passion fruit surface was associated with more tubules, platelets, and thick waxy layers and had a more regular network structure than the yellow passion fruit surface. The highest concentrations of alkanes, terpenoids and fatty acids were detected in the purple fruit mature stage, which may account for its longer storage period and greater resistance to biotic stress than yellow passion fruit. *Fusarium kyushuense*, *F. concentricum*, *Colletotrichum truncatum*, and *Alternaria alternata* were the most aggressive fungal pathogens causing postharvest decay. Both the wounded and nonwounded yellow passion fruit were more susceptible to the pathogens than the purple passion fruit. We also identified genes and signaling pathways involved in the biosynthesis and transport of wax in passion fruit via transcriptome sequencing. Genome-wide identification and expression profiling of the β-ketoacyl-CoA synthase and Eceriferum gene families were performed. A simple and efficient *Agrobacterium*-mediated plant transformation system for passion fruit was established, with a regeneration efficiency of 86% and a transformation efficiency of 29%.

Progress in Smart Vegetable Seedling Production

Yuan Huang[1*], Zhilong Bie[1], Shengyong Xu[2], Zuojun Tan[2], Baoqi Wang[2], Lei Li[2], Xia Cai[2] and Jianuo Xu[1]
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Vegetable growers often use seedling transplantation in production. The quality of the seedlings directly impacts the quality and yield of the vegetable products. However, the

seedling production efficiency is low. With the development of information technologies such as deep learning, the Internet of Things (IOT), big data, and artificial intelligence (AI), there is a need to develop smart techniques for vegetable seedling production. Our group members belong to different disciplines, such as vegetable science, artificial intelligence, and the Internet of Things. We developed a nondestructive detection algorithm for key phenotypes of the canopy of watermelon plug seedlings based on deep learning. We also developed a deep learning-based point cloud processing method for segmentation and occlusion leaf restoration of seedlings. A nondestructive measurement method for determining the root phenotype of pumpkin rootstock via AZURE KINECT was established. An intelligent greenhouse seedling height inspection robot (G-ROBOT), which is expected to be an intelligent assistant for seedling research and production, was developed by our group. A new grafting method for watermelon to inhibit rootstock regrowth and a method for simultaneously monitoring phloem and xylem reconnection in grafted watermelon seedlings were developed. A nondestructive method for detecting the healing state of grafted seedlings of melon crops via a hyperspectral fluorescence tracer was established. The above smart technique increases vegetable seedling production efficiency and seedling quality.

Use of Cover Crops for Sustainable Vegetable Cropping Systems: 10-Year Experiment in Mediterranean Environment

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Industrialized agriculture, characterized by heavy chemical inputs, mechanization, and monoculture, has led to significant environmental challenges. The need for sustainable practices, which balance productivity with the preservation of natural resources for future generations, is critical. Cover crops serve as an essential tool for sustainable agriculture. These crops are grown during fallow periods or intercropped with cash crops, providing protective soil cover and improving overall system resilience. The study outlines the functional types of cover crops: winter cover crops, catch crops, smother crops, green manure crops, and living mulches. Field trials conducted over ten years in the Mediterranean environment demonstrated multiple benefits of cover crops. The results show significant improvements in soil physical properties. Soil organic matter was increased due to cover crop biomass decomposition, which provides a substrate for soil microorganisms. Furthermore, cover crops minimized nutrient leaching and improved nitrogen availability for subsequent cash crops. The research also highlights the role of cover crops in weed suppression. Cover crops compete with weeds for water, light, and nutrients, while some species exhibit allelopathic properties that inhibit weed growth. Despite

these advantages, challenges remain in the widespread adoption of cover crops. These include the need for additional resources, such as labour and capital, and the complexities involved in managing nutrient dynamics, especially nitrogen. In conclusion, the 10-year experiment demonstrates the potential of cover crops to enhance the sustainability of Mediterranean vegetable cropping systems by improving soil health, conserving nutrients, and controlling weeds, thus contributing to the development of more resilient agricultural systems.

Genome-Wide Analysis and Expression Profiling of Pseudo-Response Regulator (PRR) Genes in Cabbage (*Brassica oleracea* L.) under Abiotic Stress Conditions

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The gene family of pseudoresponse regulators (PRRs) plays crucial roles in the developmental processes and stress adaptation of plants. Despite their importance, there has been limited research on the PRR gene family within *Brassica oleracea*, which is commonly known as cabbage. This research focused on uncovering the functions of PRR genes in cabbage. We identified 10 BoPRR genes within the cabbage genome via bioinformatic techniques. Our study delves into their gene structure, conserved protein motifs, and cis-regulatory elements and performs synteny analysis. We utilized fluorescence-based real-time quantitative PCR (RT–qPCR) to investigate the expression profiles of these genes under different environmental stress conditions. Through phylogenetic analysis, the BoPRR genes in *Brassica oleracea* were classified into three major groups and found to be distributed among four chromosomes. The promoter regions of these genes are enriched with elements sensitive to light, cold, drought, and abscisic acid (ABA) signaling. Expression analysis revealed that all 10 BoPRR genes were notably expressed in cabbage leaves, especially when subjected to various abiotic stresses. This study represents a pioneering comprehensive analysis of the PRR gene family in cabbage, contributing to the foundational knowledge for future research on the abiotic stress response. Furthermore, this study provides novel genetic insights for developing cabbage cultivars with enhanced stress resistance.

Genome Editing Using CRISPR/CAS9 System: A Productive Tool to Accelerate Genetic Improvement in Commercial Palms

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Palms (date palm, oil palm, coconut palm) are commercial perennial woody trees with high commercial significance. The increasing pressure on the human population has reinforced genetic improvement in commercial palms, as they are important for meeting the need for vegetable oil and food. A variety of standard breeding techniques can be used to genetically improve commercial palms; however, these approaches are constrained by heterozygosity, complicated genomes, and a perennial nature. Genetic improvement is necessary for sustainable production in commercial palms. CRISPR/Cas9-based genome editing could be a very promising tool for the functional characterization of genes related to genetic improvement in palms. However, genetic transformation and *in vitro* regeneration enable the generation of multiple genetically improved clonal plants. Here, palm plumules, florescence, and seeds were used for callus induction. The desired trait-related genes were selected for single guide RNA (sgRNA) targeting specific genomic sites followed by the protospacer-adjacent motif (PAM) motif in the target site with the sequence NGG and ligation into the CRISPR system. After successful Agrobacterium-mediated genetic transformation, positive transformants were screened through GFP detection. GFP-positive calluses were transformed into a coculture medium for proliferation and regeneration. At the histological level, positive GFP-positive calli were further confirmed through polymerase chain reaction (PCR) and sequencing. This study reveals an efficient Agrobacterium-mediated genetic transformation method for palms. In the future, these findings may serve as a foundation for genetic improvement and functional investigations of desirable candidate genes for the sustainable production of commercial palms.

Fruit Hollowness and Browning in Huangguanli Plum and Associated Lignin Accumulation

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Plum is an economically and nutritionally important stone fruit that is grown worldwide. Fruit hollowness and browning (HB) are among the most common limiting factors that adversely affect the fruit quality of plums. Here, Huangguan plum fruit were sampled at 10, 25, 40, 55, 70, and 80 days after full bloom, and we found that HBs began at the veraison stage, the HB percentage reached 37.73% at the mature stage, and the fruit shape index of the HB plum was significantly greater than that of the non-HB plum. HB fruit presented a relatively high total lignin content ($P \leq 0.001$). The lignin monomers of the HB fruits consisted mainly of guaiacyl lignin (22.6%) and syringyl lignin (10.8%). Both the 4CL and PAL enzyme activities exceeded those of non-HB fruit during the fruit development and ripening periods. The expression of

eight *Ps4CL* genes was greater in HB fruit than in non-HB fruit. *Ps4CL1*, *Ps4CL2*, *Ps4CL7*, and *Ps4CL8* may be involved in plumfruit lignin biosynthesis, and the Ps4CL gene family contains many cis-acting elements related to plant endogenous hormones. WGCNA revealed core hub genes (*Ps4CL5*, *Ps4CL7*, and *Ps4CL8*), each of which had at least 30 coexpressed genes. The qRT–PCR results revealed that the *Ps4CL* genes presented tissue- and temporal-specific expression profiles. In conclusion, the key periods for HB occurrence were identified, and the dynamics of lignin content, monomer type, and related enzyme activity were determined. WGNCA analysis identified key genes involved in the lignin biosynthetic pathway in the Huanguan plum.

Flower and Fruit Management of Table Grapes in China

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This study included the flower and fruit management of the Chinese table grapes 'Shine Muscut', 'Summer Black' and 'Kyoho' by using gibberellin plant growth regulators and the tip of the flower. In terms of the flower tip, generally 3~7 cm or 12~18 small flowers are left at the tip of the flower one week before flowering. Generally, table grapes are treated twice with 12.5~50 mg/kg gibberellins and 0.5~5 mg/kg CPPU to obtain seedless varieties.

The Terpene Synthase (TPS) Gene Family in Kiwifruit Shows High Functional Redundancy, and a Subset of TPS Likely FulfillOverlapping Functions in Fruit Flavor, Floral Bouquet and Defense

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Volatile terpenes are important compounds that influence the flavor and aroma of kiwifruit. Terpenes in plants also impact floral bouquets and defend against pests and pathogens in leaves and fruits. To better understand the overlapping roles that terpenes may play in plants, a systematic gene, chemical and biochemical analysis of terpenes and terpene synthases (TPSs) was performed in Red5 kiwifruit (*Actinidia* spp.). Analysis of the Red5 genome revealed that it contains only 22 TPS gene models, of which fifteen encode full-length TPSs. Thirteen TPSs can account for the major terpene volatiles produced in different tissues of Red5 kiwifruit and in response to different stimuli. The small Red5 TPS family displays surprisingly high functional redundancy, with five TPSs producing linalool/nerolidol. The treatment of leaves and fruits with methyl jasmonate increased the expression of a subset of defense-related TPS genes and stimulated the release of terpenes. Six TPS genes were induced upon herbivory of leaves by the economically important insect pest Ctenopseustis obliquana (brown-headed leaf roller), and emission, but not accumulation, of (E)- and (Z)-nerolidol was strongly linked to herbivory. Our results provide a framework for understanding the overlapping biological and ecological roles of terpenes in Actinidia and other horticultural crops.

Using Rice Straw as an Alternative Growing Media for Vegetable Production in Egypt

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The agricultural sector is deemed to be one of the leading sectors in the Egyptian national economy. Rice is one of Egypt's most important grains, and its production plays a major role in the strategy of producing food within the country. The annual amount of agricultural waste in Egypt reaches 40 million tons. Rice, corn, wheat, barley, cotton and sugarcane are the economic crops with the highest rates of waste. In the case of rice straw, approximately 4 million tons of waste are produced annually, and farmers burn rice straw to prepare their soils for planting the next season. Thus, the burning of rice straw in open fields can cause several environmental problems, including dark fog phenomena and air pollution from harmful emissions and/or poisoning gases. Therefore, finding solutions to this problem involves converting rice straw into compost or animal fodder or cultivating and producing mushrooms. One successful method to benefit from rice straw is to use compacted bales of rice straw to produce vegetable crops in greenhouses or open fields. This method was successful when used in lands infected with soil-borne diseases, root-knot nematodes, or highly saline soils. The experiments were conducted to grow strawberries, cucumbers, and peppers on compacted bales of rice straw, which had positive effects on the environment and high economic returns for the farmers.

Effect of Foliar Spray of Yeast Extract and Potassium Nitrate on Yield and Fruit Quality on "*Ziziphus jujuba* L." Trees

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The present study was conducted during two successive seasons, 2017 and 2018, at King Saud University, Saudi Arabia, to investigate the effects of foliar sprays on *Ziziphus jujuba* trees via yeast extract at 1% and 2% and potassium nitrate (KNO_3) at 1% and 2%. All the treatments were foliar applied twice (December 15–January 15) in both seasons. The yield and fruit quality were studied. Compared with the control (water only), the treatments significantly improved yield; fruit physical characteristics; fruit chemical characteristics; moisture content; and chlorophyll a, b, and total chlorophyll contents in both seasons. Yeast spray treatments significantly decreased the juice content of vitamin C (mg/100 g), whereas KNO_3 spray treatments increased the juice content of vitamin C in both seasons. It can be concluded that foliar application of KNO_3 at 2% resulted in the highest yield, fruit weight, flesh weight, fruit volume, fruit length and fruit diameter, whereas yeast extract at 2% resulted in the highest TSS% and total sugar content in this study.

Ornamental Horticulture and Landscaping

Global Floriculture Trends and Opportunities for Pakistan

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Floriculture, a potential horticultural enterprise, offers higher returns to growers and stakeholders to fulfill local demands and earn foreign exchange while generating year-round employment opportunities. During the last few decades, several modern trends and interventions have been used to produce high-quality ornamentals, and a rapid shift has been witnessed toward floricultural crop production both locally and internationally. This discussion describes some of the modern trends, which are being adopted in different parts of the world; developments in local floriculture, particularly at the University of Agriculture, Faisalabad, Pakistan; and opportunities for floriculture stakeholders in Pakistan to obtain higher returns from their floricultural enterprises via these interventions. These interventions include but are not limited to greenhouses and open field cut flower production, cut foliage production, high-quality containerized ornamental plant production for local and export markets, flower seed production, supply chain management, virtual marketing, flower dehydration and value-added product development from flower crops, etc. The use of these modern trends and technologies would not only help improve floricultural production in Pakistan and help Pakistani stakeholders enter the global trade but also improve the socioeconomic livelihood of local farmers by increasing the comparatively low-cost but high-value floricultural crops compared with other horticultural or agronomic crops grown in the country.

Innovative Technologies for Sustainable Urban Landscape

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The landscape was based on cultural and spiritual trends. It is shifting from spiritual foundations to contemporary designs. Historically, in the developed world, aesthetic gratification has remained a dominant consideration. Prioritizing the functional capacities of physical features in landscape design is a result of the increasing popularity of global environmental issues. The incorporation of eco-friendly practices such as landscaping in a way that conserves natural resources is at the core of contemporary trends in landscape design that focus on sustainability and conservation. Initiatives are underway to encourage local flora and discourage exotics. Examples of these methods include conserving water, adding drought-tolerant plant species and using organic pots instead of plastic or clay pots. Additionally, these projects have received encouragement from global initiatives such as "Mix it Up" and "Edible Landscape," which encourage the cultivation of edibles alongside ornamentals to preserve biodiversity and

increase urban productivity. Traditions and culture have always had an impact on how decisions are made about designing a landscape, but as environmental concerns have become more prevalent, modern trends such as vertical, green wall, layered landscaping, green roofs, and diverse land use for things such as spiritual, cultural, and functional gardens involving the use of organic products in landscape design have been successful.

Urban Horticulture: A Sustainable Approach after Devastating Floods in Pakistan Caused Food Security Crisis

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The flash floods triggered by unusual heavy rains in Pakistan have deluged the country and devastated Agri farms, creating shortages of food, fruits and vegetables as well as skyrocketing the prices of eatables. This has impacted more than 2 million acres of crops and killed more than 800,000 heads of livestock across Pakistan. Given the current alarming situation, there is a dire need to overcome food insecurity with some sustainable approaches. The idea of edible gardening seems to be a viable option for the supplementary production of horticultural food crops in urban and suburban areas. The edible landscape seems to be a contemporary component of urban horticulture (UH). The role of UH in response to the dietary requirements of urban dwellers involves the use of local resources and the recognition of the importance of economic and resource use, which will not affect residents' health, food safety, or environmental conditions. Horticultural plants are the best option for food consumption (fresh or processed) and for aesthetic gratification in cities and surroundings. In Pakistan, the idea of urban horticulture is becoming popular, and many growers are involved in the cultivation of vegetables in cities and their surroundings due to the high demand. A survey was conducted in Faisalabad, and public perceptions were collected through a validated questionnaire to understand public perceptions and opinions about the acceptability of UH.

Exogenous Application of Bio-foliar on Bells of Ireland (*Moluccella laevis* L.) for Production Optimization

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Moluccella laevis L. (Bells of Ireland) is an annual herb belonging to the Lamiaceae family that is native to Turkey and Syria. It features spikes of fragrant white flowers enclosed within green calyxes, which are used mainly as ornamental and cut flowers. To address the demand for sustainable floriculture production, the introduction of novel crops such as Bells of Ireland, along with low-cost biological elicitors, is imperative. This study explored the impact of natural

growth stimulants derived from Moringa leaf (MLE), willow leaf (WLE), and seaweed (SWE) on the growth, flowering, and postharvest life of *Moluccella laevis* L. The overarching goal was to optimize the production and quality of Bells of Ireland flowers. The experimental design included varying concentrations of MLE, WLE, and SWE (10 ml, 20 ml, and 30 ml/1000 ml) administered at 10-day intervals after transplanting. The experiment adopted a completely randomized design (CRD). The evaluated parameters were plant height, plant canopy, leaf area, number of leaves, chlorophyll content, stalk length, number of stalks per plant, number of florets per stalk, shelf life, and drying. The application of biostimulants enhanced the production and quality of Bells in Ireland. However, MLE, WLE at high dose rates, and SWE at low dose rates produced better results. The application of 10 ml/L seaweed extract produced excellent results, with significantly better results for most of the parameters under study. This study is expected to contribute to the advancement of sustainable and resilient floriculture practices.

Biostimulants for Sustainable Petunia Production: A Comparative Study on Growth, Flowering, and Environmental Impact

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Petunias from the genus Petunia and family Solanaceae, commonly classified as *Petunia hybrida,* are popular flowering plants that are valued for various reasons, making them important in horticulture, gardening, and landscaping. The cultivation of petunia typically requires a high degree of chemical fertilizers, but excessive fertilizer affects soil fertility. Biostimulants are currently extensively used because of their nature-friendly impact, negligible side effects, and limited number of mineral fertilizers, which ultimately reduce chemical pollution in the environment. The experiment was conducted in the Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan. The experiment was carried out to evaluate the efficacy of four commercial biostimulants as foliar applications, i.e., Seamaxx, Quantis, Isabion, and Planofix, on the growth and development of *Petunia hybrida*. This study was developed according to a complete randomized design. Different morphological parameters (plant height, flowering time, total blooming period,

number of flowers, leaf length, leaf width, leaf area, number of leaves, and number of branches) and physiological parameters (flower fresh weight and flower dry weight) were evaluated. Statistical analysis was performed via Statistix 8.1, and a 5% probability level comparison of the means was performed via the LSD test. Plants grown without biostimulant application (distilled water) exhibited poor development. The application of 300 µl/L Planofix increased the growth and development of *Petunia hybrida*. The results suggest that Planofix, which contains naphthaleneacetic acid, has good potential for improving the growth characteristics of petunia plants.

Optimal Indigenous Soilless Substrate for High-Quality Cut Flower Production of *Matthiola incana L.* in Punjab, Pakistan

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The stock (*Matthiola incana L.*), a member of the family Brassicaceae, is a cool-season annual flower that is very popular as a specialty cut flower because its racemes have elegant colors, viz. pink, lavender, purple, white, yellow, red, etc. This study was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2022--23 to optimize indigenous soilless substrates for high-quality cut stock production. There were ten treatments in this experiment: control (soil + silt + Farmyard manure, 1:1:1; v/v/v), sugarcane bagasse + peanut hulls + sugarcane pressmud (50:30:20; v/v/v), sugarcane bagasse + rice hulls ash + sugarcane pressmud (50:30:20; v/v/v), sugarcane bagasse + rice hulls ash + composted farmyard manure (50:30:20; v/v/v), sugarcane bagasse + peanut hulls + composted farmyard manure (50:30:20; v/v/v), UAF Gro (100%), sesame straw + rice hulls ash + sugarcance pressmud (50:30:20; v/v/v), sesame straw + rice hulls ash + composted farmyard manure (50:30:20; v/v/v), sesame straw + peanut hulls + sugarcane pressmud (50:30:20; v/v/v) and sesame straw + peanut hulls + composted farmyard manure (50:30:20; v/v/v). The experiment was carried out according to a randomized complete block design (RCBD) with three replications of 18 plants each, and treatments were applied to lily crates 45×60 cm in size. The following data were collected: plant height, flower quality, leaf area, total chlorophyll content, survival percentage, production time and flower diameter. The results revealed that the tallest plants (38.4 cm) with the greatest flower diameter (43.02 cm) were recorded among the sugarcane bagasse + peanut hull + composted farmyard manure, 50:30:20; v/v/v. Similarly, the largest leaf area (6.91 cm2) along with the highest leaf total chlorophyll content (77.7 SPAD) and the highest survival percentage (89.66%) were recorded in the plants growing in UAF Gro, 100%. Similarly, the best flower quality (8.73) and maximum production time (57.1 d) were recorded for plants grown in sugarcane bagasse + coco-coir + composted farmyard manure,

50:30:20; v/v/v. The shortest plant height (16.38 cm), flower diameter (20.35 cm), minimum leaf chlorophyll content (68.6 SPAD), smallest leaf area (1.39 cm2) and shortest production time (69.4 d) were recorded for plants in the control treatment (soil + silt + FYM, 1:1:1; v/v/v). In summary, a substrate composed of (sugarcane bagasse + composted peanut hulls + composted farmyard manure 50:30:20; v/v/v) and UAF Gro (100%) may be used instead of peatmoss or any other expensive imported soilless substrate for best quality cut stock production.

Evaluating the Growth and Production of Cut Stock (*Matthiola incana* L.) Using Macro and Micronutrients along with Biostimulants

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Matthiola incana, commonly known as a stock, belongs to the Brassicaceae family and is recognized as a valuable specialty cut flower because of its wide range of colors, high-quality stems, and reasonably long vase life. Moreover, there are limited choices available for flower consumers in the subcontinent, particularly Pakistan. Therefore, a field study was conducted on *Matthiola incana* L. 'Column Rose Pink' at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2022--23 to optimize macro- and micronutrients along with biostimulants to develop optimal nutrient protocols to grow stock cut flowers in the subtropics. The shortest production time (95.5 d) was recorded with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}, whereas the longest production time (111.7 d) was recorded for plants with no additional fertilizer (control). The tallest 57.4 cm tall plants were recorded with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}. The shortest plant height (36.3 cm) was recorded for the plants in which no fertilizer was applied (control). The greatest leaf area (45.0 cm^2) was recorded when the plants were sprayed with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}, whereas the smallest leaf area (38.9 cm^2) was recorded in the plants with no fertilizer applied (control). The highest leaf total chlorophyll content (114.2 SPAD) was recorded when the plants were sprayed with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}, whereas the lowest leaf total chlorophyll content (87.9 SPAD) was recorded in the plants in which no nutrients were applied (control). The greatest race and stem diameter (54.8 mm and 9.1 mm, respectively) were noted when the plants were sprayed with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}. The least raceme and stem diameter (40.9 mm and 5.9 mm, respectively) were recorded for the plants that received no additional nutrients (control). The highest stem fresh and dry weights (46.6 g and 5.8 g, respectively) were recorded when the plants were sprayed with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}. The lowest stem fresh and dry weights (27.3 g and 3.0 g, respectively) were noted in the plants that received no fertilizer (control). The flower quality was best (9) when the plants were treated with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}. The lowest

flower quality (6) was recorded with no additional nutrients (control). The longest vase life (10 d) was recorded when the plants were treated with NPK @ 90:45:45 kg ha^{-1} + isabion @ 2 mL L^{-1}, whereas the shortest vase life (6.6 d) was recorded when no nutrients (control) were applied. In summary, stock should be fertilized with NPK (90:45:45 kg ha^{-1}) + isabion for commercial cut flower production.

Changes in Antioxidant Enzyme Activities, Hormone Levels and Growth Traits of Rose Induced by Three Native Strains of *Trichoderma harzianum*

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Roses (*Rosa* spp.) are considered popular ornamental plants for urban landscapes because of their petals and their ability to beautify public gardens and improve the environment. *Trichoderma harzianum* has been applied to various plants as a potential biocontrol agent to help plants resist pathogens. In our study, three native strains of *T. harzianum* were inoculated together on the soil in pots in which *R. chinensis* 'Shi-Jie-Mei' (ten-sister Roses' was planted, and the results were compared with those of noninoculated Roses to determine changes in growth traits. The results of the analysis revealed that many traits, including the number of branches, the height of the stems, the fresh weight, the dry weight, and the water content of the leaves and stems, significantly increased. The activities of antioxidant enzymes, such as catalase, peroxidase, and superoxide dismutase, in the leaves also significantly increased compared with those in the control. In addition, the levels of hormones, such as salicylic acid, indole-3-acetic acid, gibberellins, jasmonic acid, zeatin, and abscisic acid, in leaves were significantly increased by *T. harzianum*. Our results indicated that *T. harzianum* could improve the growth traits of rose plants by regulating their antioxidant enzyme activities and phytohormone levels.

Cut Foliage Crops- A Potential Floricultural Enterprise for Southern Punjab

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Cut foliage production is a relatively new, innovative market-led sector of commercial floriculture. It is an integral part of any floral arrangement and is a popular floriculture entity. However, the best-suited species and their cultivation via optimal protocols are very important.

Therefore, a study was conducted on selected cut foliage species individually, viz. *Asparagus densiflorus*, *Rascus hypophyllum*, *Scindapsus aureus* and *Phoenix canariensis*. An experiment was conducted to optimize production protocols for selected cut foliage species under local agroclimatic conditions. There were a total of ten treatments with three replications, each with four plants of uniform size. The substrate components used were silt (S), UAF-Gro (UG), coco-coir (CC), peanut hull (PH), sugarcane press mud (SPM), rice hull (RH), sesame straw (SS) and rice hull ash (RHA) in various ratios, while silt was used as a control. The substrate compositions included the following [on a % (v/v) basis]: silt (100%); UAF-Gro (100%); S (30%) + CC (40%) + C. FYM (30%); SS (50%) + RHA (20%) + C. FYM (30%); SS (50%) + PH (20%) + C. FYM (30%); CC (50%) + RH (20%) + SPM (30%); SS (60%) + RHA (20%) + SPM (20%); CC (30%) + RH (40%) + C. FYM (30%); SS (60%) + PH (20% + SPM (20%) and S (30%) + CC (40%) + UG (30%). The experiments for all the crops were laid out individually according to a complete randomized design (CRD) in a greenhouse. The results revealed that the substrate combination (S: CC: C. FYM) had the greatest effect on plant heights of 74.7 cm, 42 cm and 30 cm for phoenix palm, money plant and asparagus, respectively, followed by CC:RH:SPM for all the tested species. The highest number of marketable stems was also recorded for all the tested species, with values of (4), (3.3), and (8.1) for phoenix palm, money plants and asparagus, respectively, when S:CC:C was applied. FYM followed by CC:RH:SPM. The highest number of leaves (10.7) was recorded for S:CC:U-Gro, followed by CC:RH:SPM for phoenix palm, whereas the greatest number of leaves (20) was recorded for the money plant with CC:RH:SPM. The plants treated with 100% silt presented retarded growth, with reduced plant heights of 42.5 cm, 40 cm, and 16.7 cm for phoenix palm, money plants and asparagus, respectively. The Ruscus plants exhibited the best growth, with a 95.5% survival percentage, when treated with the CC:RH:SPM combination. The CC:RH:SPM substrate combination was the best for most of the tested growth parameters for the tested cut foliage crops and can be used for commercial production of high-quality cut foliage stems.

Optimal Nutritional Regimes for High Quality Flower and Seed Yield of Marigold (*Tagetes erecta* L.)- A Popular Annual Flower in Punjab, Pakistan

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Marigold (*Tagetes erecta* L.), a member of the Asteraceae family, is a popular winter annual flower grown extensively as bedding plant in Pakistan. In addition to its aesthetic value, it also has significant ornamental and medicinal importance. A study was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2022--23 to optimize nutrient application for the optimal flower and seed production of marigold in the agroclimatic conditions of Faisalabad, Punjab, Pakistan. There were six treatments in this experiment: the control, N@90 kg ha-1, NPK (90:45:45 kg ha-1), NPK (90:45:45 kg ha-1 + micronutrients (1% Fe, B and Zn each), NPK (90:45:45 kg ha-1 + 0.4% isabion) and NPK (90:45:45 kg ha-1 + 0.4% humic acid). The experiment was performed according to a randomized complete block design (RCBD) with three replications of 30 plants each. The following data were collected: plant height, plant canopy diameter, number of flowers per plant, flower diameter, leaf area, leaf total chlorophyll content, production time, harvest index, seed yield per plant, seed moisture content and 1000-seed weight. The results revealed that the tallest plants (43.6 cm), greatest plant canopy diameter (36.0 cm) and greatest flower diameter (15.86 mm) were recorded in the plants supplied with NPK + Isabion (0.4%). The largest leaf area (26.13 cm^2), highest leaf total chlorophyll content (24.50 SPAD) and maximum production time (145.8 d) were recorded for the plants fertilized with NPK + humic acid (0.4%). Similarly, the highest seed yield per plant (2.10 g), greatest harvest index (14.64%) and 1000-seed weight (9.60 g) were recorded in plants supplied with NPK 90:45:45 kg ha^{-1} along with micronutrients @ 1% Fe, B and Zn each. However, the greatest number of flowers (5.2) and seed moisture content (10.26%) were observed in the plants fertilized with 90:45:45 kg $ha^{-1\ NPK}$. The shortest plant height (35.6 cm) and plant canopy diameter (26.1 cm), minimum leaf chlorophyll content (13.12 SPAD) and smallest leaf area (11.88 cm2) were recorded for the plants where no nutrients were applied. Similarly, the smallest flower diameter (11.79 mm), shortest production time (123.8 d), lowest harvest index (10.55%) and lowest seed moisture content (5.80%) were recorded in the plants with no additional fertilizer. Moreover, the lowest number of flowers (3.80), seed yield per plant (1.64 g) and 1000 seed weight (8.40 g) were recorded for the plants supplied with N @ 90 kg ha-1, followed by the control, where no additional fertilizer was applied. In summary, the application of NPK along with micronutrients @ 1% Fe, B and Zn each along with Isabion + humic acid (0.4%) may be used in combination instead of traditional fertilizer applications for higher yields of the best-quality marigold flowers and seed yield.

Abiotic Stresses

Mitigation of Drought-Induced Adverse Effects in Chilli Genotypes through Exogenous Application of Glycine Betaine

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Drought is one of the main constraints threatening sustainable agricultural productivity worldwide. Scientists have developed various strategies to mitigate the harmful effects of drought stress in plants. One of these strategies involves the application of different types of osmolytes, which help plants overcome the deleterious effects caused by drought stress. Chilli (*Capsicum frutescenes* Mill.) It is one of the most important vegetables and condiments worldwide. Chili plants are very sensitive to water deficit conditions. In this study, two drought-tolerant genotypes (Chilli Hot Queen and High Fly 2) and two sensitive genotypes (Red Giant and Sky Red) were subjected to drought stress (control and 45% field capacity, FC). The plants were also sprayed with glycine betaine (GB, 0 and 10 mM) solution to ameliorate the adverse effects of imposed drought stress. The control or unstressed plants were irrigated normally, whereas for the 0 mM GB spray, the plants were sprayed with distilled water only. All morphological (plant height, number of leaves, number of flowers and number of fruits per plant and individual fruit weight) and physiological attributes (relative leaf water content, water use efficiency, rates of photosynthesis and transpiration, stomatal conductivity) decreased under drought stress compared with those under the control (normal irrigation). This reduction was more prominent in drought-sensitive genotypes than in drought-tolerant genotypes. However, capsaicin and dihydrocapsaicin contents increased under drought stress. Malondialdehyde and hydrogen peroxide concentrations and electrolyte leakage were greater in drought-sensitive genotypes than in drought-tolerant genotypes when subjected to drought stress. On the other hand, the proline content and antioxidant enzymatic activities also increased under drought stress, but the increase was notable in the drought-tolerant genotypes compared with the drought-sensitive genotypes. Foliar application of 10 mM GB (glycine betaine) reduced the adverse effects of drought stress on growth, physiological parameters, and gas exchange characteristics. Similarly, foliar application of 10 mM GB decreased the hydrogen peroxide and magnesium concentrations and electrolyte leakage and increased the leaf proline and protein contents and antioxidant enzymatic activities in drought-stressed plants. However, foliar application of 10 mM GB had no effect on individual fruit weight or capsaicinoid (capsaicin and dihydrocaosaicin) content.

Effects of Drought Stress on Three Forest Species of Arid Environment; Evidences from Growth, Physiology, and Biochemical Attributes under Control Condition

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Drought stress is a major abiotic factor limiting plant growth and production. A greenhouse study was conducted on three important tree species in arid environments: *Conocarpus erectus*, *Acacia modesta*, and *Salix tetrasperma*. Young saplings were subjected to control (C), medium (MWD), and severe soil water deficit (SWD) treatments. The results revealed that in the leaves, stems, and roots of all three species, dry weight production remained similar to that of C under MWD but decreased significantly under SWD. The greatest decrease in total dry weight was detected in *Salix tetrasperma,* and the lowest decrease was detected in *Acacia modesta* under SWD. The root:shoot ratio increased significantly in both *Conocarpus erectus* and *Acacia modesta* under both the MWD and the SWD. Furthermore, the chlorophyll content decreased, whereas the proline content increased significantly in both the MWD and SWD treatments. The production of oxidants (hydrogen peroxide and superoxide anions) and antioxidants (superoxide dismutase, catalase, peroxidase, and ascorbate peroxidase) increased significantly under both the MWD and SWD treatments and was highest in *Acacia modesta* in both the MWD and SWD treatments. Therefore, we may conclude that all three species can tolerate moderate water stress due to increased root production and an effective antioxidant defense mechanism.

Improving Pea Plant Tolerance to Salinity Stress Using *Bacillus subtillus* Amended Soil

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The physiological tolerances of plants to the osmotic and ionic components of salinity stress at the plant level were reviewed. The response of plant growth to salinity and plant adaptations to salinity are distinct: osmotic stress tolerance and salinity affect and limit yield potential and pulse crops. Two cultivars of *Pisum sativum* L. with different sensitivities to NaCl were used. Therefore, an experiment was conducted to evaluate the salinity-induced physiological

response of peas by estimating the germination rate, sugar content, catalytic activity, protein content, and chlorophyll content and detecting Na^+ and Cl^- in pea plants. The results indicate that the rate of germination, percentage reduction in fresh and dry weight, relative protein content, sugar content, catalase activity, peroxidase activity and salt tolerance of both genotypes of field peas were significantly influenced by different levels of salinity. The radicals and plumules of the mentor genotype were damaged by applying 380 to 400 ppm NaCl salt stress. However, among these two pea genotypes, the green cross performed better under the 400 ppm level of salinity with *Bacillus subtilis* (OSR3), and this genotype may be recommended for cultivation in field conditions in Pakistan and can also be used in future breeding programs for the development of salt-tolerant pea cultivars.

Management of Chromium Stress in Tomato by Using Aqueous Plant Extract

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Tomato (*Solanum lycopersicum* L.) is the second most common vegetable after potato and onion and is the most common and ancient crop in the world. Unfortunately, in Pakistan, tomato yield is very low compared with worldwide production. Many biotic and abiotic factors hamper tomato production. One of the destructive abiotic factors is the stress caused by heavy metals, such as hexavalent chromium. In the present work, the effects of plant extracts (onion and garlic extracts) on the growth of tomato plants grown under Cr(VI) stress were studied via pot experiments. Different growth parameters, such as plant height, root and shoot length and biomass, were studied after 45 d of seed germination. Moreover, various physiological attributes, such as total chlorophyll content (CHL) and reducing sugars (SUG), have been studied. However, biochemical traits, i.e., total protein content (TPC), catalase (CAT) and polyphenol oxidase (PPO) activity, were also studied after 45 d. Compared with the respective positive controls (300 and 500 mg kg-1), the soil amendments with onion peel extracts at different concentrations (2, 4, 6 and 8%) significantly ($P \leq 0.05$) increased the growth of the tomato plants. However, the application of garlic extract had a negative effect on the growth of tomato plants compared with the negative (no treatment) and positive controls (300 and 500 mg kg^{-1}). Furthermore, the physiological attributes were significantly enhanced by adding onion extract to Cr(VI)-rich soil compared with the positive control. However, the biochemical activities increased in response to hexavalent chromium stress and decreased significantly with the application of onion extract. Thus, onion extract could be used as a soil amendment to control Cr(VI) stress in cultivated areas of tomato. However, further studies under field conditions are needed to determine the impact of onion extract on the growth and physiology of tomato plants growing in Cr(VI)-rich soil.

Investigating the Morpho-Physiological and Anatomical Impact of Salt Stress on *Matthiola incana* and its Amelioration through Foliar Application of Selenium and Salicylic Acid

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Salinity represents a significant environmental challenge that often leads to substantial harm to plants. Salinity has a detrimental effect on the growth of plants. Researchers are investigating strategies to optimize the quality and yield of ornamental cut flowers under harsh environmental stresses such as salinity. In the present research, we tested different salinity levels (20, 40, 60, and 80 mM) to estimate the effects of salt stress on the morphophysiological and anatomical features of the cut flower *Matthiola incana* (stock flower) and to increase salt tolerance via the use of selenium and salicylic acid. An increased growth rate was observed when selenium and salicylic acid were used separately or in combination. Morphological parameters, including plant height, number of flowers, root fresh weight, root dry weight, shoot fresh weight and shoot dry weight, were increased by selenium and salicylic acid application. Anatomical studies of the roots, stems, leaves, leaf upper epidermis and leaf lower epidermis also revealed improvements owing to the exogenous spray of selenium and salicylic acid. However, an increased quantum yield of photosystem II (PSII), decreased NPQt (an estimate of nonphotochemical quenching), increased linear electron flow, a decreased ratio of incoming light that is lost via nonregulated processes (PhiNO) and increased Fv/FM (the maximum photochemical efficiency of PSII) were observed with the exogenous application of selenium and salicylic acid.

Influence of Chromium Stress on Plant Morphological, Physiological and Anatomical Attributes of *Stevia rebaudiana* L.

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Increasing chromium (Cr) contamination in agricultural soils threatens crop yields and quality. This study examines how *Stevia rebaudiana*, a perennial plant prized for its sweet leaves and therapeutic benefits, responds to Cr stress in terms of its morphophysiological and anatomical responses. The experiment was conducted in a completely randomized design, with different concentrations of Cr, including 0.75 ppm, 1.25 ppm and 1.75 ppm, applied to the plants. The results of the morphological attributes indicated that Cr treatment had a positive effect on plant height, whereas shoot length and root length exhibited mixed responses. Low concentrations of Cr increased root length, suggesting an adaptive response to increase nutrient uptake. However, relatively high Cr concentrations inhibited root growth. The number of leaves increased under both Cr-treated and untreated conditions, indicating the tolerance and positive response of the plants to Cr stress. Anatomically, stevia plants exposed to Cr stress presented modifications such as increased cortical area, indicating structural adaptations to cope with heavy metal contamination. However, higher Cr concentrations led to a decrease in the number of palisade and spongy cells, suggesting adverse effects on leaf tissue structure. Higher Cr concentrations physiologically led to higher rates of photosynthetic activity, transpiration, and stomatal conductance. This contrasts with the common understanding that chemical stress causes stomatal closure and reduced photosynthesis. The degradation of photosynthetic pigments may explain the reduced light-harvesting capacity observed in some plant species. This study provides valuable insights into the morphological, anatomical, and physiological adaptations of stevia to Cr stress, which can inform agricultural practices and future research aiming to mitigate the adverse effects of heavy metal pollution on stevia cultivation.

Abiotic Stress Resilience of Jamun (*Syzygium cumini*) Under Interactive Salinity and Water Scarcity

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Jamun (*Syzygium cumini*) is a highly valued tree species of the flowering plant family Myrtaceae. Despite being a highly nutraceutical fruit crop, jamun is cultivated primarily as a minor fruit crop in Pakistan. Moreover, jamun is also considered a vulnerable plant species in saline soil and water scarcity conditions, but its ability to tolerate abiotic stress is still unknown. Therefore, an extensive study was conducted at Pakistan Agricultural Research Council - Arid

Zone Research Centre, Dera Ismail Khan, to investigate the morphophysiological responses and stress tolerance ability of jamun against salinity and water shortages. One-year-old jamun plants were transplanted into growth media with different salinity and water scarcity levels. Five salt stress treatments (control, 5 dS m^{-1}, 10 dS m^{-1}, 15 dS m^{-1}, and 20 dS m^{-1}) were applied, and the combined effects of salt and water stress were also investigated at the same salt concentration. Water stress was followed by both unwatered conditions and normal irrigation water fortnightly. The experiment was performed according to a completely randomized design (CRD), and data were recorded every four weeks. The results revealed that most of the morphophysiological parameters tended to decrease with increasing salt concentration, which was accompanied by water stress. The plant mortality rate was greater at higher levels of salt (20 dS m-1) alone and in combination with water stress. Compared with root biomass, salt stress had a greater inhibitory effect on shoot growth, which indicates the high salt tolerance ability of the root system of plants. A 70% decrease in the dry weight of roots and shoots was observed at 15 dSm^{-1} alone and was accompanied by water stress. Moreover, the Na^+ concentration also reached a maximum (0.47 mmol g^{-1}) in the same treatment. The salt tolerance of jamun plants was significantly reduced at high salt concentrations in media because of increased Na^+ accumulation and limited K^+ uptake. Conclusively, our findings highlighted that jamun can grow well in soil with salinity levels of ≤ 15 dS m^{-1}, but its growth may be limited under water scarcity.

Evaluation of Performance of Different Mandarin Cultivars under the Sandy Soil of Dera Ghazi Khan

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Citrus is one of the most important commercial fruit crops grown in all parts of the world, and areas under citrus cultivation are in continuous expansion. Therefore, the focus of the present study was on the growth performance of different mandarin cultivars in the sandy soil of Dera Ghazi Khan. Three different mandarin cultivars were used in the present study, and data were collected at different intervals to assess their performance in the sandy soil of Dera Ghazi Khan, Pakistan. The results revealed that all the plants of each replication were grown successfully, and no mortality was noted. The greatest number of branches was found in mandarin cv. Less seeded Kinnow (11.6), followed by kinnow (10) and Feutrell's early stage (8.7) during interval 2. A similar trend was observed in interval 1. However, the greatest number of leaves was found

in mandarin cv. Less seeded Kinnow (104), followed by Feutrell's early (92.3) and Kinnow (89) during interval 2. A similar trend was observed in interval 1; the highest number of leaves was found in Less Seeded Kinnow (92.7), and the minimum was found in Feutrell's early stage (82.3). The greatest leaf width was found in mandarin cv. Feutrell's early (3.3 cm), followed by Less Seeded Kinnow (2.70 cm) and Kinnow (2.3 cm) during interval 2. A similar trend was observed in interval 1; the greatest leaf width was found in Feutrell's early stage (3.07 cm), and the minimum width was found in Kinnow (1.90 cm). The greatest plant height was found in Less Seeded Kinnow (4.07 ft), and the minimum was found in Kinnow (2.9 ft). The longest shoot length was found in mandarin cv. Feutrell's early stage (27.1 mm), followed by the shorter-seeded Kinnow (25.5 mm) and Kinnow (24.6 mm) stages during interval 2. The greatest shoot thickness was found in Kinnow (8.9 mm), followed by Feutrell's early (4 mm) and Less Seeded Kinnow (3.8 mm). The leaf shape and color as well as the mortality rate of the mandarin cultivar were observed and discussed. However, no mortality was observed in the present study after the plants were transplanted into the sandy soil of Dera Ghazi Khan.

Strigolactone (Gr24) Ameliorates the Adverse Cadmium Impact on *Gladiolus grandifloras* via Modulating the Photosynthetic Apparatus and Antioxidative Defense Mechanism

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Cadmium (Cd) is a trace element that induces severe toxicity symptoms in ornamental plants. Strigolactone (SL), a phytohormone, acts as a mediator of plant growth in the context of heavy metal stress. The present pot experiment examined the ability of exogenous supplementation with SL (4 µM) to mitigate Cd stress (0.5 mM) damage in *Gladiolus grandifloras* cv. Rose Supreme. The results revealed that, in Cd-stressed plants, morphological growth traits, the leaf chlorophyll concentration, and the photosynthetic machinery noticeably abridged. However, foliar spraying of SL increased growth attributes and improved proline and soluble protein levels in plant tissues, which resulted in an increased vase life of gladiolus flowers. The levels of genes associated with oxidative stress, such as MDA, GB and H_2O_2, increased in Cd-stressed plants. Foliar spray of SL mitigated this trend; however, the activities of antioxidant enzymes, i.e., SOD, POD, CAT and APX, increased when the Cd-stressed plants were treated with SL. The results obtained in this study suggest that exogenous SL could effectively alleviate the

antagonistic effects of Cd stress on sword lily by stimulating oxidative defense-associated antioxidants. These findings are beneficial for enhancing the production of elegant gladiolus cut-flower plants in Cd-polluted soils or irrigation water.

Postharvest Science and Technology

Recent Trends in Preharvest Management Strategies to Preserve Postharvest Quality of Fruits: An Overview

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Preharvest factors such as genotype, mineral nutrition, irrigation water quality, insect pests, and diseases directly or indirectly influence the growth, development and maturation of fruits and significantly influence their overall postharvest quality and physiology. Inappropriate and poor preharvest management strategies contribute to substantial quality losses in fruits, resulting in various issues, such as shape disorders, wilting, cracking, spots, rots, quiescent infections (stem end rot, anthracnose), physiological disorders, delayed fruit maturation, inadequate color development, compromised flavor quality, overripe fruit, physical damage, lower marketability and nutritional imbalances. Previously, various preharvest management strategies, such as defoliation, deblossoming, tree age, canopy position, delayed harvest, harvest location, pollen source, pollination frequency, soil, tree nutrient status, low-biuret urea pruning intensities, foliar applications of plant growth regulators, polyamines, putrescine, methyl jasmonate, macro- and micronutrients, ethephon, calcium chloride, salicylic acid, amino acid, glutamic acid, oxalic acid, garlic extract, ascorbic acid, benzyl amino purine, moringa leaf extract, biostimulants, 24-epibrassinolide and seaweed extract, have been used to preserve the overall postharvest quality of various fruits. Hence, it is crucial to consider a preharvest management strategy that ultimately maintains the overall postharvest quality of fruits. This overview describes the recent developments in preharvest management strategies related to the postharvest quality of fruits.

Harvest Maturity Affects Postharvest Quality of Fresh and Dry 'Santa Rosa' and 'Black Amber' Plum Fruit Quality

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The maturity stage at harvest and the type of cultivar affect the postharvest quality and value-added products developed from fresh fruit, as do those from plum (*Prunus silicina*) fruit. For this purpose, an integrated study was executed to assess the effects of harvest maturity stages

and cultivars on plum fruit quality at the shelf period. Two plum cultivars (cv. 'Santa Rosa' and 'Black Amber') were harvested at two maturity stages (Maturity-I: minimum mature [for cv. Santa Rosa (red: 80%, black: 20%); for cv. Black Amber (yellow: 40%, black: 60%)] and Maturity-II: well mature [for cv. Santa Rosa (red: 20%, black: 80%); for cv. Black Amber (yellow: 10%, black: 90%)] and were evaluated at ambient mean conditions (25°C ± 2°C; RH 60--65%) for fresh fruit quality at the shelf and for nutrition of dried plum. These factors were investigated in two independent experiments. The results of the 1st experiment revealed that the plum fruit of both cultivars harvested at maturity-I presented higher respiration rates and ethylene production but lower fruit weight loss than did fruits harvested at maturity-II. Moreover, relatively high vitamin C content; titratable acidity (TA); and high enzymatic activities of superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) were noted in fresh plum fruit harvested at maturity-I in both plum cultivars. A better fruit color and greater total soluble solids (TSS), juice pH, total phenolic content (TPC), antioxidant, carotenoid, anthocyanin and organoleptic attributes were observed in the plum fruits of both cultivars harvested at maturity II. The results revealed that dry plums harvested at maturity-II presented greater moisture, protein, and total caloric contents and retained a greater taste, aroma, texture, and flavor than did fresh plum harvested at maturity-I. As a result, the plum fruits of both cultivars harvested at maturity-I presented greater physical, physiological and antioxidative enzymes. However, the biochemical and phytochemical attributes of fresh plum were greater than those of mature plum, whereas the proximate and organoleptic attributes of dried plum were greater.

Nano-Emulsion Coating Maintains the Quality of Harvested Guavas under Ambient Storage

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Guava (*Psidium guajava* L.) is an important fruit crop in tropical and subtropical regions of the world. Guava has high nutritional importance and is available in large amounts throughout the year, with a high yield. However, it tends to be sensitive to physiological and environmental deterioration. This problem can be managed by adopting pre- and postharvest management. The aim of this study was to determine the efficacy of a nanoemulsion-based edible coating on the shelf-life of guava fruit. A nanoemulsion was prepared by using 3% acacia seed oil. Coated and noncoated (control) fruits were stored at 18°C and 80±5% RH. Compared with the noncoated fruits, the nanoemulsion coating reduced weight loss, membrane leakage, lipid peroxidation, and the hydrogen peroxide concentration. The nanoemulsion acted as a barrier to the degradation of ascorbic acid and citric acid. Nanoemulsions suppressed the activities of softening enzymes such as polygalacturonase, pectin methylesterase, and cellulase enzymes,

which strengthened the cell wall. Furthermore, the coated fruit presented increased activities of ascorbate peroxidase, catalase, superoxide dismutase, and peroxidase and increased antioxidant capacity. Compared with control fruits, nanoemulsion-coated fruits preserved total soluble solids, pH, and ripening indices. The nanoemulsion coating had a significant effect on sensory attributes such as color, taste, aroma, disease incidence, and overall acceptability.

Valorizing Citrus Peel Waste through Nanoparticle Development for Enhanced Shelf Life and Food Safety

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Deterioration of foods and biowastes causes economic losses and environmental damage; hence, nanotechnology can be used to address these issues. This study aimed to explore the potential of citrus peel-derived silver nanoparticles (CSNs) for improving the safety and shelf-life (SL) of fresh fruits and vegetables (F&V). The secondary data were systematically acquired and analyzed. The CSNs biosynthesized from peels or peel extracts of *Citrus sinensis*, *C. tangerine*, *C. limon*, *C. grandis*, *C. maxima*, and *C. reticulata* exhibited antioxidant and antibacterial potential. Silver nanoparticles (AgNPs) from other sources increased the SL of F&V by 3–25 d. For example, AgNP (tea leaf extract) coating increased the SL of cherry tomatoes (3 d, 25°C). Additionally, AgNP-(montmorillonite) was placed in a box to enhance the SL of cut kiwifruit and cut pineapple (5 d, 5°C). Moreover, AgNP-(sodium alginate) films extended the SL of pea and carrot (10 d, 27°C). Similarly, the AgNP-(agar) coating reduced weight loss and inhibited pathogens in lime and apple. Furthermore, AgNP-(polyethylene) packaging decreased weight loss and delayed browning of apple slices (12 d, 5°C). The AgNP-(CS-GL-) hybrid film and AgNP-(CS-GL) composite extended the SL of red grapes for 14 d and 18 d, respectively, while ensuring a fresh appearance. Finally, coating tomatoes with AgNPs (Melia azedarach) decreased their weight loss, providing a barrier against *E. coli*, *Streptococcus* sp., *Klebsiella* sp., *Bacillus* sp., *Salmonella* sp., and *Aspergillus niger*, hence increasing their SL (20–25 d, 25°C). These studies suggest the need to assess the potential of CSNs for enhancing food safety and the SL of fresh F&Vs as a sustainable approach for the food industry.

Production and Supply Chain Management of Strawberry in Pakistan

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Strawberry production has received much appreciation in recent years because of its high demand in the national market. However, uncertain productivity, variation in fruit quality, and high postharvest losses pose serious challenges to making strawberry production a sustainable and profitable farming business in Pakistan. A comprehensive supply chain analysis of strawberry cv. Chandler grown in a subtropical climate identified key factors influencing productivity, fruit quality, and hence profitability. Based on these findings, various field trials and postharvest studies have been conducted to improve the productivity and optimize the postharvest handling of strawberries. Field studies have suggested that transplanting at 25–30°C (day temperature) favors plant growth, flowering, yield, and fruit quality. Preharvest applications of 3 µM EBL, 0.5 mM methyl jasmonate, 1 mM oxalic acid and 0.5% $CaCl_2$ before flowering favor vegetative growth and increase yield. Early harvest (120 to 135 d after transplanting) of medium-sized strawberry fruits with >70% red surface color packed in ~500 g plastic boxes with low-density polyethylene resulted in better storage potential. Hypobaric treatment at 20 kPa for 2 hours, short-term exposure to ozone and ultrasound, and fumigation with 1.5 mM sodium nitroprusside were also identified as potential postharvest techniques to increase the storage life of strawberries. Overall, these interventions led to considerable increases in yield, improvements in fruit quality and significant extensions in the storage life of strawberries.

Comparative Evaluation of Eco-Friendly Edible Coatings on Pears: Sodium Benzoate, Olive Oil, Bee Wax, and Corn Starch as Sustainable Preservation Strategies

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This research explores the efficacy of five different treatments applied to babughosha pears (*Pyrus communis* L.) over a 15-day experimental period to increase shelf-life while maintaining vital physiochemical and organoleptic parameters essential for commercial viability. The treatments included starch solution (T_1), pure olive oil (T_2), a composite mixture of all the treatments (T_3), bee wax solution (T_4), and sodium benzoate solution (T_5), with an untreated control group (T_0). Six assessments were conducted throughout the experiment to evaluate the moisture content, total soluble solids (TSS), pH, hardness, weight loss, and organoleptic

parameters. The results indicated that the application of edible coatings, such as pure olive oil (T_2) and the composite mixture (T_3), effectively reduced weight loss and maintained fruit plumpness, as the highest weight of 74.3 g at ambient temperature and 75.4 g at refrigerated temperature was observed for T_2. These treatments prevented moisture loss, resulting in increased shelf-life. A firmness of 73.0 N at ambient temperature for T_3 and 74.3 N at refrigerated temperature for T_2 was observed and was also well preserved in these treatments, which is consistent with the delay in ripening due to the presence of polysaccharide-based edible coatings. These findings suggest that these treatments can significantly increase the shelf-life of pears and reduce the rate of deterioration, especially at ambient temperatures.

Exploring the Nutritional and Physiochemical Attributes of Cucumber-Ginger Drink during Storage

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The cucumber-ginger beverage is a healthy beverage that combines cucumber, ginger, mint, lemon, and honey. The blends of cucumber (*Cucumis sativus* L.), mint, lemon (*Citrus limon*) and honey with ginger (*Zingiber officinale*) juice at 0% (C1), 2% (C2), 4% (C4), 6% (C4) and 8% (C5) (v/v) correspond to the production of a new vegetable drink that will contain beneficial nutrients and phytochemicals for well-being. A drink blend without ginger extract but with water (Co) was used as a control sample. All accessible drinks are artificial and contain many chemicals, which may be harmful and unfavorable to the health of users. This work was planned to develop a nutritious vegetable drink. Five vegetable blends with different ginger juice percentages were made and subjected to sensorial evaluation, by which the best drink was designated using a 9-point hedonic scale. The drinks were subsequently subjected to physicochemical, nutritive, phytochemical, and microbial studies and shelf-life evaluation. The radical scavenging activity (RSA) and concentrations of phytochemicals such as total phenolic content (TPC) and total flavonoid content (TFC) present in the drinks were also determined via a UV–Vis spectrophotometer. The results revealed significant reductions in pH (4.32--3.35), total soluble solids (11.66--9.42%), and nonreducing sugars (2.06--0.21 mg/ml). The results revealed a significant increase in titrated acidity (0.04–0.21 citric acid mg/100 ml), reducing sugars (2.55–2.13 mg/ml) and vitamin C (00.137–00.198 mg/ml). Among the treated drinks, C2 (2% ginger juice) was sensorially accepted. Alternatively, C5 (8% ginger juice) had the lowest overall acceptability among the formulated drinks and had the greatest nutritive profile.

Screening and Quantification of Pesticide Residues in Marketed Mango in Punjab, Pakistan

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The indiscriminate use of pesticides for pest management, especially in perishable crops such as fruits and vegetables, is one of the major issues for agricultural and food commodities around the globe. This problem is a major concern for the health of all types of nontarget biota, the environment, and, most importantly, humans. In this study, 150 mango samples were collected from 5 major cities (Lahore, Faisalabad, Multan, Rawalpindi, and Bahawalpur) in Punjab, Pakistan, which were selected on the basis of population. The samples were collected in polythene zippers and placed in refrigerated containers for transportation. Each sample consisted of 3 subsamples that were pooled after homogenization with acetonitrile and subjected to pesticide residual analysis or stored at -80°C for later analysis. A total of 10 g of each sample was extracted via the QuEChERS extraction kit (Part No. 5982-5755+5982-5058) purchased from Agilent Technologies, which consists of 6 g of MgSO4 and 1.05 g of NaOAc. The samples were subsequently cleaned via a QuEChERS cleanup kit with solid-phase extraction (SPE), which included MgSO4 with primary and secondary amines. All the samples were analyzed for residues of 8 pesticides (Lambda cyhalothrin, cypermethrin, indoxacarb, imidacloprid, pyriproxifin, acetacloprid, buprofezine and chlorpyrifos) from different pesticide groups via gas chromatography coupled with mass spectrometry (GC–MS). Overall, among the total samples collected from all the city markets, 74.25% of the samples were contaminated with residues of different pesticides, and 25.75% of the samples were found to be free of any chemical residues, but 35.5% of the samples presented residue values above the safe limits of maximum residual limits (MRLs), which are specified by the Codex Alimentarius Commission or the European Union. The recoveries ranged from 88.37 to 99.02%, with 1.07% to 3.97% RSDs for all the samples in both years. Pesticide residues were determined from five major cities in Punjab, Pakistan. The concentrations quantified for different pesticides are alarming in fruits, as the violation rate poses a great threat to human health, which, in particular, advocates the mitigation of pesticide application and the promotion of IPM.

Morpho-nutritional and Anatomical Characterization of *Rubus* Species from Muzaffarabad Division of Azad Jammu and Kashmir

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The genetic diversity of fruit crop species in general and *Rubus* species in particular is threatened by commercialization, which demands the preservation of these genetic resources as soon as possible, not only for the long-term survival of these species but also to ensure enough variability for breeding programs. *Rubus* species are widely distributed throughout the Azad Jammu and Kashmir regions; however, no attempts have been made to determine how *Rubus* species address climate change and adapt successfully under unfavorable climatic conditions. Therefore, this study was designed to evaluate the morphological, nutritional and anatomical characteristics of *Rubus* species collected from the Muzaffarabad Division of Azad Jammu and Kashmir. A total of 530 Rubus species were collected from 106 sites. The collected samples were processed for identification via herbarium sheets. Based on taxonomic studies, a total of four *Rubus* species were identified, i.e., *R. ellipticus*, *R. occidentalis*, *R. niveus* and *R. macilentus*. Adequate differences were observed in their morpho-nutritional and anatomical characteristics. The results regarding the leaf traits of the studied species revealed variation in the leaf area, number of leaves per shoot, leaf shape, number of leaf lobes, shape of the leaf base, petiole length and petiole thickness, whereas all the species presented a uniform leaf margin (serve), leaf venation (arcuate) and color (green). Data pertaining to fruit traits revealed variations in fruit shape, fruit diameter, fruit color, the nature of fruiting, the date of fruit setting and the number of fruits per shoot. Data regarding anatomical traits revealed variation in terms of leaf thickness, palisade thickness, spongy tissue thickness and the cell tension ratio for all the studied species. Similarly, the data concerning stomatal traits also showed variation for all the parameters, including stomatal length and width, trichome density and length, stomatal density and the stomatal pore index, for all the studied species. Promising *Rubus* species screened by morphonutritional and anatomical characterization will be further investigated through SSR markers to confirm genetic variations.

Carboxymethyl Cellulose Coating Delays Quality Deterioration in Harvested Table Grapes during Postharvest Cold and Ambient Storage

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Table grape is one of the most consumed and admirable fruits in the world. Harvested grape berries are susceptible to shattering and rachis browning during postharvest storage. Berry shattering and rachis browning are considered major factors that potentially affect the storage life potential of table grapes harvested during storage. Therefore, these constraints should be appropriately managed to extend the storage life while maintaining the overall eating quality. In this work, table grapes were coated with 0, 0.25, 0.5, 1.0, and 2% carboxymethyl cellulose (CMC) and stored at 5°C and 20°C. The results revealed that the table grapes coated with 0.5% CMC presented lower weight loss, disease incidence, rachis browning, soluble quinone, browning degree, berry shattering percentage, electrolyte leakage and malondialdehyde content than did the control at both storage temperatures. On the other hand, the table grapes that were coated with 0.5% CMC also had greater enzymatic and nonenzymatic antioxidative activities than did the control. Compared with the control, the application of the 0.5% CMC coating suppressed the increase in total soluble solids and the ripening index and preserved higher titratable acidity and ascorbic acid contents during storage at both temperatures. In addition, the coated table grapes presented better sensory attributes until the end of storage at both temperatures than did the control. Therefore, the 0.5% CMC coating could be considered suitable for preserving the postharvest quality of the table grapes harvested during storage at 5°C and 20°C.

Breeding and Biotechnology and other Horticulture-related Aspects

Exploration and Identification of the NPR1 Gene Family Member Mediated Defense in Chili against Gemini-Virus Infection

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Understanding NPR1 gene expression is crucial for improving chili pepper resistance. NPR1 genes are known to provide broad-spectrum resistance to various phytopathogens by activating the systemic acquired resistance (SAR) mechanism. However, owing to limited information on chili CaNPR genes and their role in biotic stress, their utilization in biotic stress resistance genetic breeding is limited. This study identified five CaNPR genes in chili, categorized them on the basis of conserved sequences, and revealed conserved motifs through MEME analysis and sequence alignment. The promoter regions of CaNPR genes contain biotic stress-related cis-elements, indicating their involvement in biotic stress responses. Moreover, these gene promoters included components related to light, development, and hormone responsiveness, suggesting their roles in plant hormone responses and development. MicroRNAs play a vital role in regulating these five genes, highlighting their importance in chili gene regulation. Inoculation with cotton leaf curl Khokhran virus adversely affects chili plant growth, resulting in stunted development, fibrous roots, and visible virus symptoms. This also led to decreased chlorophyll and carotenoid levels but increased phenolic compound, flavonoid, and antioxidant enzyme activities in virus-infected leaves. qPCR analysis of two local chili varieties, one susceptible (V1) and the other resistant (V2) to geminivirus, revealed that CaNPR1 likely provides extended resistance and plays a role in chili plant defense mechanisms, whereas the remaining genes are activated during the early stages of infection. These findings shed light on the function of chili CaNPR in biotic stress responses and identify potential genes for biotic stress resistance breeding. However, further research, including gene cloning and functional analysis, is needed to confirm the roles of these genes in various physiological and biological processes. This in silico analysis enhances our genome-wide understanding of chili CaNPR genes.

Exploring Ploidy Manipulation in Potato for Improved Yield and Quality

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The exploitation of ploidy modifications in potato production has become a highly advanced method that is attracting significant interest because of its potential to lead to revolutionary changes in the agricultural industry. The extensive analysis includes the various features of ploidy alterations in potatoes, investigating their effects on crop productivity, quality, and ability to withstand challenges. Understanding the complexity of ploidy is critical for comprehending the significance of alterations caused by ploidy manipulations. Potatoes have a wide range of ploidy levels, with diploids, triploids, and tetraploids being the most common. Each variety has distinct genetic features that influence plant physiology and morphology. A thorough review of the genetic foundations of each ploidy level provides insight into the implications for potato production. Classical breeding methods, such as the production of polyploids via colchicine and current biotechnology technologies, are all employed to manipulate ploidy. Ploidy manipulations have significant agronomic consequences, affecting the resilience of potatoes to pests, diseases, and environmental stressors. Research has shown that specific variations in ploidy lead to increased resilience, which presents a promising opportunity for sustainable agriculture. Furthermore, examination of tuber quality, nutritional composition, and overall yield after close analysis offers vital knowledge for potato growers aiming to increase production efficiency. By consolidating research findings, it offers a significant resource for academics, agronomists, and policymakers who are interested in using ploidy alterations in potato to their fullest extent to address the issues of contemporary agriculture and guarantee worldwide food security. However, to assess the feasibility of using ploidy alteration on a large scale in potato production, both economic and ecological factors must be considered.

Role of Ornamental Plants in Phytoremediation of Nickel Contaminated Soils

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Soil heavy metal toxicity has detrimental effects on both plants and human health. These materials are introduced into the soil by a variety of methods, including smelting and coal burning. Nickel (Ni) is an important heavy metal that causes various morphological, biochemical, and physiological problems in plants. Ornamental plants are used for ornamental purposes and could also be used for heavy phytoremediation. Therefore, the present study investigated the phytoremediation capacity of Snapdragon (*Antirrhinum majus*), Stock (*Matthiola incana*) and Gladiolus (*Gladiolus grandiflora*) against different levels of Ni. Data on

different attributes, such as morphology (fresh weight, dry weight and length of both shoots and roots), physiology (stomatal and substomatal conductance, transpiration rate, net photosynthetic rate, and water use efficiency), water relationships (relative water contents), the membrane stability index, pigments (total chlorophyll content), antioxidative enzymes (catalase, peroxidase, and superoxide dismutase), oxidative enzymes (H_2O_2 and MDA), and phytoremediation efficiency, were recorded. Higher Ni levels have adverse effects on morphological attributes, water relationships, pigments and physiological responses. Additionally, the activity of antioxidant enzymes increased under metal stress, and all the crops presented positive phytoextraction. In conclusion, ornamental plants have the potential for effective phytoextraction of soil heavy metals, contributing to soil remediation efforts.

Studies on Identification of Phenological Stages in Two Varieties of Date Palm (*Phoenix dactylifera* L.) and Relationship of Growth Patterns with Various Climatic Factors

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In terms of fruit color and chemical makeup, date palm (*Phoenix dactylifera* L.) undergoes five different stages of growth and development. The names Hababouk, Kimri, Khalal, Rutab, and Tamar are given to these stages. Every variety has a different length for each stage on the basis of the area and variety categorization. Numerous studies have been conducted on local varieties such as Dhakki and Gulistan; however, there is a dearth of research on the identification of phonological stages. The results of the present study revealed that both varieties underwent five different stages of growth: Hababouk, Kimri, Khalal, Rutab, and Tamar. This study further explains the relationships of climatic factors such as growing degree days (GDD), temperature and humidity with the growth patterns of two varieties of date palm. The date variety Dhakki took a total of 143 days from pollination until harvest, whereas Gulistan took approximately 126 days from pollination to harvest. Hababouk and Kimri were found to be the longest stages throughout the growing period of both varieties. Temperature was found to be positively related to spathe growth when a correlation study was conducted; however, the associations of temperature with fruit length, fruit diameter and fruit drop were found to be negatively correlated. The relative humidity in the air was negatively correlated with spathe growth, fruit length, fruit diameter and fruit drop.

Effective Air Temperature Accumulated as Crop Heat Units is a Robust Representative of Grapevine Phenology

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Grapevine phenology is highly sensitive to prevailing climatic conditions, and the air temperature is considered the main driver of phenology. Owing to increasing climatic variability, increased air temperature has posed a major challenge for the sustainability of existing cropping systems. Therefore, accurate identification of the timings of critical developmental stages is crucial to ensure the sustainability of global viticulture production systems. The present research was designed to assess the effects of effective air temperature in the form of growing degree days (GDDs) on the phenological development of table grape cultivars in a new emerging viticulture region. To achieve this goal, key developmental stages of grapevines, i.e., bud burst, the 5-leaf stage, blooming, berry set, veraison and harvest, were observed at two locations, i.e., Islamabad and Chakwal, with distinct climatic conditions in the Pothwar region of Pakistan. The phenological progression of the grapevine cultivars King Ruby, Perlette, NARC Black and Sugra One was recorded when 50% of the sample vines reached that stage. Early bud burst was observed for the Perlette and King Rubies but not for the NARC Black cultivar. Similarly, the active growth period (bud burst to harvest) varied from 95−120, 96−118, 105−126 and 104−130 d in cvs. Perlette, King's Ruby, NARC Black and Sugra One, respectively. The length of the active growth cycle (bud burst to harvest) for the 2020 vintage was 15−21 d greater than that for 2019, which was strongly related to the temperature variability and accumulated GDD. Despite substantial variability in phenological timings, the relative crop heat units varied within a narrow range. The temperature action in the form of an accumulated crop heat unit is a better representative of the active growth cycle of grapevines and hence offers a viable tool for the early prediction of key phenological events. The robustness of the GDD approach in accurately forecasting phenological timings would help in genotype- and site-specific vineyard management under varying climatic conditions.

Cultivar-Specific Responses of Strawberry (*Fragaria × ananassa* Duch.) to Climatic Variability in Azad Jammu and Kashmir: A Runner Health Evaluation

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The successful nursery production of strawberry, a prominent aggregate fruit, is heavily influenced by the prevailing climatic conditions in the region where runners are cultivated. Azad Jammu and Kashmir, with their conducive climates, serve as ideal environments for high-quality runner production of diverse strawberry cultivars. Despite this, standardized guidelines for selecting transplantation areas and cultivating different strawberry cultivars in the region are lacking. This study aimed to assess the health of three strawberry cultivars, Chandler, Sea Scape and Tribute, in various locations within the Poonch district. With a randomized complete block design (RCBD), the experiment was conducted at three different sites: Chotta Galla, Khai Galla, and Hajira. The results revealed that areas characterized by lower temperatures presented increased runner production, whereas regions with higher temperatures presented increased flower and fruit production. Certain strawberry cultivars present limited flower and fruit production, which correlates fruit production with the fruit/leaf ratio. However, flowering and runner production in strawberry plants are contingent on the temperature of the cropping year. The outcomes of this study suggest that strawberries transplanted in cooler locations have a greater capacity for generating robust runners, whereas those transplanted in slightly warmer locations exhibit superior overall performance in terms of both yield and fruit quality.

New Exotic Vegetable for Pakistan: Malabar Spinach (*Basella rubra* L.)

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Basella rubra L., also known as malabar spinach, ceylon spinach, climber spinach and vine spinach, is less known and unexplored as an excellent source of nutrients and biologically active compounds for food and nonfood applications. It is used as a vegetable in many countries, such as the Philippines, Thailand, China, Mongolia, India, Sri Lanka, and many African countries. This crop is suitable for home, market garden and hedge plants. Additionally, the oil obtained from its seeds can become a source of safe vegetable oil. This plant is good for health because of the

presence of minerals, proteins, oils, carbohydrates, fibers and vitamins. In the summer season, Malabar spinach can be used in place of normal spinach (i.e., *Spinacea oleracea* L.), as it has similar nutritional and medicinal value. Different studies have shown that plants are rich in vitamin A and vitamin C, along with flavonoids, saponins, carotenoids, many amino acids and organic acids. Basella plants are extremely heat tolerant and fast-growing perennial vines that are widely cultivated as hot-season vegetables. The true spinach is highly preferred in winter worldwide. However, Malabar spinach prefers warm climates. This can cause malabar spinach to be consumed, similar to true spinach, during the summer when true spinach can rarely be found on the market. Malabar spinach can grow from seeds or seedlings. Soaking for one day is recommended for plants grown with seeds. Seeds can germinate for 10−21 days under proper circumstances. The plant is suitable for continuous harvesting. The stem, branches, leaves and young flower sprouts can be harvested during the production season. The yield may reach 1.5 kg per plant. The plants were harvested at orderly intervals for up to 8 months. Therefore, this crop will serve as an alternative to spinach in the summer season, and the introduction of this crop will increase farmer income and livelihoods.

Future Strategy of Date Palm Production and its Issues in South Punjab

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Date palm (*Phoenix dactylifera* L.) is the 3rd major fruit crop of Pakistan in terms of production and export. Pakistan is the 5th largest date producer and the 5th largest exporter of dates in the world. As highly nutritious fruit, it plays a vital role in oasis life and is a major income source because it provides many date palm products. The major issues associated with reducing the production of date palm can be summarized as seeded plant populations, pollen shortages at pollination, fewer available pure plants, limited cultivars, varieties with greater yields but small fruits, a lack of intercultural practices and good agricultural practices, rains at pollination and fruit ripening times, and a lack of plant protection measures, especially against red palm weevils. There are strategies to overcome these issues, such as the deficiency of date pollens, which could be made up by mixing the date pollens with wheat flour or saw dust of cheel as filler, and the availability of true-type plants is achievable by importing high-market-value cultivars for acclimatization and multiplication through registered nurseries. Fruit size could be improved through thinning, which is hazardous to rains, by covering bunches with polythene

bags/polypropylene bags. Integrated pest management can reduce damage caused by red palm weevils. Postharvest losses can be minimized by facilitating farmers with the latest postharvest techniques and mechanization. The high mortality of suckers after planting can be overcome by adopting the recommended weight or age of suckers and proper aftercare.

Comparative Analysis of Capsicum Cultivars for Cultivation Systems, Productivity and Quality under Partially Controlled Greenhouse

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Increasing urbanization, soil salinity and temperature, along with decreasing water resources, require alternative production systems (e.g., soilless cultivation), particularly in arid to semiarid zones, for high-value crops such as bell pepper to ensure sustainable production and thereby food security for the sprawling population. The present study, therefore, was executed to evaluate the performance of different bell pepper cultivars under three soilless cultivation systems in a partially environmentally controlled greenhouse equipped with a fan and pad evaporative cooling system. The study was conducted under a split-plot design with a two-factor factorial arrangement (cultivation system × cultivars). The following treatment combinations were adopted: cultivation systems [grow bags (GB), Dutch bucket culture (DB) and trough system (TS)] and bell pepper cultivars (Bachata, Red Jet, Mikel, Olympus, Almirante, Dashen, Mercury, Root seed 4, Root seed 5, Root seed 6). The results indicated that the "Red Jet" cultivar under the trough/channel cultivation system significantly ($p \leq 0.05$) increased the morphological (shoot length, shoot fresh weight), gaseous exchange (photosynthetic rate (*A*), stomatal conductance (*gs*), water use efficiency (*WUE*), nutritive content (K, Ca, Mg) and yield attributes, followed by growing in bag culture. However, biochemical attributes (total soluble solids, titratable acidity, total phenolic contents and antioxidative enzyme activities (SOD, POX, and CAT)) were found to be greatest under the grow bag cultivation system. In conclusion, the cultivation system performance with respect to morphophysiological, nutritive and yield attributes was in the order of trough system> grow bags> Dutch bucket system; however, with respect to biochemical attributes, it was in the order of grow bags> trough system> Dutch bucket.

Nutrient and Water Management

Quantifying Impact of High-Efficiency Irrigation Systems on Yield, Quality and Health of Horticultural Crops with Judicious Use of Inputs

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This study rigorously examines the transformative effects of high-efficiency irrigation systems on horticultural crops. A critical aspect of our investigation revolves around water resource management. Our quantitative analysis revealed a substantial increase in crop yield, with notable increases ranging from 25% to 55%. This improvement indicates a significant improvement in agricultural productivity, shedding light on the quantitative benefits of advanced irrigation technologies. Our findings highlight the substantial water-saving potential inherent in high-efficiency irrigation systems, with efficiency gains of up to 65%. Through meticulous measurements and analysis, we quantify the impact of these systems in addressing pressing concerns related to sustainable water utilization in horticultural practices. In addition to quantitative metrics, we investigated the qualitative aspects of crop outcomes. The optimized use of water resources has a marked effect on crop quality, with improved quality attributes of fruits and vegetables. Furthermore, our research elucidates the environmental advantages of these systems, including the ability to create weed-free conditions and reduce humidity levels. These conditions increase the overall quality of produce and act as preventive measures against diseases and insect pest incidence. In conclusion, this study provides a comprehensive understanding of the multifaceted benefits of high-efficiency irrigation systems leading to the sustainable production of horticultural crops.

Physiological and Transcriptional Responses of Watermelon Genotypes to Low Boron Conditions

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Boron (B) is an essential microelement for the growth and physiological functioning of higher plants. Boron deficiency is a widespread agricultural problem that negatively impacts plant growth, yield and quality. In the present study, a combination of vegetative and reproductive growth parameters and transcriptome analysis was used to study the response of watermelon genotypes 'Wanfu Lai (WL)' and 'Feizhou Huangzi (FH)' under low-B (0.25 µM B) conditions. Plants exposed to the optimum B concentration (75 µM B) were categorized as controls. B deficiency severely restricted the growth of 'WL' plants, as evidenced by decreased dry mass production, reduced photosynthetic capacity and root growth inhibition, whereas 'FH' plants presented fewer growth defects under low-B conditions. The results of SEM analysis revealed fewer structural defects in the shape of the stamen, pollen topography and stigma papilla cell integration in 'FH' than in 'WL' under low-B conditions. According to the transcriptomic results, the low-B tolerance mechanism of Feizhou Huangzi was closely associated with the greater upregulation of DEGs in roots (70%) and leaves (44%), with a particular identification of more B transporter genes (NIP5;1, BOR2) than 'WL'. Moreover, greater enrichment of DEGs related to peroxidase (POD), the cellular oxidant detoxification process and the plant hormonal signaling pathway and high gene expression of the BOR2 gene helped in the inhibition of the ROS signaling cascade, which reduced the root growth inhibition of 'FH' and promoted the continuous uptake of B from the roots and its transport toward the shoot, resulting in improved plant growth. In conclusion, the low B stress tolerance of FH is mediated mainly by the NIP5;1 and BOR2 signaling networks, which promote plant growth. This research provides a comprehensive understanding of the differential physiological and transcriptional responses of watermelon genotypes to B deficiency.

Optimization of yield, fruit quality and nutritional status of strawberry by using various sources of NPK fertilizers

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Strawberry (*Fragaria* × *ananassa* Duch) is an important and delicious fruit crop with a prime position in fruit markets worldwide that is consumed all over the world for edible purposes and processing purposes. Adequate nutrient contents and ratios in the soil are the foundations for

good plant nutritional status. Nitrogen is the major nutrient taken up by strawberries. During spring, strawberry plants need increased demand for N and P fertilizers, and this demand continues to increase in the blossoming and fruit-setting phases. The present study was carried out in the research area of the Department of Horticulture, PMAS AAUR. To fulfill the chilling requirements of the crop, strawberry runners cv. “Chandler” were kept for 8–15 d in a cool chamber. Various sources of NPK were combined according to the following ratios: T_1: control/untreated, T_2: 17 N: 17P: 17K: 2 g/plant, T_3: 17 N: 17P: 17K 4 g/plant, T_4: 17 N: 17P: 17K 6 g/plant, T_5: 23 N: 23P: 23K 2 g/plant, T_6: 23 N: 23P: 23K 4 g/plant, and T_7: 23 N: 23P: 23K 6 g/plant. Data regarding vegetative and reproductive growth were taken from five randomly selected plants from each treatment. T_3: 17 N: 17P: 17K 4 g/plant and T_5: 23 N: 23P: 23K 2 g/plant had a significant effect on the vegetative growth (plant height, number of leaves, number of runners, leaf area, fresh and dry weight of leaves, and fresh and dry weight of plants) parameters as well as fruit quality parameters (firmness, vitamin C, and titratable acidity) and gave good results compared with those of the control-treated plants in terms of flower initiation, number of fruits, fruit set percentage, fruit size, and weight.

Planting Date and Nitrogen Management Interactions in Sweet Pepper

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Nitrogen is the most limiting element in crop production, as it influences both root and shoot growth. It is estimated that nearly 50% of the world’s food is grown with synthetic nitrogen fertilizer. The development of economically and environmentally sound nitrogen fertilizer management practices is becoming increasingly important. The optimum planting date for sweet pepper production is key to better yield, as it determines the period of maximum crop potential, efficient use of resources, and reduced competition of plants with weeds and insect pests. Therefore, the present study was conducted to evaluate the effects of three planting dates, i.e., February 15th, March 2nd and March 16th, and four nitrogen levels, i.e., 75, 100, 125 and 150 kg/ha, on the growth, biomass and yield of sweet pepper during 2017 and 2018 under agroclimatic conditions in Multan, Pakistan. Plant growth (plant height, canopy diameter, and stem diameter) and biomass (fresh and dry) were significantly greater on February 15th, when they were planted, and markedly decreased as planting was delayed. Similarly, the yield attributes (fruit number, average fruit weight, fruit weight per plant and yield) were also significantly greater at the earliest planting, and lower values for yield attributes were obtained at later plantings. Variations in nitrogen levels significantly influence the growth and yield of sweet pepper. Compared with the other nitrogen levels, the nitrogen application rate of 150

kg/ha resulted in significantly greater values for all growth parameters and yield attributes. Compared with that in 2018, vegetative growth in 2017 was greater. The yield characteristics were greater in 2018 than in 2017, which may be due to climate variability. It may be concluded that the highest values of growth, biomass and yield were obtained under semiarid conditions in Multan, Pakistan, when sweet pepper cv. Ganga was planted on 15th February and treated with 150 kg N/ha.

Role of Potassium Humate and Vermicompost on Nutrient Availability, Growth, and Yield Attributes of Soybean

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Soil fertility and productivity can be enhanced by the addition of organic matter, which improves different properties of the soil. It contains different functional groups that can increase nutrient availability after decomposition through a specific mechanism. Potassium humate and vermicompost are both organic materials that improve soil characteristics, principally through chelation. A pot experiment was planned to estimate the influence of vermicompost and potassium humate on the growth, nutrient availability, and yield-related attributes of soybean. All the treatments were randomized according to a completely randomized design with 4 replications. The experiment included four treatments: T_1 (control), T_2 (vermicompost), T_3 (potassium humate), and T_4 (combined application of vermicompost and potassium humate). Two soybean genotypes (Rawal and NARC-3) were evaluated in the present study. The crop was harvested at maturity, and the data were subjected to ANOVA and comparison of means under the CRD design via the Statistics 8.1 package. Compared with the control, the application of vermicompost and potassium humate significantly increased the growth- and yield-related attributes of both soybean genotypes. There were 13%, 11% and 16% increases in the N, P and K concentrations, respectively, in the shoots of soybean. Compared with those in the control treatment, the amount of nitrogen and phosphorus translocated from the roots to the shoot was 7% greater. The total grain weight was 10% greater than that in the control treatment. The results further revealed that, compared with the control, the application

of vermicompost increased the root and shoot dry weights and length of soybean plants. Among the two promising soybean genotypes, the overall performance of Rawal was greater than that of NARC-3, which produced more grains and biomass than the control.

Vermi-Compost Use in Horticultural Crops

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The decrease in soil fertility is a major restraint for horticultural crop production in Pakistan. The use of organic plant nutrient source compost not only recycles organic horticultural waste, causing environmental pollution but also conserves a rich pool of nutrient resources, which can reduce the sole dependence on chemical fertilizers. Vermicomposting horticultural and other crop waste can be managed, which results in improved soil health and enhanced soil microbial activity. It is used in soil media and for nursery management of horticultural crops. Horticultural crops and field waste, such as pruning material, fruit and vegetable waste, kitchen waste, cow manure and red wiggler, were used during the preparation of the vermi-compost. Vermi-compost was prepared through a commercial composting method. For orchards, vegetables and ornamental commercial horticultural crops, the Vermi-composting method is a wise and judicious way to achieve sustainable production under a changing climatic scenario.

Effect of Moringa Leaf Extract on Seed Germination, Seedling Growth and Yield in Cumin

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Spices are used to enhance food taste and are a source of food flavor and color. In addition, they act as preservatives and provide nutritional and health benefits. Cumin (*Cuminum cyminum*), locally known as 'Zeera', is a flowering plant of the Apiaceae family. It is often used as a condiment and flavoring in oriental dishes. Poor and delayed germination are major problems in the commercial cultivation of Cumin. Seed soaking in Moringa leaf extract (MLE) has improved germination, seedling vigor, growth and yield traits in several crops. A study was carried out to estimate the effects of seed soaking in MLE on the germination, seedling traits and yield attributes of cumin. Four different concentrations of MLE, i.e., 0% (control), 3%, 5% and 7%, were used as soaking treatments for cumin seeds. Cumin seeds were soaked for 12 hours in the abovementioned solutions and then sown. Data for germination, seedling length, seedling vigor index, chlorophyll content and yield per plant were recorded. The maximum seed germination percentage and chlorophyll content were noted in seeds treated with MLE 5%. The greatest seedling length, seedling vigor index and seed yield per plant were observed for seeds soaked in MLE 7%. This increased seedling vigor was associated with an increase in SOD, POD and CAT in seeds soaked in MLE 7%. It was concluded that an MLE of 7% can be used to improve seedling traits as well as the yield of cumin.

Enhancing the Quality of Grapes and Altering Bacterial Diversity with BiocharInoculated Soil Bacterium

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One of the major problems in fruit development is soil deterioration. In response, a study was conducted to determine the effects of biochar inoculated with *Rhizobium leguminosarum* PETP01 on the microbial community, soil quality, and grape (*Vitis vinifera* L.) quality. According to field trials, in contrast with the control group, the biochar-inoculated treatment resulted in 8%, 4%, and 3.5% increases in grape fruit weight, length, and width, respectively ($p \leq 0.05$). Furthermore, in the biochar-inoculated group, the total soluble protein content and hardness of the grapes increased by 27% and 10.9%, respectively, whereas the overall acidity decreased by 14%. The physicochemical and biological properties of the soil, including electrical conductivity, alkali-hydrolyzed nitrogen, accessible phosphorus, accessible potassium, organic material, and enzyme activity, significantly ($p < 0.05$) improved after the addition of biochar. Following charcoal inoculation, 16S rRNA sequencing data revealed decreases ($p < 0.05$) in Acidobacteria, Chloroflexi, Rokubacteria, and Nitrospirae and increases in Gemmatimonadetes, Actinobacteria,

Bacteroidetes, and Planctomycetes. These results suggest that the use of biochar inoculated with *Rhizobium leguminosarum* PETP01 as a soil amendment agent has the potential to increase grape fruit quality, increase the soil nutrient content, and change bacterial community dynamics.

Optimization of Nutritional Regimes for Quality Flower and Seed Yield of Dahlia (*Dahlia pinnata* L.) and Celosia (*Celosia argentea* L.) in Punjab, Pakistan

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Dahlia (*Dahlia pinnata* L.), a member of the Asteraceae family, and Celosia (*Celosia argentea* L.), a member Dahlia of the Amaranthaceae family, are popular annual flowers that are grown extensively as bedding plants in Pakistan. A study was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2022--23 to optimize nutritional regimes for higher flower yield and seed production of dahlia and celosia under agroclimatic conditions in Faisalabad, Punjab, Pakistan. There were six treatments in this experiment: the control, N@90 kg ha-1, NPK (90:45:45 kg ha-1), NPK (90:45:45 kg ha-1 + micronutrients (1% Fe, B and Zn each), NPK (90:45:45 kg ha-1 + 0.4% isabion) and NPK (90:45:45 kg ha-1 + 0.4% humic acid). The experiments were performed individually for both species according to a randomized complete block design (RCBD) with three replications of 30 plants each. The following data were recorded: plant height, plant canopy diameter, number of flowers per plant, flower diameter, leaf area, total leaf chlorophyll content, production time and number of branches. In dahlia tallest plants were recorded (40 cm) when treated with NPK + Isabion (0.4%), followed by NPK + micronutrients (1% Fe, B and Zn each) at a height of 36 cm. Similarly, the greatest flower diameter (58 mm) was recorded in the NPK + Isabion treatment (0.4%), followed by the NPK + micronutrient treatment (1% Fe, B or Zn). The highest number of flowers (12) was recorded when plants were treated with NPK + isabian (0.4%). The highest chlorophyll content was observed in the plants treated with NPK + isabian (0.4%) (56 SPAD). In celosia, the largest leaf area was observed in the NPK + isabian treatment (0.4%, 44.9 cm2). The greatest plant canopy was observed when plants were treated with NPK + isabian (0.4%) (39 cm), followed by when they were treated with NPK+ micronutrients (1% Fe, B and Zn each) (37 cm). The maximum number of flowers (7) was observed when plants were treated with NPK + isabian (0.4%), followed by when they were treated with NPK + micronutrients (1% Fe, B and Zn each) (6). The tallest plant height was recorded (41 cm) when plants were treated with NPK + isabian (0.4%), followed by when they were treated with NPK + humic acid (0.4%) (34 cm). The greatest flower diameter (3.1 mm) was recorded when the plants were treated with NPK + isabian (0.4%), and the lowest flower diameter was observed when the plants were treated

with NPK + humic acid (0.4%) (2.5 mm). The greatest number of branches (7) was recorded when plants were treated with NPK + isabian (0.4%), followed by when they were treated with NPK+ micronutrients (1% Fe, B and Zn each) (6). Isabians perform well overall in both summer and winter annually.

Propagation and Nursery Management, and Biotic Stresses

Unveiling the Role of *NAC* Genes in Passion Fruit Resistance to Pathogenic Stress: Insights into Hormonal Dynamics and Antioxidant Activity

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The *NAC* gene family, a prominent group of plant transcription factors, plays pivotal roles in various aspects of plant biology, including growth, development, metabolism, and responses to biotic and abiotic stresses. Despite its well-established importance, the involvement of *NAC* genes in the resistance of passion fruit to pathogenic stress pathways remains unexplored. This study investigated the response of passion fruit to infections with *F. kyushuense* and *A. alternata*. Upon infection, the levels of hormones such as salicylic acid (SA), jasmonic acid (JA), and abscisic acid (ABA), as well as total antioxidant activity, exhibited a dynamic pattern with an initial increase followed by a decrease. Notably, the levels of most hormones peaked at 9–12 days post infection (dpi), while the total antioxidant activity reached its maximum at 6 dpi. Correlation analysis involving 15 *PeNAC* genes revealed a positive association between the *PeNAC063*, *PeNAC001*, *PeNAC028*, *PeNAC058*, and *PeNAC033* genes. *PeNAC003*, *PeNAC063*, and *PeNAC028* were positively correlated with ABA, JA, and SA. Furthermore, the transient overexpression of *PeNAC063* in passion fruit peel significantly enhanced resistance to *F. kyushuense*. These findings provide valuable insights into the intricate interplay among NAC genes, hormonal regulation, and antioxidant activity during plant stress responses. The identified correlations pave the way for a deeper understanding of the molecular mechanisms underlying plant stress resistance and offer a foundation for genetic strategies aimed at improving plant resilience.

Enhancing Growth and Development of Mango Nursery Plants through Nutritional Management

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Nutrition is an important component for the growth and development of nursery plants. Therefore, the present study aimed to optimize nutrition for the growth and development of mango nursery plants. Healthy and uniform seedlings were subjected to the following

treatments: T1 (control), T2 (KSOL® as the basal application), T3 (KSOL® as the foliar application), T4 (KSOL® as the basal application + Plantafol® as the foliar application) and T5 (Plantafol® as the foliar application). Doses of 2% and 1% were applied via the basal and foliar application methods, respectively. These treatments were applied at 15- and 30-d intervals separately. Data regarding vegetative growth and nutrient contents were recorded. The results revealed that nutrient application at 15 d intervals resulted in a maximum plant height (38 cm), scion length (17 cm), scion girth (8 mm), number of flushes (2.5) and respiration rate (2.60 µmol $m^{-2}s^{-1}$) at T_2 compared with the minimum plant height (22 cm) and respiration rate (2 µmol $m^{-2}s^{-1}$) at T_1. Moreover, the scion girth (6 mm) and number of flushes (1.5) were found to be minimal for T_3 and $T_{4,}$ respectively. Similarly, nutrients applied at 30-d intervals resulted in the maximum number of leaves (10.53), scion length (18 cm), number of flushes (1.7), total chlorophyll content (25.9 µg/g) and respiration rate (2.4 µmol $m^{-2}s^{-1}$) in T_2. However, the minimum number of leaves (6.1) was the number of flushes (1.3) at T_1 and T_5. For leaf nutrient analysis, higher nitrogen (2% dry weight), phosphorus (0.73% dry weight) and potassium (2% dry weight) contents were recorded in T_2 than in the other treatments. Therefore, T2 (KSOL® as a basal application) was found to be best for the vegetative growth and development of mango nursery seedlings.

Metabolomic Characterization of Biochar Induced Biotic Stress Resistance in *Solanum lycopersicum*

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Solanum lycopersicum (tomato) is an important commercial crop worldwide, and its successful cultivation faces many challenges, including fungal diseases caused by *Alternaria solani*. In the last two decades, biochar has gained attention as a soil amendment to improve crop yield and sustainably mitigate biotic and abiotic stresses. The mechanism of the biochar-mediated plant stress response at the metabolic level is not known. In this study, we prepared biochar from green waste. A series of pot experiments were conducted with a range of biochar concentrations, and the effects of biochar on early blight stress were analyzed. Finally, we explored the metabolome of the plants by using standard H^1 NMR spectra. Our results indicated that biochar not only influences the soil and plants but also that the biochar itself undergoes weathering. The growth parameters revealed a nonlinear relationship between the biochar and the plants. Compared with the control, biochar amendments at rates of 5, 10 and 15% (v/v) resulted in 28%, 3.7% and 25% increases in biomass, respectively. In mitigating biotic

stress, 5% biochar was more effective at suppressing early blight symptoms. During early blight, the tomato metabolome was influenced by the presence of 5% and 10% biochar and formed separate clusters from the control, which had no biochar. Stressed plants also formed distinct clusters from unstressed plants within the same soil amendment, indicating the accumulation of defense-related metabolites. These observations not only highlight the discernible impact of early blight stress on the plant metabolome but also highlight biochar-mediated stress mitigation at the metabolic level.

Sprouting and Growth Response of Dragon Fruit (*Hylocereus udantus*) to Various Cutting Lengths and Hormonal Application Methods

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Dragon fruit is considered the emerging exotic fruit crop with the highest economic value and was recently grown in the most tropical and subtropical zones of Pakistan; however, this tropical fruit is new to the lands of Sindh, and few studies have been conducted in the nursery and field stages. In this context, it is necessary to assess the performance of this valued fruit at the nursery stage. Therefore, this research study was conducted at the Horticulture Garden, Department of Horticulture, Sindh Agriculture University Tandojam, from 2022–2023, with the aim of scrutinizing the sprouting and growth performance of dragon plants in response to various cutting lengths and application methods of rooting hormone (NAA). In this context, a factorial study was conducted in a completely randomized design (CRD). The factors included different cutting lengths, T_1= 4 inches, T_2 = 6 inches, T_3 =8 inches, and T_4 =10 inches, and the hormonal application methods quick dip and powder dip. The treatment combinations of both factors were repeated three times. The findings of the present study revealed that the number of sprouts per cutting, days to sprouting, sprouting percentage (%), rooting percentage (%), root depth (cm), root diameter (cm) and survival percentage (%) were greater in the 6-inch cuttings produced via the quick dip method than in the other methods. Moreover, the greatest results for plant height (cm), stem girth (cm) and fresh shoot biomass (g) were noted for the T4 cuttings, which were 10 inches long. Hence, it was concluded that the 6-inch cuttings produced via the quick dip method presented ideal nursery performance.

Performance of Bitter Gourd Grafted onto Wild Bitter Gourd Genotypes

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Vegetable grafting is being used to overcome production-related issues. In this study, we assessed the impact of rootstock on the growth and yield of bitter gourd. We used three combinations of bitter gourd: Aswad grafted onto Aswad (BG3/BG3), Aswad grafted onto Faisalabad Long (BG3/BG4), and Aswad grafted onto wild-type bitter gourd (BG3/WT). Aswad and Faisalabad Long are two bitter gourd varieties, whereas WT is a wild rootstock of bitter gourd. Self-grafted Aswad plants were used as controls in this study. We used hole insertion and tongue approach methods of grafting to prepare grafted transplants. The results of our study indicated that, compared with self-grafted Aswad plants and Aswad plants grafted onto wild-type rootstock, Aswad grafted onto Faisalabad long improved bitter gourd growth and development. Compared with the other grafting combinations (BG3/BG3 and BG3/WT), the plants grafted onto Faisalabad Long (BG3/BG4) plants presented significantly greater plant height, stem girth, number of secondary shoots, number of leaves, fresh weight of roots and shoots, dry weight of roots and shoots, fresh and dry weights, number of male and female flowers, number of fruits per plant, fruit length, fruit diameter, per fruit weight, number of seeds per fruit, and seed weight. For some attributes, the (BG3/WT) combination had very poor performance, such as plant fresh and dry weights, number of leaves, and number of flowers and fruits. However, the control treatment had better performance than did the BG3/WT combination in terms of all attributes except the number of seeds per fruit, fruit diameter and fruit length. Both rootstocks had obvious effects on the performance of bitter gourd. Overall, more vigorous and healthy fruits were collected from BG3/BG4 plants. Considering the results of our study, it is suggested that Faisalabad Long (BG4) is a relatively better rootstock for improving the growth and yield of bitter gourd under field conditions.

Comparative Study of Enzymatic Responses in Leaves and Calli of Cholistan Desert's Medicinal Plants

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This research was planned for a comparative study of the endogenous enzymatic activities of different medicinal plants in the Cholistan desert, including the leaves of field-grown plants and *in vitro*-developed calli. Indian rennet (*Withania coagulans*), Jimson weed (*Datura stramonium*) and Cucamelon (*Melothria scabra*) were assessed for their enzyme activities. Fresh leaves were obtained from Cholistan plants, while calli were developed on MS media supplemented with 2,4-D. Catalase, superoxide dismutase and peroxidase activities were determined via a spectrophotometer. Higher SOD, CAT, and POD activities were detected in the calli than in the leaves. Catalase and peroxidase activities were greater in *W. coagulans* than in *M. scabra* and *D. stramonium*, whereas superoxide dismutase activity was greater in *D. stramonium* and *W. coagulans* than in *M. scabra*. Under the interaction of species and plant source, the highest activities of catalase were recorded in the callus and peroxidase in the leaves of *W. coagulans,* and superoxide dismutase was analyzed in the callus of *D. stramonium*.

Tea Leaf Residue: A Potential Agriculture-Based Waste Material as Substrate Mix for Nursery Production and Growth of *Anthirinum* (Snapdragon)

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Growing substrates are very important for the growth and development of plants. Maximizing the yield of flowering crops by selecting an optimized growing substrate, a study was conducted to evaluate the physicochemical characteristics and effects of tea leaf residue, an agriculture-based waste material used as a substrate for nursery production of *Antirrhinum* (Snapdragon). The experiment was conducted in the research area of the Floriculture Program HRI, National Agriculture Research Centre, Islamabad. The leaf residue that remains during the processing of tea leaves after drying and curing was collected from the National Tea & High Value Crops Research Institute (NTHRI) Shinkiari. The experiment was performed in accordance with a randomized complete block design (RCBD). There were five treatments, and each treatment was replicated three times. Each replicate consisted of 20 seeds, which were planted in plastic pots (5×6-inch surface area). The substrate mixtures were pasteurized, well dried and filled in plastic pots after being lined with small holes on the base for proper drainage as per the following treatments, viz. Silt (100%) control, tea residue (100%), tea leaf residue+silt (50:50;v/v), tea leaf residue+silt (70:30; v/v), tea leaf residue+silt (30:70; v/v), and substrate samples weighing 250 g from each treatment were collected for physio-chemical analysis, and data collection was performed on a weekly basis for all the growth parameters. Among these,

tea leaf residue+silt (70:30; v/v) performed best for all growth attributes (% germination, days to germinate, seedling length, number of leaves, root length, weight, and chlorophyll content SPAD) for premium quality nursery production of *Antirrhinum* (Snapdragon) and would be best for commercial production.

Mitigation of Early Blight in Tomato Plant: Evaluating *Trichoderma harzianum*, *Cassia fistula* and *Azadirachta indica* Leaves Powder

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Tomatoes in Pakistan are typically grown in both open fields and greenhouses. However, tomato production in Pakistan faces challenges such as water scarcity, pest and disease issues (including diseases such as early blight), and market-related factors affecting prices and profitability for farmers. In the present study, tomato seedlings were grown under the stress of early blight disease caused by the deadly pathogen *Alternaria solani*. To control this disease, the antagonistic fungus *Trichoderma harzianum* and leaf powder of two different plants, *Cassia fistula* (Amaltas) and *Azadirachta indica* (Neem), were used to control the effect of *A. solani*. Various growth parameters, such as root and shoot length and fresh and dry weights, were studied after 15 d. Furthermore, the biochemical (total protein content and catalase and peroxidase activities) and physiological (total protein content and reducing sugars) attributes of the tomato plants were also investigated. The results revealed that the growth parameters of the tomato seedlings significantly decreased by 70 to 80% when they were infested by late blight disease. However, soil amendments with *Trichoderma harzianum* + *Cassia fistula* negated the effect of the pathogen and increased plant growth. Furthermore, the physiological and biochemical traits exhibited greater production and less activity, respectively, in the *T. harzianum* + *C. fistula plants*. The trend of better growth in plants was *T. harzianum* + *C. fistula* > *T. harzianum* > *C. fistula* >. Therefore, soil amendment with *T. harzianum* + *C. fistula* in pathogen-infested soil could be implemented to combat late blight. These results indicate that the presence of *Trichoderma harizanum* promotes the growth of *A. solani*, possibly through melatonin production under stress conditions, resulting in better growth and yield in tomato.

Citrus Huanglongbing Pathogen Detection in Bahawalpur, Pakistan

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Huanglongbing (HLB), also known as citrus greening disease, is one of the most common causes of citrus decline worldwide, including in Pakistan. Adequate knowledge of the disease incidence and molecular detection of *Candidatus Liberibacter asiaticus*, the gram-negative bacterial agent of HLB disease, is needed for HLB eradication and control measures. From this perspective, a study was conducted on five commercially grown Citrus cultivars, including sweet orange (Musambi), rough lemon, early Feutrel, Kinnow and grapefruit (Shamber). Bahawalpur and its surrounding areas, including Yazman, Ahmad Pur, Khair Pur, and Hasil Pur, were selected for this project. Random samples of trees throughout the orchards were evaluated on the basis of asymmetrical unripe fruit and blotchy mottle symptoms. The highest disease incidence was recorded in Bahawalpur, and the lowest was recorded in Hasil Pur. Leaf samples were taken from infected trees to isolate DNA and confirm the presence of the huanglongbing pathogen via two primer pairs that amplified particular β operon (~703 bp) and ribosomal DNA (~1160 bp) regions. Among the cultivars, sweet orange (Musambi) presented a highly susceptible response with 80% disease incidence, whereas grapefruit (Shamber) presented the lowest disease incidence (20%) in all the observed areas. This study could be highly effective in planning management strategies for HLB.

Poisonousness of Three Different Essential Oils against Red Palm Weevil (*Coleoptera*: Dryophthoridae)

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The Asian palm weevil, also known as red palm weevil (RPW) or *Rhynchophorus ferrugineus* (Olivier, 1790) (Coleoptera: Curculionidae), has long been regarded as an annoying pest of many palm trees (Arecaceae), particularly date palm. It is challenging to observe adults on palm trees. Larvae inhabit and feed inside date palm trees, shielding them from inclement weather. The palm must be dissected, and then the red palm weevils must be identified. Nearly all the commercially grown date palm varieties in the country are susceptible to damage, including Aseel, Hillawi, Karbalain, Mozawati, Kechen, and Dhaki. Although adult red palm weevils are more active in the summer, they can be found inside palm trees throughout the year. Environmentally safe methods are needed to control red palm weevils. In this study, the feeding toxicity of three essential oils, i.e., piper, clove, and eucalyptus oils, was tested against red palm weevil larvae via a feeding bioassay. The results revealed that the percent mortality

was greatest when the samples were treated with a higher dose of clove oil than with the other two essential oils. Moreover, the LC_{50} value of clove oil was minimal, indicating greater toxicity. Our study concluded that clove oil is useful against *R. ferrugineus,* so we suggest that it should be properly placed in IPM strategies against this pest. However, more work is needed to test and improve the effectiveness of such bioactive compounds in the laboratory and under field conditions.

Poster Presentations

Fresh Juice Safety and Quality: A Case Study of Pomegranate Fresh Juice Vendors of Multan, Pakistan

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Fresh fruit juice is a common beverage in many countries, including Pakistan, and many consumers are attracted to roadside juice vendors/stalls during the hot summer season. However, the food safety and quality of fresh juice has not been widely studied and warrants investigation. Multan, a metropolitan and highly populated city, has many fresh juice vendors, including pomegranate fresh juice vendors. In view of these findings, a study was carried out to quantify the physicochemical and microbial characteristics of pomegranate aril and fresh juice sourced from various pomegranate fresh juice vendors of Multan. A total of fifteen pomegranate fresh juice vendors were selected, and pomegranate aril and juice samples were collected. The sampled materials were instantly transferred to the Postharvest Science and Technology Lab, MNS University of Agriculture Multan, for analysis. The range of bacterial counts in this study was approximately 1–1.8 × 106 CFU/ml. Moreover, the results indicated a significant difference in the physicochemical and microbial loads of the juice. The titratable acidity (TA) of the pomegranate juice samples ranged from 0.22−0.36%, the total soluble solids (TSS) content ranged from 16−19.67 Brix, the vitamin C content ranged from 73−114 mg/100 ml, the juice pH ranged from 3.7−4.1, and the TSS:TA ratio ranged from 48−85. The microbial loads of most of the fruit juices were higher than the specifications set for fruit juices sold in the WHO and other parts of the world. There is no specification set for the permissible level of microbes in fresh fruit juices being served in Pakistan. As the dominant isolates were colonies of organisms, the poor hygienic practice of the fruit juice handlers and lack of a sound knowledge source of the fruit aril, in addition to the conducive physicochemical profiles of the fruit juices, might have contributed to the high microbial load. Thus, there is a need to increase awareness among pomegranate fresh juice vendors to improve the microbial quality, safety, and shelf-life of the final product.

Effect of Various Concentrations of Salicylic Acid, Calcium Chloride and Aluminium Sulphate Solutions on Vase Life of Cut Sunflower (*Helianthus annuus* L.) cv. 'Vincent Choice'

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Sunflower (*Helianthus annuus* L.) is a summer-season flower used as a cut flower and belongs to the Compositae family. Maintaining the quality and extending the vase life of cut sunflowers poses challenges in postharvest management. To address this issue, research was conducted using three different preservative solutions. The preservative solutions for this experiment were distilled water (control), 1 mM salicylic acid, 10% sucrose, 2 mM salicylic acid + 10% sucrose, 3 mM salicylic acid + 10% sucrose, 2.5 mM calcium chloride, 5 mM calcium chloride, 10% sucrose, 7 mM calcium chloride + 10% sucrose, 100 mg aluminum sulfate + 10% sucrose, 200 mg aluminum sulfate + 10% sucrose and 300 mg aluminum sulfate + 10% sucrose. The experiment was designed according to a completely randomized design (CRD) with ten treatments and five replications with two cut flower stems in each jar, resulting in a total of one hundred cut flower stems. The data collected were analyzed for significance via analysis of variance (ANOVA). The treatment means were compared via the LSD test at a significance level of 5% to assess differences between the treatments. The best results were recorded in the T_5 treatment (5 mM calcium chloride + 10% sucrose) for most of the parameters, e.g., prolonged vase life (11 d), maximum water uptake (415 ml), minimum change in stem fresh weight (17.8 g), best flower quality (4.5), maximum dry weight (38.6 g), delayed senescence (9.2 d), delayed abscission of florets (9.8 d), maximum days to start petal necrosis (10.1 d), delayed stem necrosis (9.3 d), delayed stem bending (9.6 d), minimum ion leakage percentage in flower petals (91%), maximum increase in EC (596.80 $\mu S\ cm^{-1}$), and maximum change in TDS (331 mg/L) in the vase solution. Therefore, T5 (5 mM calcium chloride + 10% sucrose) is recommended for use as a preservative solution to prolong the vase life of sunflower (*Helianthus annuus* L.) cultivar 'Vincent choice' with the best quality.

Efficacy of Plant Growth Promoting Rhizobacteria (PGPR) to Improve Vegetative and Reproductive Growth of Stock (*Matthiola incana* L. cv. Harmony)

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The stock (*Matthiola incana* L.) is a charming flowering plant belonging to the Brassicaceae family. In this study, various strains of rhizobacteria were used to observe their effects on the potted *Matthiola incana*. Treatments were as follows: viz. T_0: Control, T_1 *Bacillus* spp. (MN54), T_2 *Pseudomonas* spp. (FB12), T_3 *Arthrobacter* spp. (R2), T_4 *Pseudomonas* spp. + *Bacillus* spp. (MNS4 + FB12), T_5 *Bacillus* spp. + *Arthrobacter* spp. (MN54 + R2), T_6 *Pseudomonas* spp. + *Arthrobacter* spp. (FB12 + R2) and T_7 *Pseudomonas* spp. + *Bacillus* spp. + *Arthrobacter* spp. (MN54 + FB12 + R2). A completely randomized design (CRD) was used to layout the experiment. There were ten replications per treatment. The collected data were analyzed via analysis of variance (ANOVA), and the treatment means were compared via the least significant difference (LSD) test. Compared with all the treatments, the T_7 treatment, which included a combination of three RBSs (*Pseudomonas* spp. + *Bacillus* spp. + *Arthrobacter* spp.), had the best results for all the parameters, i.e., significantly greater number of leaves per plant (46.20), number of branches per plant (11.8), plant height (58.60 cm), leaf area index (19.5 cm^2), stem diameter (11.03 mm), plant fresh weight (74.6 g), plant dry weight (18.35 g), days to 1st bud initiation (76.39), number of flowers per plant (10.8), flower diameter (75.62 mm), and flower weight (11.3 g). On the other hand, significantly poor results for all parameters were noted in treatment T_0 (control). In conclusion, the application of different rhizobacterial strains increased the growth and flowering of *M. incana* L. in general. However, $T_{7,}$ i.e., the combination of three rhizobacterial strains (*Pseudomonas* spp. + *Bacillus* spp. + *Arthrobacter* spp.), was the most effective at improving the vegetative and reproductive growth of stocks (*Matthiola incana* L. cv. Harmony).

Domestication of Wild Black Raspberries at Rawalakot, Azad Jammu and Kashmir

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Raspberries are the third most popular berry after strawberries and blueberries. Black raspberries are deciduous shrubs in temperate regions. Owing to the ideal climatic conditions for its growth, black raspberry plants have been found wild under Rawalakot conditions. Therefore, large plantations could be found in the wild. However, no studies have been conducted to exploit their commercial potential. In general, berry crops have better postharvest fruit quality when the plant microclimate is improved by having an open canopy and maximum air circulation. Open canopies and optimum air circulation can be attained by the proper combination of plant spacing, vegetative thinning and training. In this study, wild plants from different localities were collected and grown under rain-fed conditions in Rawalakot via three different trellizing systems: hedgerow (control), V-trellis and single-sided shift trellis. Rows were planted in an east–west orientation, with approximately 10 feet row–row distance and 3 feet plant–plant distance. After the first year of growth, various parameters related to vegetative, morphological and fruit quality were collected from wild raspberry plants trained under different trellis systems. After all the production and postharvest handling protocols are studied, there is a great possibility that local communities will show some interest in consuming this highly nutritious fruit in fresh form. Moreover, local farmers can earn additional income after growing this crop on a commercial scale, and with the increase in production, a small-scale industry could be established for developing value-added products in the future.

Effect of Gum Arabic (GA) Edible Coating on Quality Preservation and Shelf-Life Extension of Fresh-Cut Broccoli (*Brassica oleracea* var. Italica) Florets

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Broccoli (*Brassica oleracea* var. Italica) is a cruciferous vegetable rich in bioactive compounds; its susceptibility to yellowing is very high, resulting in economic and nutritional losses. The aim of this study was to assess the impact of gum arabic (GA [10%]) coating on the storage life of freshly cut 'Broccoli' florets during storage at 10 ± 1°C for 8 d. At two-day intervals, the florets were assessed for titratable acidity (TA), total soluble solids (TSS), ascorbic acid content, malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) levels, as well as their electrolyte leakage (EL) and total antioxidants. We also observed carotenoids, superoxide anions (O^{2-}), phenolics, and the total amount of antioxidant enzymes. The results revealed that GA-coated 'Broccoli' florets presented markedly greater SOD, CAT, and APX enzyme activities than did the control florets (GA [0%]). However, compared with the control, the GA coating substantially

suppressed physiological weight loss and significantly reduced the MDA, EL, H_2O_2 and O^{2-} contents in 'Broccoli' florets. Compared with the control, treatment of broccoli florets with the GA coating also suppressed the increase in POD activity and resulted in substantially greater TA, total antioxidant, TSS, carotenoid, and total chlorophyll contents and ascorbic acid activity. In conclusion, GA coating could be an effective approach for improving the storage life of fresh-cut broccoli florets.

Prospects of Floral Preservation as an Emerging Enterprise in Floriculture Industry

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Floral preservation is emerging as a transformative aspect of the floriculture industry. The preserved flower market size is expected to reach $271.3 million by 2031. As the demand for sustainable and long-lasting floral arrangements increases, the prospects of floral preservation are gaining momentum, providing a unique niche for horticulturists and entrepreneurs. Various techniques have been developed to facilitate the preservation of flowers, ensuring their longevity without compromising their natural beauty. Drying is the traditional and oldest method, where flowers are carefully dehydrated to retain their original form. Among modern techniques, silica gel preservation is quite effective, particularly for delicate blooms. The choice of drying method depends on the flower species and the effectiveness of the method in preserving the original flower color. Therefore, innovations in traditional methods are needed to increase the effectiveness of floral preservation and enhance the ability of the species to be preserved effectively. Additionally, cost effectiveness and profitability are other aspects to be managed for sustainable industry development. This paper particularly explores the prospects of floral preservation and compares various traditional methods with novel techniques to optimize drying possibilities with greater precision and accuracy to cater to the demand for sustainable and long-lasting floral preservation. As the floral preservation industry continues to flourish, it presents an effective approach for those looking to combine creativity with sustainability in a promising venture.

Effect of KNO_3 and $MgSO_4$ Used as Seed Priming Chemical on the Tomato (*Solanum lycopersicum* L.) Seed Germination Percentage

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The tomato, scientifically known as *Solanum lycopersicum* L., is a member of the Solanaceae family. It is a widely consumed fruit rich in beneficial compounds that promote good health. Seed priming is a highly effective method that improves seed efficiency and guarantees the production of high-quality seeds. This study aims to investigate the impact of halopriming, namely, the use of magnesium sulfate ($MgSO_4$) and potassium nitrate (KNO_3) at various concentrations (0%, 0.5%, 1%, 2%, 4%, and 8%), on a total of 450 tomato seeds. The seeds were immersed in the halopriming solution for 24 hours at a constant room temperature of 25 ± 1°C. This study aimed to increase the germination process, overcome seed dormancy, increase the consistency of root emergence, and increase the germination rate of tomato seeds by utilizing KNO_3 and $MgSO_4$. The incorporation of KNO_3 and $MgSO_4$ increased the germination rate of the tomato seeds. When lower concentrations (0.5%, 1%, and 2%) of KNO_3 and MgS04 were used, the germination percentage, fresh weight, dry weight, mean germination time, germination index, vigor index, and seedling length improved. Optimal seed priming was achieved with lower doses of KNO_3 and $MgSO_4$. Seed priming with $MgSO_4$ and KNO_3 increased root emergence and hence the germination rate and uniformity, accelerated germination, and disrupted seed dormancy.

Impact of Octanoic Acid on Food-Borne Pathogens and Quality of the Mabroom Dates (*Phoenix dactylifera* L.)

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The presence and spread of postharvest decay or mold-causing fungi are important factors that cause serious threats and economic losses to fresh dates during storage. Octanoic acid is known for its antimicrobial activities. It has been studied for its potential use in controlling the growth of certain pathogenic microorganisms, including bacteria and fungi. This study aimed to investigate the impact of octanoic acid (OA) on the presence of food-borne pathogens and postharvest decay on mabroom dates (*Phoenix dactylifera* L.). Mabroom dates at the full ripening stage were obtained from the National Agriculture and Food Corporation (NAFCO) and divided into five groups (G_1 to G_5) and then treated with different concentrations of OA (0%, 1%, 2% and 3.5%). Group five remained untreated. The samples were dried and incubated in a moist chamber at 25°C ±2 for 7 d, after which signs and decay symptoms were observed and recorded. The identities of the isolated pathogens were confirmed via microscopic testing. The results revealed significant differences ($P \leq 0.01$) among the groups. OA 3.5% had the greatest inhibitory effect on postharvest pathogens, followed by OA2% and OA1%. Moreover, no significant ($p \leq 0.05$) effects were recorded between the OA1% and control groups. *Aspergillus niger*, *Rhizopus* sp., *Penicillium* spp., and *Botrytis* spp. were detected at high levels in the control groups, followed by OA1%. In conclusion, 3.5% octanoic acid can enhance date quality through its high antimicrobial activity, reducing the effect of postharvest decay and minimizing date losses during storage.

Morphological and Biochemical Insights into Sweet Cherry (*Prunus avium* L.) Cultivars of Ziarat, Balochistan

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Balochistan, the largest province of Pakistan, is known for its diverse climatic conditions and topographical variations and provides a unique environment conducive to the cultivation of temperate fruit crops. In recent years, the cultivation of sweet cherries has gained significant attention as a promising agricultural venture in the region. The present research aimed to characterize the morphological and biochemical traits of three native sweet cherry cultivars, Babazhai, Sera Badaghora and Thora, selected from the Ziarat district. The results revealed significant variability in morphological parameters among cultivars, particularly in total fruit weight and fruit firmness, with values ranging from 3.13−5.97 g and 20.76−22.9 N, respectively. The biochemical attributes revealed distinct variations across cultivars. The pH varied between 5.11 and 6, the total soluble solids ranged from 17.12 to 32.33 °Brix, the titratable acidity ranged from 1.1% to 2.8%, and the ascorbic acid content ranged from 2.79 to 3.71 mg 100 g^{-1}.

The total phenolic content and anthocyanin content varied between 1.92–2.14 mg GAE g^{-1} and 0.17–0.93 mg 100 g-1 FW, respectively. Notably, compared with the other cultivars, the cultivar Babazhai presented higher total sugar content (15.03%), reducing sugar content (10%) and nonreducing sugar content (4.93%). The activities of enzymes, including superoxide dismutase (SOD), peroxidase (POD), polyphenol oxidase (PPO) and ascorbate peroxidase (APX), varied among cultivars. Thora presented the highest SOD (0.489 U/mg protein), POD (1.056 U/kg protein), PPO (0.845 U/kg protein) and APX (5.97 U/kg protein) activities, whereas Sera Badaghora presented the maximum catalase (CAT) activity (0.103 U/kg protein). The observed variations in morphological and biochemical characteristics among sweet cherry cultivars highlight the impacts of environmental factors, genetic diversity and the specific horticultural practices implemented in these orchards. These findings provide valuable insights for the optimization of cultivation practices, selection of cultivars and improvement of sweet cherry quality under the unique agroclimatic conditions of Balochistan.

A Comprehensive Study on the Characterization and Evaluation of Tomato (*Solanum lycopersicum* L.) Genotypes in Punjab, Pakistan

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Tomato is a significant summer vegetable crop belonging to the Solanaceae family. Tomato is an excellent source of essential nutrients such as vitamins A and C, minerals and the anticancer compound lycopene. The present study aimed to characterize locally grown tomato cultivars in Punjab, focusing on morphological, biochemical and genetic aspects. The morphological, biochemical and genetic diversity among cultivars was observed via tomato descriptors, biochemical analysis and the use of suitable molecular markers. Seedlings of selected tomato cultivars were raised to study their physical and biochemical parameters, and later, molecular studies were conducted utilizing DNA extracted from young leaves. The results revealed that physical parameters did not significantly differ across tomato cultivars, whereas plant height varied. The cultivar La-3847 recorded the maximum plant height, whereas the cultivar Nadir recorded the minimum plant height. Physiological parameter results revealed that cultivars La-3847, Nadir, 19612, 16241 Nagina and Naqeeb presented higher levels of lycopene, carotenoids, chlorophyll a and b, vitamin C, TA, TSS, and TSS: TA and exhibited greater SOD, POD and CAT activity than did the cultivars Abhilash, 19308, 1624 and 19612. Genetic characterization revealed dissimilarity among all the genotypes, with maximum variation observed between cultivar 19612 and Abhilash and minimum dissimilarity among cultivar La-

3847, Stripped Stuffer, Pakit and 16241. Overall, the results highlighted 16241, Nadir and La-3847 as the best-performing cultivars, providing valuable insights for the effective and efficient use of tomato germplasm in Punjab.

Optimization of Dehydration Temperature for Apple Slices

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The shelf life of fruits and vegetables is highly dependent on their water concentration. Dehydration is the oldest method for preserving food materials. However, it is limited by the small number of fruits and vegetables. Pakistan is among the major fruit-producing countries and has the lowest share of fruit exports. Postharvest losses are approximately 30–40% in Pakistan. These losses can either be minimized by improving storage conditions or value addition. The primary goal of the present study was to add value to apple slices through dehydration. Apple fruits of uniform size and color were purchased from a local market, washed thoroughly under running tap water to remove dirt, cut into uniform slices with the help of a slicer and subjected to various temperatures (46°C, 48°C, and 50°C) to determine the optimum temperature for dehydration of apple. Fruit quality parameters, such as sucrose, fructose, glucose, total phenolics, flavonoids, and ascorbic acids, and some sensory parameters, such as texture, flavor, acceptability and color, were assessed. The results revealed that fruits stored at 48°C presented the highest values for sucrose, fructose, glucose, total phenolic, flavonoid, and ascorbic acid contents and some sensory parameters, such as texture, flavor, acceptability and color, followed by fruits stored at 50°C. These results indicate that 48°C is the optimal temperature for the dehydration of apple slices.

Evaluation of Indigenous Soilless Substrates for Containerized Plant Production

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Peat moss and coco coir are standard soilless substrates that are used worldwide for containerized plant production but are not readily available in Pakistan throughout the year because of their hiking prices and import restrictions. Therefore, indigenous agro-industrial byproducts with low cost and physico-chemical attributes comparable with those of peat moss and coco coir are needed. For this purpose, indigenous agro-industrial byproducts, viz., sesame

straw, date palm coir, sugarcane pressmud, sugar beet waste and pine bark, were collected, cleaned, crushed (where needed) and blended for physico-chemical analyses. Zonal geranium 'Pinto White' was used to evaluate the efficacy of various combinations of selected indigenous soilless substrates on plant growth and production. Three experiments were conducted, with six treatments for each experiment, which were replicated three times. The blending of sesame straw with sugarcane pressmud and pine bark (4:4:2 by volume) yielded the best results, and the marketable plants presented the tallest height (35.0 cm), canopy diameter (20 cm), leaf area (29 cm^2), leaf chlorophyll content (62.1 SPAD) and number of flowers per plant (5.0 No.) and the shortest production time (103 d). Compared with the other blended substrates, the blending of sesame straw with sugarcane pressmud and pine bark resulted in a lower pH (6.8), EC (1.37 dS cm^{-1}), and bulk density (0.19 g cm^{-3}) but high-water retention (34.7%). However, the shrinkage of substrates in containers was greatest (7.7%) when sesame straw was blended with sugarcane pressmud and pine bark. The blending of these agricultural wastes (sesame straw, sugarcane pressmud, and pine bark) significantly improved the physicochemical characteristics of the substrates as well as the plant growth and production attributes.

Rhizome Production Ability of Tissue Cultures and Seed Rhizome-Derived Propagation Materials under Protective Shading Net

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The selection of appropriate propagation material and provision of optimal environmental conditions are among the key factors that primarily contribute to ginger rhizome production. This study outlines the assessment of tissue culture and seed rhizome-derived propagation material for plant growth and rhizome production under a 65% green shading net. The vegetative performance and comparative rhizome production ability of tissue culture-generated plants, transplants of successive mini-rhizomes and seed rhizomes of two ginger types, namely, Chinese and Thai, were transplanted under shaded nets. The Chinese mini-rhizomes produced long, statured, upright plants with broad leaves on thick and sturdy stems, whereas the tissue culture-generated plants of both types were characterized by dense vegetative growth with more tillers and leaves. Seed rhizome plants exhibit compromised

vegetative growth compared with the propagation material produced from tissue culture. Rhizome initiation was observed in Chinese mini-rhizomes after 130 d of planting, while the tissue culture and seed rhizome plants had thick and numerous roots without any rhizome development. The Chinese mini-rhizome develops horizontally, creeping larger rhizomes with more fingers among all propagation materials. In contrast, the tissue culture-generated plants produced smaller knobs that grew in the radial orientation with limited proliferation. The rhizome development ability of Chinese seeds lies between that of mini-rhizome and tissue culture-generated plants, while seeds derived from Thailand present the least potential for rhizome development. These findings support the selection of tissue culture-generated plants for ginger seed production and the utilization of successive generations of mini-rhizomes as a seed source for commercial ginger cultivation.

Effect of Plant Growth Promoting Rhizobacteria (PGPR) on Flowering and Vegetative Growth of Sweet William (*Dianthus barbatus*)

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Sweet William (*Dianthus barbatus*), a flower of the family Caryophyllaceae, also called bunch pink or born pink, is grown for its clusters of small brightly colored flowers. The present study was carried out to evaluate the effects of rhizobacteria on the floral and vegetative development of Sweet William. Three different rhizobacterial strains, viz. MN54 (Bacillus spp.), FB12 (*Pseudomonas* spp.) and R2 (*Arthrobacter* spp.) were applied. Data were collected at the mature stage of plant growth on various parameters, such as plant height, number of shoots per plant, number of leaves per plant, stem diameter, root length, flower diameter, days to first flower bud emergence, plant fresh weight, and plant dry weight. The experiment was arranged according to a completely randomized design (CRD) with eight treatments and three replications with three plants in each replication, and a total of 72 plants were used in this experiment. The data were analyzed via Fisher's analysis of variance technique, whereas the treatment means were compared via the least significant difference (LSD) test at the 5% significance level. Most parameters, i.e., plant height (18.1 cm), number of leaves per plant (37.5), leaf area (5.3 cm²), number of shoots per plant (11.2), stem diameter (0.83 cm), root length (9.8 cm), fresh weight (59.0 g), dry weight (14.73 g), days to first flower bud emergence (57.7), and flower diameter (73.78 mm), were good in the T7 treatment. It can be concluded

that T7 (*Bacillus + Pseudomonas + Arthrobacter*) is best at improving the growth and flowering characteristics of Sweet William. Therefore, these PGPRs, i.e., Bacillus spp., Pseudomonas spp. and Arthrobacter spp., should be used in combination to achieve high-quality growth and flowering of sweet william.

Optimizing Post Harvest Performance of Cut Lisianthus (*Eustoma grandiflorum*) by Using Different Pulsing Solutions

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The global cut flower market is a thriving industry, and lisianthus (*Eustoma grandiflorum*) is among the promising cut flowers worldwide. However, maintaining the quality and prolonging the postharvest life of cut flowers pose significant challenges in postharvest management. In the present research, five different compounds at various concentrations were used as pulsing treatments to optimize the postharvest life of cut Lisianthus flowers. The pulsing solutions included the following treatments: distilled water (T_0), 2% sucrose (T_1), 2% sucrose + 4 ml/L lime juice (T_2), and 2% sucrose + 8 ml/L. lime juice (T_3), 2% sucrose + 50 mg/L chitosan (T_4), 2% sucrose + 100 mg/L chitosan (T_5), 2% sucrose + 150 mg/L citric acid (T_6), 2% sucrose + 250 mg/L citric acid (T_7), 2% sucrose + 7.5 ml/L sodium hypochlorite (T_8), and 2% sucrose + 15 ml/L sodium hypochlorite (T_9). The experiment was performed according to a completely randomized design (CRD) with five replications, with two flowers in each replication and ten cut lisianthus stems in each treatment. The analysis of variance (ANOVA) technique was used to determine the overall significance of the current research trial, and the treatment means were compared via the least significant difference (LSD) test at the 5% significance level. The results revealed that 2% sucrose + 50 mg/L chitosan (T_4) provided the best results among all the treatments because it resulted in a longer fermentation life (10.7), maximum water uptake (196.6 ml), minimum change in stem fresh weight (5.38 g), maximum number of open buds (45.74%), greater flower diameter (20.1 mm), better flower quality (9), minimum change in pH (2.16) and minimum ion leakage percentage (78.1%). Therefore, it is recommended that 2% sucrose + 50 mg/L chitosan (T_4) be used for the pulsing treatment of cut Lisianthus flowers.

Novel active Packaging and Lower Cost Materials for Enhancing the Shelf Life of Strawberry (*Fragaria × ananassa* Duch) in Pothar Region

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Strawberry is a highly perishable fruit that requires proper postharvest handling and storage to maintain its quality and extend its shelf-life. However, conventional packaging methods are often inadequate or expensive for preserving strawberry freshness and preventing microbial spoilage. Therefore, novel active packaging and lower-cost materials are needed to address these challenges and improve the marketability of strawberry products. Novel active packaging and lower-cost materials are two of the most promising advances in the field of food preservation. Active packaging refers to the use of substances that can interact with food or the environment to extend shelf-life, improve quality, or enhance safety. Lower-cost materials can provide similar or better performance than conventional materials at a lower price or with less environmental impact. Some examples of novel active packaging and lower-cost materials for enhancing the shelf-life of strawberries are edible coatings, nanocomposite films, and intelligent packaging. Nanotechnology also plays a vital role in novel packaging systems to increase food shelf-life under active packaging systems. The use of optimized active packaging films based on chitosan, essential oils, and silver ZnO, Ag, TiO2, AlOx, and SnO2 nanoparticles can inhibit mold growth and pathogenic bacteria in strawberries. Novel active packaging and lower-cost materials can help maintain the freshness, flavor, color, and texture of strawberries for longer periods of time, thus reducing food waste and increasing consumer satisfaction.

The Impact of Climate Change on Grape Quality and Strategies for Sustainability

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Grapes (*Vitis vinifera* L.) are fascinating fruits with diverse colors and are enriched with essential nutrients such as vitamins A and C, minerals, and antioxidants, and grapes make a valuable

contribution to a wholesome diet. It is a nonclimacteric fruit and is deciduous. All grapes, including the skin, leaves and seeds, are utilized for medicinal purposes. Globally, climate change significantly impacts the quality of grapes. The increase in temperature, shifts in rainfall patterns, and increased frequency of extreme weather events are altering the growing conditions for grapes. These alterations have potential repercussions on flavor, sugar levels, acidity, and overall quality of the fruit. Elevated temperatures may lead to increased sugar content and reduced acidity, resulting in grapes that are sweeter but potentially lacking balance in taste and quality. Furthermore, changes in rainfall patterns influence water availability for vines, subsequently affecting their growth and fruit development. Additionally, extreme weather events, such as hailstorms, threaten grape integrity and diminish grape quality. Therefore, strategies such as the development of improved genotypes and precision techniques that may sustain the high quality and distinctive characteristics of grapes are urgently needed. The viticulture industry must navigate these challenges to ensure the continued excellence of grape-based products in the face of a changing climate.

The Significance of Ornamental Horticulture in Enhancing Esthetic Value

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Ornamental horticulture is an agricultural field that emphasizes the beauty and visual appeal of plants and focuses on the cultivation and management of plants for aesthetic purposes. The main purpose of ornamental horticulture is to improve the environment by incorporating ornamental plants into landscapes, gardens, and urban spaces. This practice not only contributes to the aesthetic richness of the environment but also provides relaxing effects and psychological benefits to the individual. Ornamental horticulture involves a wide range of plant species, such as flowers, shrubs, trees, and lawns, and includes various aspects, such as plant breeding, landscaping, and maintenance. This includes the development and breeding of new varieties of plants with improved characteristics, such as disease resistance, color change, and adaptability to different environmental conditions. Additionally, ornamental horticulture aims to promote sustainable and environmentally friendly landscape design practices that incorporate principles of nature conservation, water efficiency, and biodiversity. As urbanization increases, ornamental horticulture becomes important in reducing the impact of

urban development on natural ecosystems by creating green spaces and promoting harmonious coexistence between the urban environment and nature. The latest trends in ornamental horticulture are likely to be influenced by advances in biotechnology, precision agriculture, and sustainable landscaping practices. The development of genetically modified ornamental plants with improved characteristics and the use of advanced precision breeding techniques play important roles in shaping this industry. Additionally, there is an increased emphasis on environmentally friendly landscaping solutions, such as the use of native plants, water-efficient irrigation systems, and organic fertilizers, reflecting broader societal shifts toward sustainability. Integrating smart technologies such as automated irrigation systems and sensor-based monitoring into landscape management is expected to further optimize resource use and contribute to the overall resilience of ornamental horticulture practices in the face of evolving environmental challenges.

Threats to Mango Fruit Industry in Pakistan

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Mango (*Mangifera indica* L.) belongs to the Anacardiaceae family, and it is the most important commercially grown fruit with several health benefits. It is grown worldwide in tropical and subtropical areas. Pakistan is the second major cultivated fruit crop that is widely cultivated in Sindh and Punjab, and Pakistani mangoes are in high demand worldwide because of their unique flavor and taste. Pakistan is the 4th largest producer and the 3rd largest exporter of mango and exports mangoes to Middle Eastern countries, Iran, Germany, Japan, China and Hong Kong. However, its export is not consistent due to alternate bearing, unfruitfulness, poor fruit set, diseases such as powdery mildew, anthracnose, dieback disease and malformation. Furthermore, fruit flies, poor management practices and a lack of proper postharvest facilities are major threats. However, these issues can be resolved through plant protection measures, proper management strategies, the introduction of exotic varieties and the use of biotechnological tools for crop improvement, production, and export.

Postharvest Application of Methyl Jasmonate to Enhance the Shelf Life of Loquat Fruit

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Eriobotrya japonica is a small, round or pear-shaped fruit with a tart and somewhat sweet taste. It is a member of the Rosaceae family; it originated in China and is grown worldwide. Fruit, which has a unique fuzzy skin, is frequently eaten raw, in salads, or as a base for jams and sweets. The fruit of loquat trees is full of nutrients and offers various health benefits. Numerous elements, including antioxidants, fiber, vitamins and minerals, water, and low-calorie alternatives, make health choices. Owing to its high vitamin and antioxidant contents, loquat has the potential to become invasive in certain areas and displace native vegetation if it is not adequately managed. Loquat fruits are highly sensitive to environmental factors, which lead to a relatively low yield and uneven fruit set. Loquats can also swiftly spoil if not handled properly, similar to many other fruits. Methyl jasmonate is a plant signaling molecule that is well known for its function in the generation of secondary metabolites and stress responses. In this study, different MeJA concentrations were applied to harvested loquat fruits, and data were collected after three days. The effects of these treatments on the biochemical and physiological parameters that affect shelf-life were evaluated. The findings showed that the application of methyl jasmonate greatly increased the shelf-life of loquat fruits by regulating ethylene production, preserving firmness, and lowering the rate of physiological decay. The results provide useful insights into the possible application of MeJA as a postharvest treatment to increase the quality and extend the marketable time of loquat fruit.

Botanical Characterization of *Capsicum annum* for Varietal Development

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Capsicum annum is a versatile crop belonging to the Solanaceae family that is consumed as a vegetable and spice in Pakistan. It holds immense economic value in the country, contributing

to its agricultural sector. It is a great source of vitamin C and antioxidants that help support a healthy immune system and promote overall well-being. The present study was conducted at the experimental field of Horticultural Research Institute (HRI), National Agricultural Research Centre (NARC), Islamabad. The experiment was conducted in a randomized complete block design (RCBD). The present study focused on the single-fruit selection of the chili advanced line NARC-Chilli 16/4, revealing valuable insights into its botanical characteristics. The data were recorded for different morphological parameters according to the descriptors of the Federal Seed Certification and Registration Department. The distinguishing characteristics of ten (10) single-fruit selections of NARC-Chilli-16/4. The maximum fruit length was noted in "(AB)*4", followed by "(Ad)*5", "(Aa)*1" and (AB)*4. The results revealed that there was not much variability among the studied lines. However, the minimum fruit length (8 cm) was noted in (Aa)*2 and "(Ad)*5" (9.5) cm. In our study, line (AB)*4 performed better and presented desirable characteristics, such as dense foliage, longer fruit length, and high fruit density.

Vertical Farming: A Sustainable Approach to Ensure Global Food Security

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With the increasing global population, the demand for food is continuously increasing. Therefore, to meet growing food requirements, methods that optimize space utilization and increase yield per acre are crucial. Vertical farming has emerged as a promising alternative to conventional practices, requiring less space and water resources for crop production. This is an innovative agricultural approach in which crops are cultivated vertically within a controlled environment. This becomes particularly significant as arable land faces depletion due to pollution and erosion, necessitating solutions such as vertical farming to produce high-quality food without extensive cultivation areas. The advantages of vertical farming are manifold and include increased efficiency, which minimizes water and land usage. Crops can be cultivated throughout the year, which is not achievable in traditional farming. Additionally, the controlled environment in vertical farming protects crops from environmental stresses such as droughts and floods. Currently, technologies such as LED lighting, ventilation systems, heating mechanisms, sensors, and mobile applications are used in control environments for smart cultivation. Furthermore, in vertical farming, techniques such as hydroponics, aeroponics, and aquaponics enable crop production without the use of traditional soil. Moreover, this method

facilitates the production of pesticide-free and disease-resistant crops, contributing to sustainable agriculture by conserving natural resources. In essence, vertical farming is at the forefront of a transformative shift toward a more sustainable and efficient agricultural future.

Effect of Acetylsalicylic Acid and Storage Durations on Post-Harvest Quality of Apple

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Apples belong to the family "Rosaceae" and are highly nutritious fruits that contain bioactive compounds such as minerals, vitamins, and cellulose. However, its quality deteriorates during storage. Therefore, an experiment was conducted to evaluate the effects of acetylsalicylic acid (ASA) content and storage duration on the postharvest quality of apples. The experiment was conducted in a completely randomized design (CRD) with a two-factor factorial arrangement. The fruits were dipped in 0.4 mL-1 acetylsalicylic acid (ASA) solution for 0, 2, 4 and 6 minutes. The fruits were transferred to storage after drying and stored for 5, 10, 15 and 20 days. The findings of the experiment indicated that storage duration significantly affects fruit quality parameters. The maximum titratable acidity (0.56%), minimum fruit pH (4.4) and fruit weight loss (1.1%) were recorded for fruits stored for 5 d. Furthermore, the ASA dipping time significantly affected fruit quality attributes, and the maximum fruit firmness (2 kg cm^{-2}) was recorded for fruits treated with ASA for 6 minutes. The interaction of the acetylsalicylic acid dipping time and storage duration significantly affected the fruit firmness and TSS of apple as well. The maximum firmness (2.17 kg cm^{-2}) was noted in fruits stored for 20 d, and the maximum TSS (13.8 °Brix) was recorded in fruits stored for 20 d. However, the minimum fruit firmness (8.6 °Brix) was recorded at 5 d of storage in untreated fruits.

Comparative Field Study of Different Grape Varieties under Agro-Climatic Conditions of Islamabad

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Grapes (*Vitis vinifera* L.) belong to the family Vitaceae, which comprises 12 genera and 60 species. It is native to temperate zones and is a nonclimacteric berry fruit that grows on perennial and deciduous woody vines. It is a rich source of flavonoids, antioxidants, vitamins and minerals. An experiment was designed to evaluate the growth performance of different varieties of grapes under the agroclimatic conditions of Islamabad. The experiment was carried out in a randomized complete block design (RCBD) with three replications and 5 plants per replication. The varieties included 'NARC Razaki', 'Abaseen' and 'King Ruby'. The data were recorded for plant height, number of branches per plant, number of leaves per plant and leaf area. The results indicated that the maximum plant height (58.93 cm), number of branches per plant (4.88), number of leaves per plant (35.33) and leaf area (0.65 cm) were recorded in 'NARC Razzaki', whereas the minimum plant height (31.21 cm), number of branches per plant (2.88), number of leaves per plant (25.42) and leaf area (0.3164 cm) were recorded in 'King Ruby'. The results revealed that 'NARC Razzaki' performed better under the agroclimatic conditions of Islamabad than did 'Abaseen' and 'King Ruby'.

Exploration of Olive Bioactive Compounds, Health Benefits, and Industrial Applications

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Olive "*Olea europaea*" belongs to the Oleaceae family and is a great source of bioactive compounds such as triglycerides, fatty acids, carotenoids and phenolic compounds that help in the prevention of diseases such as hypertension, stroke, bone health, cholesterol, cardiovascular health, diabetes, cancer, and neurological disease. The major producers of olives are Spain, Italy, Iran and Greece. Pakistan is cultivated in Balochistan and Pothohar areas, and many diverse local and exotic species exist in these regions. Olive is a source of edible oil, which is a liquid fat extracted from the fleshy portion of fruit. Olive oil can be categorized into extra virgin olive oil, virgin olive oil, olive oil and secondary pressed olive oil on the basis of its physical, chemical and organoleptic properties. Leaf extracts from olives are harnessed to create dietary products, with pharmaceutical companies developing natural and safe supplements. The potent antioxidants found in olives have led to their incorporation into various cosmetic products, such as ointments, hair care products, and skincare products. The regular consumption of products derived from olives contributes to a well-balanced diet.

Further research is essential to uncover the therapeutic benefits of olives, aiming to encourage increased consumption. This, in turn, will boost the food processing, pharmaceutical, and cosmetic industries.

Assessment of Primary Yield-defining Characteristics of Indeterminate Tomato

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Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family and is cultivated for fresh fruit and processed products. It contains many health-promoting compounds, including vitamins, carotenoids, and phenolic compounds. It is a climacteric fruit, and dramatic metabolic changes occur during its fruit development. This study focused on the evaluation of morphologically identified traits of advanced lines of indeterminate tomatoes, related to their yield potential for further breeding improvements. The experiment was conducted at the experimental field of the Vegetable Crops Research Programme, HRI, National Agricultural Research Centre, Islamabad. The experiment was performed in a randomized complete block design and included 30 parental lines of indeterminate varieties. The yield-determining traits measured during the study were the total number of clusters per entry, average number of clusters per plant, maximum number of clusters per plant, total number of fruits per entry, average number of fruits per plant, average number of fruits per cluster, and maximum number of fruits per cluster. The results revealed that lines 7, 22, 23, 42, 50, 76, 79, and 16 performed better for the major yield determinants and could be used for further breeding improvements for the development of competitive tomato hybrids.

Agro-Morphological Characterization of Chili Pepper Accession for Varietal Advancement

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Chili, also known as hot pepper, is a popular vegetable and condiment that is enjoyed worldwide. It belongs to the Solanaceae family and is rich in essential vitamins. It is consumed in salads and as a spice to add flavor to cooking. This study focused on the single-fruit selection of the chili advanced line NARC-Chili 15/5, revealing valuable insights into its agromorphological characteristics. The research was conducted in a completely randomized block design under a walk-in tunnel in the experimental field of the Vegetable Crops Research Programme, HRI, National Agricultural Research Center, Islamabad. The plant material comprised fourteen single-fruit varieties of chili advanced lines. The distinguishing morphological characteristics, such as plant height, leaf shape, fruit shape, leaf and node anthocyanin contents, number of fruits, fruit length, and fruit width, were recorded according to the descriptors of the Federal Seed Certification and Registration Department. There was not much variability in almost all the traits except for a few exceptions, such as fruit shape, fruit length, and fruit density, which indicates that only one gene difference defines it in the direction of near-isogenic lines of chilies. Fruit shapes varied such that cylindrical and narrow triangular shapes were observed. The fruit density was greatest for the (A1d) *3 and (A2c) *3 single-fruit selections. The fruit length of single fruit selection fluctuates between 8 and 15 cm, and the maximum fruit length (14.5 cm) was observed in A1d *3, whereas the minimum (8 cm) was noted in Diff., Ex. *3. Based on these observations, it was concluded that (A1d) *3 and (A2c) *3 presented the best performance, exhibiting desirable characteristics such as 3 locules, longer fruit lengths ranging between 12 and 14.5 cm, and very high fruit density. Hence, (A1d) *3 and (A2c) *3 are selected for presentation to the FSCRD for varietal advancement.

Morphological Characterization of Local Apricot Cultivars Growing in Gilgit Baltistan

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The apricot *Prunus armeniaca* L. belongs to the "Rosaceae" family and is the most important temperate fruit. Turkey is the leading country in terms of apricot production, whereas Pakistan ranks 6th at the global level. In Pakistan, Gilgit Baltistan and Balochistan are major contributors to apricot fruit production. It has great economic, medicinal, and nutritional importance and is a rich source of antioxidants, carotenoids, flavonoids, phenolics, vitamins, organic acids, proteins, and minerals (Ca^{++}, Mg^{++}, K^{+}, etc.). The objective of this study was to characterize four local apricot cultivars of Gilgit Baltistan through morphological characterization. Four local genotypes (Shakanda, Marghulam, Charmaghz, and Kharpacholi) were studied in this study, and significant variations in fruit shape, size, length, suture, and fruit color were detected. The

results revealed that the apricot fruit shape varied from obligate to ovate among the studied cultivars. The maximum fruit size (20.56 cm2) was observed in ‘‘Charmaghz’’, whereas the minimum fruit size (8.70 cm2) was observed in ‘‘Kharopacholi’. Similarly, the maximum fruit length (4.55 cm) was noted in "Charmaghz,” whereas the minimum fruit length (2.95 cm) was noted in "Kharpacholi." The color of the fruits of the studied cultivars also varied from light yellow to orange, and the color of the fruits of “Shakanda” was light orange, that of “Marghulam” was orange, that of “Charmaghz” was light yellow, and that of “Kharpacholi” was yellow. The findings of this study showed that the apricot cultivars are highly diverse and can be used for future breeding programs.

Survey of Cold Chain Logistics in Fruits from Iran and Afghanistan

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Pakistan suffers 25–40% postharvest losses of fruits and vegetables, mainly due to the underdeveloped value chain. Cold chain logistics are used on a very limited scale for the transport of perishable goods within the country. To analyze the bilateral trade scenario of fruits between Pakistan and its two neighbors, Iran and Afghanistan, a survey was conducted at the Islamabad fruit market. Fruits were imported from both these countries in refrigerated as well as nonrefrigerated trucks. The quality and packaging of the products in the nonrefrigerated trucks were found to have inferior standards, whereas the commodities transported in the reefer trucks had superior quality and were retailed at higher prices. For example, the Amiri variety of apricots brought from Afghanistan to Islamabad in reefer trucks through the Chamman border was retailed at PKR 370 per kg, whereas the same variety brought in nonrefrigerated trucks was retailed at PKR 300 per kg. Other fruits such as grapes, apples, and pomegranates imported from Afghanistan and Iran in reefer containers had higher prices than those brought in nonrefrigerated trucks. Reefer containers are also used to export some fruits, such as mangoes, bananas, and Kinnow, to these countries, but to a limited extent. Compared with nonrefrigerated transport, refrigerated transportation was also more profitable for the truck industry. There is a need to expand the use of refrigerated transport for these perishable products within the country and with the adjoining countries to help reduce postharvest food losses and increase the economic benefit for all the stakeholders in the value chain.

Comparative Evaluation of Various Soilless Substrates and Nutritional Regimes on Growth, Yield and Quality of *Lilium* hybrids

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An experiment was performed to compare the effects of various substrates and nutritional regimens on the growth, yield, and quality of Lilium. In this context, an experiment was performed according to a completely randomized design with three replicates of 15 plants. The treatments consisted of silt (control), coco coir, and sugarcane press mud with NPK and calcium on *Asiatic Lilium* cv. Tracer. NPK treatments comprised 30 g per 60×37×23 cm^3 plastic crates, and calcium was applied at a rate of 20 g per 60×37×23 cm^3 plastic crates. The leaf area, leaf total chlorophyll content, and fresh weight of the stems improved in the silt + NPK + calcium treatment, whereas the coco coir + NPK + calcium treatment resulted in early flowering, maximum stem length, maximum bud diameter, maximum flower diameter, maximum stem diameter, and maximum dry weight of the cut lilium. Overall, coco coir + NPK + calcium had the greatest effect on cut lilium production.

Physico-chemical Fruit Quality Attributes in Different Maturity Stages of Olive cv. BARI-II with respect to Postharvest Salicylic Acid Treatments

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Investigations have focused on the impact of salicylic acid on phytochemical and antioxidative enzymatic attributes in different fruit maturity stages of olive cv. BARI-II with respect to different shelf intervals. The study was laid out under a completely randomized design (CRD) with a three-factor (maturity stages, salicylic acid and shelf duration) factorial arrangement and three replications. The fruits of olive cv. BARI-II were harvested from the Barani Agriculture Research Institute (BARI, Chakwal) at three different maturity stages (M_1: Lemon-green, M_2: Semiripe & M_3: Full-ripe), transported to the IUB, subjected to dip treatment (5 minutes) with

different salicylic acid concentrations (T_0= Control, T1=1 mM, T2=3 mM, T3=5 mM, T4=7 mM), placed under a refrigerated shelf (6±1°C) and evaluated at 3 d intervals (0, 3, 6, 9, 12, 15). The influence of the studied factors on weight loss, biochemical attributes (total soluble solids, titratable acidity, vitamin C content, ripening index, pH, total antioxidant capacity and total phenolic content) and antioxidative enzymes, including proteins, peroxidases, catalases and superoxide dismutases, was evaluated. The maturity stage at fruit harvest had a significant effect on weight loss, total soluble solids, the ripening index, pH, total antioxidant capacity, total phenolic content, protein content, peroxidase, catalase and superoxide dismutase. Salicylic acid treatment significantly affected the total soluble solids content, titratable acidity, ripening index, total antioxidant capacity, total phenolic content, protein content, peroxidase activity, catalase activity and superoxide dismutase activity. All the studied parameters varied significantly with increasing shelf duration. Similarly, the interaction effects of fruit harvest maturity, salicylic acid content and shelf duration were significant for most of the studied parameters except pH. Overall, the postharvest physicochemical attributes of olive cv. BARI-II significantly varied at different stages of olive fruit maturity with respect to different salicylic acid treatments.

Impact of Boron and Cytokinin on Yield and Quality of Cauliflower

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Cauliflower (*Brassica oleracea* var. botrytis) is a winter vegetable crop that belongs to the family Brassicaceae. It is high in vitamin C and vitamin K and is also a good source of folate. Boron is an essential micronutrient, and its deficiency disturbs the physiological functioning of higher plants. Plants adapt their growth habits according to the availability of nutrients. Some previous studies have shown the role of ethylene and auxins as endogenous regulatory factors in the adaptation of plants to varying boron concentrations; however, less is known about cytokinins. In the present study, the impacts of B and cytokinin on the growth and yield of the cauliflower genotype Faisalabad Local 1 were investigated from 2022–2023. The plants were exposed to two concentrations of boron (2.5 kg/ha, 5 kg/ha) and cytokinin (25 ppm, 50 ppm) in eight treatment combinations, including the control. Treatments were applied in the form of foliar sprays at 20 and 40 d after transplantation, and each treatment was replicated three times. Compared with the other treatment combinations and the control, the plants exposed to the 5 kg/ha boric acid + 50 ppm cytokinin treatment presented greater plant height at harvest, number of leaves, leaf width, chlorophyll a and b content, gross plant weight, marketable curd

weight, net curd weight, curd diameter, curd yield, harvest index, ascorbic acid content, phosphate content, and potassium content. These results suggest that boron and cytokinin could play important roles in early head development and maturation, as well as yield improvement in cauliflower.

Fruit Quality and Shelf Life of Two Olive Cultivars in Response to Different Postharvest Edible Coatings

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A laboratory experiment was conducted to study the effects of different edible coatings and shelf durations on the biochemical and bioactive attributes of two olive cultivars, BARI-I and Earlik. The olive fruits were harvested from the Barani Agriculture Research Institute (BARI, Chakwal) and transported to Islamia University of Bahawalpur, where they were sorted and dipped for 3 minutes into 20% different edible coatings: gum arabic (GA), aloe vera gel (AV), and a combination of GA and AV. After coating, the olives were shelved in a refrigerator at 6±1°C and evaluated at 3-d intervals (0, 3, 6, 9, 12, and 15 d). The influences on weight loss, biochemical attributes (total soluble solids (TSS), titratable acidity (TA), ripening index, pH, total antioxidants, total phenolic content, and protein contents), and bioactive compounds (vitamin C and antioxidative enzymes, including peroxidase (POD), catalase (CAT), and superoxide dismutase (SOD)) were studied. This study revealed significant differences between the two olive cultivars in terms of weight loss, TSS, TA, ripening index, pH, total antioxidants, total phenolic content, and protein content. Different edible coatings had substantial effects on weight loss, TA, the ripening index, total antioxidant content, total phenolic content, total protein content, and the contents of vitamins C, CAT, POD, and SOD. Shelf duration significantly affected weight loss, TSS, TA, the ripening index, pH, total antioxidants, total phenolic content, protein content, and vitamin C, CAT, POD, and SOD activities. Additionally, the interactions among cultivar, edible coating, and shelf duration had a significant effect on weight loss; total soluble solids; titratable acidity; ripening index; pH; total antioxidants; total phenolic content; protein content; and the contents of vitamin C, catalase, peroxidase, and superoxide dismutase. Overall, the results of this study suggest that edible coatings and a refrigerated shelf can improve the shelf life and quality attributes of olive fruit. The combination of GA and AV was the most effective edible coating for improving the biochemical and bioactive attributes of olive fruit.

Yield and Quality of Cabbage as Influenced by Foliar Application of Boron and Auxin

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Cabbage (*Brassica oleracea* var. capitata) is a highly nutritious winter vegetable that belongs to the Brassicaceae family. Boron is an essential micronutrient that significantly affects plant growth, development, and yield. Auxin is a vital plant hormone that regulates growth, development, tropic responses, and cell elongation. Little information is available regarding the combined impact of boron and auxin on cabbage yield and development. The present study was designed to evaluate the role of boron and auxin interactions in cabbage genotypes. The trial consisted of one variety of cabbage (Faisalabad local No. 1) and nine treatment combinations, including a control with two factors: micronutrients and growth regulators. The plants were exposed to three concentrations of auxin (control, 25 ppm, 50 ppm) and three concentrations of boron (control, 2.5 kg/ha, 5 kg/ha). Treatments were applied in the form of foliar applications 20 and 40 d after transplanting, with three replicates in each treatment. Cabbage plants presented the best results in terms of the number of leaves, leaf size, chlorophyll (a, b) content, number of days for head initiation, number of days for head maturity, gross head weight, marketable weight, net head weight, head diameter, head depth, head index, harvest index, ascorbic acid content, and ion content (N, P, K) when exposed to the 50 kg/ha B + 50 ppm auxin treatment combination compared with those of the control and other treatment combinations. These results suggest that the combined application of boron and auxin improves the yield and quality of cabbage and, therefore, can be used for commercial vegetable production.

Sustainable Vertical Gardening in Urban Spaces using IoT based Technologies

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Modern technologies play an important role in promoting sustainability, profitability, and overall agricultural productivity by optimizing agricultural inputs. Vertical gardening is prevalent

as an impressive way to promote urban horticulture in confined and limited spaces. The integration of Internet of Things (IoT) technology into vertical gardening practices has emerged as a promising solution to the challenges of time and space in urban areas. Advantages include optimized space utilization, improved air quality, water conservation through smart irrigation, aesthetic enhancements, and improved psychological well-being. The IoT-based vertical gardening system involves the placement of sensors and actuators to monitor and control various parameters, such as soil moisture, temperature, light intensity, and nutrient levels. These sensors collect real-time data, allowing users to analyze the information received and make decisions regarding watering schedules, nutrient supplementation, and environmental adjustments remotely. IoT-based systems enable users to manage their vertical gardens while in their comfort zone by using web applications on their cell phones or laptops, promoting accessibility and convenience. This paper explores the idea that precise control over environmental factors results in increased plant growth and health, contributing to local food production and efficient resource utilization. The alarming increase in urban sprawl requires innovative solutions such as IoT-based vertical gardening as an imperative strategy to develop resilient and sustainable food production systems under limited time and space regimes for urban dwellers.

An Insight on Physico-Morphic Diversity in Chrysanthemum (*C. morifolium* Ramat.)

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Chrysanthemum morifolium Ramat. is a highly favored ornamental plant. The primary region for the commercial production of this commodity is East Asia, with a smaller presence in western Europe. Over the course of 1600 years of breeding, chrysanthemums have undergone significant cultivation, resulting in the development of several types, such as traditional (TC), spray cut (SCC), disbud cut (DCC), potted and groundcover (PGC), and wild chrysanthemums (WC). In 2021, Chrysanthemums were the 2393rd most traded product (out of 5,025) globally, of which the top exporters were the Netherlands ($434 M) and the top importers were the United Kingdom ($149 M). Commonly, it is used in displays as cut flowers, pot mums, and borders. The loose flower is highly sought after and utilized for creating decorations, garlands, bouquets, and offerings for religious worship. Its flowers exhibit a diverse spectrum of hues, including pink, white, yellow, bronze, orange, and salmon red, as well as numerous shapes and designs, such as spider, quilled, pompon, and anemone. Morphologically, the diversity extends

to flower forms, ranging from single to fully double inflorescences, influencing the overall aesthetic appeal of the plant. Their characteristics include height variations, leaf shapes, and textures. In this study, we identified 8 classes and 11 variants out of 13 classes. This exploration and preservation of physico-morphic diversity in Chrysanthemum not only enhances the ornamental value of this iconic flower but also contributes to its resilience under diverse environmental conditions.

Integrated Approaches for Effective Scale Insect Management on Cactus Plants

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Cacti are renowned for their resilience in arid environments and are highly susceptible to infest by scale insects, posing a significant threat to their health and overall productivity. By employing integrated pest management (IPM) techniques, comprehensive strategies are needed to manage scale insect populations on cactus. This study explores the life cycle, biology, and ecology of prevalent insect species affecting cacti, with a focus on identifying key vulnerabilities in their developmental stages. Through a combination of biological, cultural, and chemical control methods, we aim to develop a sustainable and environmentally friendly approach to mitigate scale insect infestations on cactus plants. This research involves field trials and controlled experiments to assess the efficacy of different control measures, considering factors such as climatic conditions, plant species, and insecticide resistance. Additionally, the potential role of natural enemies, such as predators and parasitoids, in regulating scale insect populations on cacti is important. This multifaceted investigation aims to provide a holistic understanding of the complex interactions between cactus plants and scale insects, offering practical insights for growers, horticulturists, and conservationists in tailoring management strategies that strike a balance between effective pest control and the preservation of cactus biodiversity.

Opportunities and Implications of Water-wise Gardening in Arid Region

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Water scarcity has become a global problem, posing significant challenges to communities worldwide. This situation has led to widespread debates on water use in gardens and amenity landscapes, especially in urban areas. Waterwise gardening is an acceptable proposition for

these debates as an ecologically yet applicable approach. In context, Pakistan is the most vulnerable nation to climate change. This comprehensive review highlights the dynamic domain of waterwise gardening in arid regions, shedding light on both its opportunities and implications. Through a meticulous analysis of the current research, this study highlights the potential benefits of waterwise gardening, encompassing resource conservation, climate resilience, and biodiversity promotion. Despite these advantages, the paper addresses the challenges and potential trade-offs associated with these practices, emphasizing the necessity for a balanced and context-specific approach. The synthesis of existing knowledge in this study serves as a valuable resource for researchers, policymakers, and practitioners aiming to enhance sustainable gardening practices in arid regions. Providing nuanced insights contributes to the ongoing dialog on mitigating environmental pressures and promoting ecologically sound approaches within water-scarce landscapes. As societies grapple with the increasing strain on water resources, understanding the complexities of waterwise gardening becomes paramount. This paper aims to bridge the gap between research and practical application, fostering a more informed and effective approach to sustainable gardening practices such as waterwise gardening in arid environments.

Empowering Capiscum with Fortification of Vermicompost and Eggshell for Fruit Quality Management

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Chili (*Capsicum annuum* L.) is a well-known popular spice around the world that is known for its unique flavor and pungency. It is one of the oldest domesticated crops and is cultivated on an area of 1.856 million hectares, with a production of 4.626 million tonnes. Peppers are consumed fresh and dried for their pungency around the world. Many factors have been responsible for the declining trends in chili production since 2007. For this purpose, scientists are converting farmers toward hybrid varieties that produce more fruits but lack aroma. Chemical fertilizers increase productivity but also have negative effects on the environment. To address flavor and production issues, researchers are rapidly switching to organic fertilizers. This research was designed to evaluate the use of organic supplements as substrate amendments and their effects on chili fruits and foliage. Crushed eggshells and vermicompost were used as additives to garden soil. Eggshell and vermicompost are rich in calcium carbonate, magnesium carbonate, calcium phosphate, organic content, and N, P, and K, respectively. Two lines, R-71 (OPV) and R-76 (OPV), and three varieties, Novistar, Jalapeno, and Anaheim, were planted for evaluation purposes via CRD design, and both morphological and biochemical parameters were observed. Different concentrations of fortifying media were used at the four

developmental stages of the plants. The results revealed a significant effect on plant height, the number of leaves, stem diameter, root length, and the number of fruits when a combination of 375 g vermicompost and 75 g eggshell was used. R-71 (OPV), along with 75 g of eggshell, was found to have a high yield, but the fruit was of low quality. Sustainable production systems for vegetables are in high demand, and amendments can greatly reduce dependency on chemical supplementation without compromising yield or quality.

A Case Study on Impact of Hospital Landscape on Well Being of Patients

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The hospital environment plays a crucial role in shaping the well-being of patients, influencing their physical and psychological experiences during the healing process. This research delves into the multifaceted aspects of the hospital landscape and its profound effects on patient well-being. The study encompasses an interdisciplinary approach, examining the physical, psychological, and cultural dimensions of hospital design. It investigates the influence of the physical environment, including layout, green spaces, and exposure to natural elements, on patient stress levels and recovery outcomes. The role of ambient noise, privacy considerations, and the integration of art and aesthetics in hospital spaces are explored to understand their impact on patient mood and satisfaction. Moreover, this research evaluated innovative approaches such as therapeutic gardens, outdoor spaces, and technological interventions, aiming to increase the overall well-being of patients. By considering cultural differences and psychological factors, this study seeks to uncover how the hospital landscape can be tailored to meet diverse patient needs, fostering a healing environment that resonates with individual preferences. The study incorporates qualitative and quantitative methods, including patient surveys and interviews, to gain valuable insights into the subjective experiences of individuals within hospital settings. Our findings contribute to the growing body of knowledge in healthcare design, providing practical recommendations for creating patient-centered environments that positively influence well-being. This research provides not only a theoretical exploration but also a practical guide for healthcare practitioners, architects, and policymakers seeking to optimize the hospital landscape for the benefit of patients. As we navigate the challenges of modern healthcare, understanding and improving the hospital environment becomes paramount in fostering a holistic approach to patient care.

Exploring Diverse Software Applications for Landscape Design and Modeling

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Landscape architecture involves aspects such as planning, designing, managing, and maintaining constructed and natural surroundings. Owing to their unique abilities, landscape architects seek to increase the comfort of both people and the environment in all communities. The introduction of software in the landscape design field provided a blessing, which not only minimized the workload for an architect but also assisted followers in visualizing the scape before its completion. It assists in identifying potential issues and optimizing the design for better functionality and aesthetics. 3D software helps with editing, such as deleting or adding, in a design replication of the elements. CAD applications include AutoCAD and Vector Works, which enable designers to generate accurate 2D and 3D representations of landscapes, facilitating efficient visualization. In addition, software such as Lumion renders the design and provides a virtual image of the project. This paper emphasizes the importance of landscape modeling assisted by different 2D and 3D software, their expanding trend in daily life, and the comparison of 2D and 3D software. AI-based interventions are further developed into real-time concepts and detailed modulations.

Impact of Gamma Rays on Vegetative and Floral Characters of Hemp (*Cannabis sativa*)

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The agricultural sector is vital to the economic growth and sustainability of a country. To address the increasing demands of human survival, the cultivation of multifunctional crops such as hemp may be a feasible choice. Hemp (*Cannabis sativa*) is an annual, C3 herbaceous plant of the Cannabaceae family that is grown mainly for seeds, fibers, and CBD. In the global economy, demand for its products is rising rapidly. Pakistan's nonnarcotic hemp variants have not been extensively documented. The present study was designed to investigate radiation mutation opportunities for the improvement of phenotypic and floral traits and to standardize the cannabis radiation protocol. Research was conducted at the Plant Propagation Unit, Dept. of Horticulture, PMAS-AAUR, to evaluate the effects of gamma rays at various doses (150 Gy, 300 Gy, 450 Gy, and 600 Gy) on both dry and soaked cannabis seeds. Different morphological and

physiological traits of the irradiated plants were assessed for stability and mutation induction. Remarkably, the findings revealed a noteworthy trend in which lower doses provided optimal responses, demonstrating the careful balance needed for gamma-ray exposure. Moreover, a comparative analysis of soaked and dry irradiated seeds highlighted the superiority of dry seeds. In the present study, approximately 16 mutants were isolated on the basis of their stability and significant phenotypic variation from the parent plant. This study provides vital insights into the broader understanding of the influence of gamma rays on *Cannabis sativa*, shedding light on dose-specific effects in addition to the essential interaction between seed conditions and irradiation efficacy. These findings expand our understanding of the response of hemp plants to gamma radiation and have implications for optimizing cultivation practices for Cannabis. This work lays the foundation for a more sophisticated approach to gamma mutation induction in *Cannabis sativa* with the potential to produce novel strains with enhanced vegetative and floral traits.

Influence of Plant Extracts as Edible Coatings on Quality of Sweet Cherry

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Sweet cherry is a highly nutritious fruit containing high concentrations of bioactive compounds and minerals, including calcium, phosphorous, potassium, and magnesium; therefore, unsurprisingly, cherry consumption has a positive impact on health. Sweet cherries are highly perishable, nonclimacteric fruits with a shelf life of 7–14 d in cold storage, so unfortunately, they deteriorate rapidly after harvest because of their very short shelf life and do not reach the optimal quality after transport and marketing. Therefore, to maintain the quality of sweet cherry prestorage, different plant extracts, such as moringa leaf extract and pomegranate peel extract, are needed, as they are natural plant extracts that can be used as edible coatings on fruits, which are becoming popular worldwide. Owing to the presence of a large amount of anthocyanin and antioxidant compounds, these plant extracts contribute to preserving fruit quality, and they are environmentally friendly alternatives applied as edible coatings on fruits to reduce decay and prolong shelf-life. Moringa leaf coating presented overall positive results, as it improved the overall antioxidant activity of sweet cherries without having negative effects on the content of bioactive compounds or even on the sensory profile of cherry fruit, which might indicate that its use could be an effective and safe approach for preserving the quality of sweet cherries.

Beneficial Effect of Olive on Disease Prevention

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A good diet containing table olives and olive oil is of great value to human health, as they act as a warrior against many major diseases. Olives have significant protective effects against coronary heart disease and cancer. Olives are awarded top health benefits, including their richness in antioxidants, because of their high quantity of polyphenols and anti-inflammatory agents, as well as their high level of monounsaturated fatty acids. They are also a good source of phytochemicals, an integral ingredient of the Mediterranean diet, and are largely consumed worldwide. A diet rich in olives is associated with a high percentage of gastric ulcers and reduces the risk of blood cancer, colorectum, cholelithiasis, and many other diseases. Olive oil is recommended for cardiac patients because it has a low level of oleanolic acid and is 80% monosaturated. Owing to the presence of vitamins, they increase the immune system of the human body while assisting in the prevention of diseases. Table olives and olive oil are highly effective against diseases such as cancer, asthma, diabetes, obesity, and cardiovascular diseases, along with their high nutritional importance.

The Smart Revolution in Horticulture against Climate Change

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Climate-smart horticulture is an innovative approach to agriculture that aims to address the challenges posed by climate change. By integrating advanced technologies, resilient crop varieties, and adaptive management practices, this approach optimizes resource utilization in the face of changing climatic conditions. Precision agriculture, which uses sensor-based irrigation and data-driven decision-making, enhances water-use efficiency to mitigate the impact of water scarcity on horticultural production. The adoption of climate-resilient crop varieties and agroecological principles strengthens crop resilience, ensures food security, promotes biodiversity, and enhances ecosystem health. In addition to these environmental

benefits, climate-smart horticulture also fosters economic resilience through crop diversification and income stream expansion. By providing farmers with climate information services, they can make informed decisions, allocate resources effectively, and minimize the risks associated with climate variability. Given the significant role of agriculture in greenhouse gas emissions and climate change, horticultural crops play a vital role in countering these negative consequences. However, the physiological response of horticultural crops to climate change, such as a shortened growing period resulting in reduced fruit and vegetable production, poses challenges. Therefore, location-specific and knowledge-intensive approaches are necessary to improve production under challenging conditions. Crop-based adaptation strategies tailored to crop nature, sensitivity, and agroecological regions are crucial. Furthermore, assessing the carbon sink potential of different horticultural crops compared with annual field crops can inform strategies to address climate change-related issues. Overall, widespread adoption of climate-smart practices is urgently needed to ensure a sustainable, resilient, and productive horticultural sector.

Global Crops Trends of Potato under Climate Change Impact and Future of Potato in Pakistan

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Potato is an important crop worldwide, with an estimated production of approximately 360 million metric tonnes and an estimated increase of approximately 20% since 1990. Asia contributes the most to production (51.4%), followed by Europe (28.7%), North America (7%), Africa (7%), South America (4.8%) and others (1.3%). Global production is skewed toward the northern part of the globe, with approximately 50% of potato production area globally having a temperate climate with a neutral to long photoperiod. China is leading in potato production, followed by India, Russia, Ukraine and the USA. Owing to climate change, the concentration of carbon dioxide has increased from 290 to 380 ppm during the last few decades, which, along with other climatic features, has variable effects on potato crops in different production areas. Southern Europe has experienced shorter winters with less water availability than usual, which has curtailed potato production. However, climate change should reduce the number of frosty days and increase the number of growing seasons in northern Europe. Potato production is predicted to improve in temperate climates, i.e., summer crops, provided that suitable varieties and irrigation sources are available, either in the form of precipitation or underground water. There is a possibility of increasing potato production in northern Pakistan because of the increasing growing period provided that water is available for irrigation. Delayed sowing due to high summer temperatures during September–October and heavy frost during December–January shortens the potato growing period, which demands mitigation strategies for high temperatures on one side and frost tolerance induction on the other side. Moreover, erratic rainfall patterns in Europe have severely hampered potato seed crops, which has caused delays in early-generation seed multiplication in Pakistan. Other problems impeding potato production include saline soils, drought and a narrow range of varieties, which can further reduce potato yield. There is a need to breed short-season varieties, particularly wild potato relatives, which have both biotic and abiotic tolerance traits. Moreover, some shotgun approaches can be utilized to avoid complete crop failure, including the use of biostimulants, potash application, plant growth-promoting bacteria and long-term water stress memory approaches.

Assessment of the Impact of Heavy Metals on Seed Germination and Growth Attributes of *Brassica oleracea* L.

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This study was conducted to examine the effects of zinc and copper on the germination and early growth of seeds of *Brassica oleracea* L. Copper and zinc were employed as sulphate solutions at four different concentrations: 20 mg/L, 40 mg/L, 60 mg/L, and 80 mg/L for copper and 200 mg/L, 400 mg/L, 600 mg/L, and 800 mg/L for zinc. We analyzed the following indicators: the germination success rate, the average germination time, the root length, the hypocotyl length (the section of the plant stem below the cotyledons), and the tolerance index. The study findings indicated that there were slight variations in the percentage of germination, with only a few insignificant deviations, as well as in the average time it took for germination to occur. Nevertheless, there was a significant delay in the development of both the roots and the hypocotyl. Furthermore, there was a decline in the tolerance index. The roots sustained a more significant level of impact than did the hypocotyl.

Phytoextraction of Arsenic from the Soil Using Ornamental Plants

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Heavy metal toxicity in soil has detrimental consequences for both plant and human health. They are introduced into the soil by a variety of methods, including smelting, coal burning, and excessive use of fertilizers, sewage sludge, and pesticides, among others. Arsenic is an important heavy metal, yet its relatively high concentrations cause various morphological, biochemical, and physiological problems in plants. Ornamental plants are utilized for aesthetic purposes and could be investigated for heavy metal phytoremediation in soil. Therefore, the present study investigated the phytoremediation capacity of snapdragon (*Antirrhinum majus*), stock (*Mathiola incana*), and gladiolus (*Gladiolus grandiflorus*) against various levels of arsenic in the soil via a CRD two-factor factorial design. The morphological (fresh weight, dry weight and length of both shoots and roots), physiological (stomatal and substomatal conductance, transpiration rate, net photosynthetic rate, and water use efficiency), water relationship (relative water content), membrane stability index, pigments (total chlorophyll content), antioxidative enzymes (catalase, peroxidase, and superoxide dismutase), oxidative enzymes (H_2O_2 and MDA), and phytoremediation efficiency were recorded. The results demonstrated that a relatively high arsenic dose (12 mg/kg) significantly reduced the morphological, physiological and biochemical attributes of all the crops. Moreover, all three crops significantly affected the phytoextraction of As from the soil. Therefore, seasonal ornamental plants could be used for the phytoextraction of arsenic from the soil.

Postharvest Oxalic Acid Dipping Treatment Maintained the Quality of Persimmon by Delaying the Fruit Ripening

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Persimmon (*Diospyros kaki* L.) is a climacteric fruit that contains abundant flavonoids, antioxidants, tannins and sugars. When a fruit reaches the ripening stage, the pulp becomes very soft, and its quality deteriorates, limiting its shelf-life. The restricted shelf life of persimmons due to pulp softness is a major handicap for transportation to distant markets. The objective of this study was to increase shelf-life and maintain quality by delaying ripening, which is generally regarded as safe (GRAS). For this purpose, fresh fruits were harvested at the color-break stage and shifted from the field to the laboratory. After initial sorting and grading, the uniformly sized fruits were treated with either water (control) or oxalic acid (5 mM) by dipping for 2–3 minutes. The fruits were dried at ambient temperature followed by storage at 4±1°C and a relative humidity of 80–85% to evaluate their shelf life for four weeks. The fruits

were evaluated for weight loss, firmness, color, overall visual quality, and total soluble solids. Compared with untreated fruits, oxalic acid-treated fruits presented reduced weight loss, total soluble solids and loss of firmness. On the other hand, untreated fruits presented relatively high levels of total soluble solids and early signs of color change, which led to early induction of fruit softness. The overall visual quality of the untreated fruit was restricted for 20 d, whereas the ripening of the oxalic acid-treated fruits was delayed for an extended storage period of 28 d. Finally, compared with the control, the postharvest oxalic acid treatment can potentially maintain quality.

Anatomical Modification in *Ziziphus* Species from the Faisalabad Region

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Rhamnaceae is one of the largest families, and Ziziphus is a genus of approximately 40 species of small trees and prickly shrubs found in subtropical and warm-temperate areas around the world. Different samples of *Ziziphus nummularia* and *Ziziphus jujuba* were collected from different regions of Faisalabad to evaluate their ability to adapt to abiotic stress tolerance. The double-staining technique was used for the preparation of permanent slides, which were examined under a microscope, and photographs of the slides were taken with a digital camera. This study provides information about the anatomical parameters of *Ziziphus nummularia* and *Ziziphus jujuba*. As different environmental conditions have different consequences that may be beneficial or harmful, the significant recorded anatomical changes included an increase in epidermal thickness. In the leaves, the metaxylem area increased in diameter due to different environmental conditions. The phloem area also increased in diameter due to different environmental conditions in both *Ziziphus* spp. In comparison with both *Ziziphus* spp., the maximum metaxylem area and phloem area were shown in *Ziziphus nummularia,* and the minimum was shown in *Ziziphus jujuba*. Stomatal density was greater on the lower side than on the upper side in both *Ziziphus* spp. This study provides information about the anatomy of *Ziziphus nummularia* and *Ziziphus jujuba*.

Effect of Different Drying Methods on Tomato Flakes Production

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Tomato (*Lycopersicum esculentum*) is a healthy source of nutrients such as fibers, proteins, vitamins, lycopene and other antioxidants. Drying is a commonly applied method to preserve tomatoes and process them into powders that can be incorporated into, for example, soups and sauces. Tomatoes are valuable highly perishable agricultural products that are dried on a large scale to extend shelf-life. The dried forms serve as raw materials for different commercial products and as ingredients for functional foods. It is also used all over the world for direct consumption. A study was carried out to determine the effects of different drying methods on tomato flake production. Two different drying methods (T_1) or oven+ (T_2) drying methods) were used, with two replications. The effects of different drying methods on tomato flakes were analyzed by determining the pH, moisture percentage, vitamin C content, total acidity, total phenolic content, total flavonoid content, DPPH content, total protein content, total sugars, reducing sugars, carotenoid content, anthocyanin content, lycopene content, fat percentage, fiber content, total soluble solids, total plate count, color analysis, and contents of minerals such as Na, Mg, k, Fe, Zn, and Cu. Both drying methods—the oven and the Sundry method—had significant effects on the color of the tomatoes after drying. The results revealed that high pH, moisture content, vitamin C content, TPC, TFC, DPPH content, total protein content, carotenoid content, anthocyanin content, color and lycopene content significantly affected T2. The fiber or fat content; total soluble solids; Fe, Zn, K and Cu contents; total plate count; and total acidity were not significantly affected. Overall, the T_2 treatment had better results than did the T1 treatment.

Salicylic Acid Dipping Treatment Extended the Post-Harvest Shelf Life of Persimmon

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Persimmon is admired due to its unique delicious taste and rich source of sugars, antioxidants, vitamins and tannins. However, soon after color breaks, the pulp becomes soft; consequently, it does not meet the quality standards of the consumer. The immediate loss of firmness as fruit ripens is a major handicap for its distribution to distant markets due to restricted shelf life. The objective of this study was to increase the shelf-life of persimmon by using salicylic acid. The fruits were harvested at the physiological mature stage and shifted to the postharvest laboratory. After initial sorting and grading, the whole lots were divided into two groups. One group was treated with distilled water (control), and the other was dipped in freshly prepared salicylic acid solution (2%) for 5 minutes. After ambient drying, the fruits were stored at 4±1°C with a relative humidity of 80–85% for 28 d. After every seven days, analysis was performed for soluble solid contents, visual appearance, firmness, color and weight loss. The results indicated that, compared with untreated fruits, salicylic acid-treated fruits presented a superior visual appearance, reduced soluble solid content, and loss of firmness. Conversely, the untreated group presented a greater soluble solid content, weight loss, early color change, and diminished visual appearance after 21 d of storage. In conclusion, postharvest SA treatment can significantly increase the shelf-life of persimmon fruit.

Optimizing Strawberry Micropropagation Using Two Different Plant Growth Regulators and Silver Nitrate as Anti-contamination Agent

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Despite the importance of micropropagation in the rapid and efficient production of disease-free strawberry plants, challenges persist in achieving optimal protocols for the successful establishment of seedlings. The existing methods lack precision and fail to harness the synergistic effects of multiple plant growth regulators. Additionally, contamination poses a persistent threat to the success of micropropagation procedures. Therefore, there is a critical need for comprehensive investigations into the optimization of strawberry micropropagation protocols, specifically explorations of the combined effects of two distinct plant growth regulators and the incorporation of silver nitrate as an anticontamination agent. This study aimed to investigate the influence of $AgNO_3$ on the percentage of surviving strawberry achenes cv. Chandler and their successful *in vitro* shoot and root development. The addition of $AgNO_3$ to MS media (0–20 mg$^{/L}$) affected the contamination percentage and survival rates of strawberry achenes. After a two-week period, notably, a significant reduction in achene contamination (5.6%) occurred at 20 mg$^{/L}$, while the highest survival rate (94.5%) was achieved at 15 mg$^{/L}$. The second experiment consisted of standardizing the micropropagation protocols. Various

combinations of indole-3-butyric acid (IBA) and 6-benzylaminopurine (BAP) doses within the range of 0.5–2 mg/L were incorporated into MS media. The combination of 1 mg/L IBA and 2 mg/L BAP resulted in promising results in terms of early shoot initiation, average number of shoots, shoot length, leaf count, and shoot fresh weight. In subsequent experiments, various concentrations of IBA (0–2 $mg^{/L}$) were used to induce root growth in *in vitro*-raised shoots. The most favorable results were obtained with 2 mg/L IBA in terms of early root induction and fresh root weight. On the basis of the above findings, the optimum doses of $AgNO_3$ and IBA with BAP improved the survival rates and shoot and root development of strawberry.

In Vitro Genotypic Response of Cassava

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Cassava is an inexpensive and rich source of carbohydrates around the world. It has helped end the world's hunger and has provided satisfactory yields, even in poor soils. Cassava is typically propagated by seeds and cuttings, but this process is labor intensive. The poor cassava multiplication rate contributes to the sluggish spread of better varieties among growers. There is a need to introduce rapid and alternative propagation methods, such as tissue culture techniques, that might offer a solution to these problems. Therefore, the objective of this study was to assess the *in vitro* genotypic response of cassava (G_1, G_2, and G_3) to MS media supplemented with PGRs [M_o (control), M_1 (MS + 3 mg/L BAP), M_2 (MS + 3 mg/L BAP + 1.5 mg/L NAA), M_3 (MS + 3 mg/L BAP + 1.5 mg/L NAA + 2 mg/L GA_3) and M_4 (MS + 1.5 mg/L NAA)]. Among the cassava genotypes, G_3 presented the maximum number of roots (4.60) and internodal distance (6.00 cm) at M_4. The maximum root length (3.24 cm) was observed in G_1 at $M_{4,}$ whereas the maximum number of leaves per explant (2.80) was recorded at M_1. G_2 presented the maximum leaf area (0.90 cm^2) at M_2 and the maximum shoot length (9.30 cm) and leaf ratio (2.76) at M_1. However, compared with the control (Mo), G_1 resulted in maximum plantlet survival (100%) at M_3 and M_4. These findings revealed a distinct genotypic response of cassava to the modified MS medium. This finding highlights the intricate dynamics of the interaction between a plant's genetic composition and the growing conditions that influence its growth. This highlights the importance of analyzing and modifying PGR concentrations according to certain cassava genotypes to increase cassava multiplication for better cultivation and productivity.

Exogenous Application of Tea Tree Oil and Trunk Injection of Methyl Jasmonate to Mitigate the Effect of Citrus Greening in Citrus

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Citrus is a widely cultivated family around the globe and is very popular among people because of its heaven taste. Its nutritious nature and extraordinary aroma caught millions of hearts. However, in Pakistan, this family has experienced devastating pressure from citrus greening. Citrus greening disease, sometimes referred to as Huanglongbing (HLB), is a debilitating vector-borne illness. Its vector has been in existence since at least 1998, and by 2003, it had extensively expanded throughout the citrus-growing regions of Pakistan. It can affect all varieties of citrus. This study was conducted to determine the effects of the exogenous application of tea tree oil (TTO) and trunk injection of methyl jasmonate (MJ) to mitigate the effects of citrus greening disease on Citrus fruit, i.e., sweet orange (*Citrus sinensis*). Sweet orange plants affected by citrus greening disease were selected and treated with TTO and MJ in the T_0, T_1, T_2 and T_3 treatment groups. In the control group (T_0), the plants were sprayed with distilled water, while those in T_1, T_2 and T_3 were sprayed with 3% TTO (spray), 1.5 µM MJ (injection), or the combination (3% TTO+1.5 µM MJ), respectively. Each treatment group included three replications. Different morphological parameters, such as fruit weight (g), decay weight (%), peel weight (g), juice weight (g), pulp weight (g), firmness (kg cm^{-2}), fruit size (cm), disease incidence (%) and biochemical parameters, such as ascorbic acid (100 mg^{1}), reducing sugars (%), nonreducing sugars (%), TSS (°Brix), TA (%), sugars (%), total sugars (%), sensory evaluation and phenolics (mg/g), were analyzed at the Postharvest Lab of Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. The results were satisfactory, as all the treatments other than the control lowered the intensity of the disease on the fruit as well as the plant. The maximum effects were recorded in the plants treated with T_3, whereas the minimum effects were recorded in the control plants. The results of T_1 and T_2 were also satisfactory. This research is successful and helps reduce the effect of citrus greening on citrus fruits; furthermore, it enhances the yield, taste and quality of orange.

Effect of Cerium on seed germination and seedling growth of okra (A*belmoschus esculentus*)

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Okra has global importance as a nutritious vegetable containing vitamins A, C, and K; protein; and fiber, with potential health benefits. Rare earth elements, such as cerium (Ce), play a role in the seed germination and seedling growth of vegetables. Cerium oxide nanoparticles (CeO_2-NPs) have been studied for their potential role in plant seed germination and stress suppression. This study used three concentrations of CeO2-NPs, viz. 2 µM, 4 µM, and 6 µM for seed priming and foliar applications. Seeds of okra were treated with distilled water in the control treatment. The results indicated that ascorbic peroxidase (APX), catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), malondialdehyde (MDA), the fresh weight of foliage, and the fresh weight of roots were significantly affected by the addition of 4 µM CeO_2-NPs. Hence, 4 µM CeO_2-NPs was the optimum treatment for increasing the seed germination rate and seedling growth. In conclusion, cerium treatments can improve the seed germination rate and seedling growth of okra. However, more research is needed to fully understand the mechanisms underlying the effects of cerium on okra seed germination.

Effect of Different Soil Amendments on Growth and Yield of Cabbage

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Soil amendments are generally used to improve conditions for plant growth; these include organic matter such as biochar, leaf manure, farmyard manure, and inoculum of beneficial microbes. Cabbage is a vital vegetable rich in essential nutrients and vitamins with potential health benefits due to its anti-inflammatory and antioxidant properties. Different soil amendments are used to increase the growth and yield of cabbage. In this study, we used biochar, leaf manure, farmyard manure, and an accelerator to observe their effects on the growth and yield of cabbage. The results indicated that biochar significantly affected the plant height, root length, and total plant fresh weight of cabbage. Leaf manure significantly affected the above-ground fresh weight of cabbage. Farmyard manure significantly affected head fresh weight and head dry weight, and acceleration significantly affected root length. In conclusion, soil amendments significantly improve plant yield and can be used for sustainable production of leafy vegetables.

Effect of Pretreatments and Drying Methods on Nutritional Quality and Drying Characteristics of Oyster Mushroom

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Oyster mushrooms (*Pleurotus ostreatus*) offer various health benefits, including immune system support and potential cholesterol reduction. However, they are very perishable and can be preserved only if properly processed. Dehydration is an effective and traditional method of preservation to prevent spoilage. In this study, pretreatment with four ascorbic acid concentrations, viz. 0.2%, 0.4%, 0.6%, 0.8%, and two different drying techniques, viz. Sundrying and oven drying were carried out to preserve the oyster mushrooms. The results revealed that oven drying performed better than sun drying in terms of all the physiological, mineral, and proximate parameters except for the moisture content and browning index (which showed mixed results). The application of 0.8% ascorbic acid with oven drying caused the maximum increase in proximate (carbohydrate%, moisture content%, ash% and fat%), mineral, NPK, phenol, flavonoid, vitamin C, and sugar contents; the antioxidant capacity; the sensory profile (color, texture, and taste); and the physiological (browning index, rehydration ratio, percentage of mold-infested samples, fresh weight and dry weight) parameters of the mushrooms compared with those of the control and the other levels of ascorbic acid applied. Thus, appropriate ascorbic acid pretreatment can significantly improve drying characteristics by maintaining the high nutritional value of oyster mushrooms.

Salt Stress Mitigation of Chia with Foliar Application of Silicon

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Salinity, a substantial problem, especially in Pakistan's soils, decreases crop growth and yield by causing osmotic, ionic, and oxidative stresses. A pot trial was conducted from 2021 to 2023 to examine the combined effects of two salinity levels, viz. 50 mmol and 100 mmol, four different concentrations of silicon (Si), namely, 50 mg, 100 mg, 150 mg, and 200 mg, and a control level (0 mg), were used. The treatments were applied as a foliar spray to chia seeds (*Salvia hispanica* L.) to evaluate their growth, productivity, and chemical components. The findings demonstrated that measurements of vegetative growth were negatively correlated with

increasing salinity. There was a direct correlation between measurements of root, floral, and vegetative development and irrigation with saline water, such as plant height, fresh weight, and dry weight; blooming growth, such as the height of the primary inflorescence; and measurements of root growth, such as root length, root weight, and salinity treatments. The combination treatment of 50 mmol salt content and 200 mg silicon had the greatest effect on these parameters. In most cases, the combination treatment of 50 mmol salt content and 150 gm silicon resulted in the second highest value. In both seasons, the combined treatment involving a salt concentration of 50 mmol and 200 mg of silicon yielded the highest antioxidant enzyme contents. The highest salinity level of 100 mmol, particularly for those that received approximately 0 mg of silicon throughout both seasons, produced the lowest values of vegetative and chemical contents. In conclusion, growing *Salvia hispanica* L. plants under a salinity level of approximately 50 mmol saltwater and spraying them with 200 mg silicon is preferable because it results in the highest growth, productivity, and chemical content.

Post-harvest Quality Conservation of Banana Fruit with Biodegradable Edible Coating

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The development of antimicrobial edible coatings for food may benefit food safety and quality standards, prolong shelf-life, and minimize the number of packaging layers. It will also decrease the cost of the fruit as well as improve the logistical management of the fruit. Moreover, gel-based edible coating materials for fruits and vegetables have recently attracted increasing interest. The main aim of this study was to determine the effects of aloe vera gel coating on the quality of bananas in cold storage. In this study, the effects of dipping aloe vera gel at concentrations of 0%, 10%, 20%, and 30% on the quality of harvested bananas were examined over a 25-d period 'at 13 ± 1°C cold storage. It was found that 30% AVG significantly delayed the incidence of decay and suppressed physiological weight loss. Compared with the control, banana fruits treated with 30% AVG presented delayed ethylene and respiration peaks. Similarly, the 30% aloe vera gel coating resulted in greater flesh firmness, protopectin, cellulose, antioxidant enzyme activity (APX, CAT, SOD and POD enzyme activity) and hemicellulose concentrations as well as lower relative ion leakage, malondialdehyde, hydrogen peroxide, superoxide anion content, and water-soluble pectin contents due to the decreased activities of cellulase, pectin methylesterase, polygalacturonase, CX enzyme content and ß-galactosidase. It also maintained a relatively high hardness. Similarly, compared with those of the control, the postharvest application of the 30% AVG coating resulted in increased ascorbic

acid content, titratable acidity (TA), and a lower ripening index (TSS/TA ratio). In summary, 30% AVG may be the optimal coating concentration to prevent ripening and quick softening of harvested bananas maintained in cold storage.

Delay of Ripening in Harvested Banana Fruits with Exogenous Oligo Chitosan Coating

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The development of antimicrobial edible coatings for food may improve standards for food safety and quality, increase shelf life, and reduce the number of packaging layers. Additionally, it will lower the cost of the fruit and enhance its logistical management. In this study, the use of an oligo chitosan edible coating was investigated to extend the postharvest storage life and maintain the quality of harvested banana fruits. The experiment followed a completely randomized design and included 4 treatments: a control group and groups treated with 0.5%, 1%, or 2% oligo-chitosan. The banana fruits were stored in a cold storage facility at 13±1°C for a storage period of 25 d. Various parameters, including weight loss, ion leakage, malondialdehyde content, hydrogen peroxide levels, superoxide anion levels, respiration rate, ethylene production, total soluble solids, titrate acidity, ascorbic acid content, pH, ripening index, antioxidant enzyme activity, cellulase activity, ascorbic peroxidase activity, peroxidase activity, pectin methyl esterase activity, fruit firmness, protein content, polygalacturonate activity, cellulase activity, cellulose content, water-soluble pectin content, protopectin content, carotenoid content, and chlorophyll content, were examined at 5-d intervals. The results demonstrated that the 2% oligo-chitosan treatment resulted in a longer storage life than did the other coating concentrations and the noncoated group at the end of storage.

Effect of Gibberellic Acid on Growth, Yield, and Flowering Attributes of Snapdragon (*Antirrhinum majus L.*)

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Snapdragon (*Antirrhinum majus L.*) is a special cut flower in Pakistan, and the role of gibberellic acid in growth, productivity and quality is widely accepted. A field experiment was conducted to

evaluate the effects of different concentrations of gibberellic acid (50, 100 and 150 ppm) on the growth, yield, and flowering attributes of Antrihinum majus under Multan conditions. Plant growth regulators are a broad category of naturally occurring or synthetically manufactured organic compounds that are thought to be advantageous in the current climate for the growth of ornamental plants. The experiment was conducted according to the CRD, with four replicates. Data regarding vegetative and reproductive growth and yield parameters were collected and analyzed according to standard statistical techniques via Statistix software, and the means were analyzed via least significant difference (LSD) tests at the 5% significance level. All the growth and yield characteristics, including plant height (27 cm), number of branches (23.83), total leaf chlorophyll content (55.26 SPAD), stem diameter (2.45 mm), number of leaves (36.6), maximum leaf area (4.53), fresh shoot weight (23.83 g), dry shoot weight (7.69 g), fresh root weight (6.72 g), dry root weight (4.31 g), root length (55.14 cm), flower fresh weight (2.81 g), flower dry weight (2.22 g), flower diameter (37.41 mm), number of flowers (10.31) and days to flowering (160), were highly influenced by GA3@100 ppm priming +foliar application. Overall, the application of priming + foliar application of GA_3 @ 100 ppm significantly affected the growth and yield attributes. In conclusion, the application of gibberellic acid had a positive effect on vegetative and reproductive growth and improved the yield of snapdragon flowers. Therefore, the application of GA3 @ 100 ppm is recommended for better snapdragon production.

Evaluation of Zinnia and Vinca Plants Performance Using Zinc Sulphate as a Nutri-priming and Foliar Application

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Floriculture is a growing sector in Pakistan, with a high demand for cut flowers, seasonal flowers, and landscape plants in major cities. However, environmental stresses are a significant hurdle to the floriculture industry, affecting seed germination and flower production. A research trial was performed at the Department of Horticulture, Bahauddin Zakariya University Multan, Pakistan, from 2021--2023 to study the effects of nutri-priming with zinc sulfate ($ZnSO_4$) on the seed germination, growth quality, and vase life of two summer flowers, viz. Zinnia (*Zinnia elegans*) and Vinca (*Catharanthus roseus*). Three concentrations of $ZnSO_{4,}$ viz. Seeds (1 mM, 1.5 mM, and 2 mM) were used for nutri-priming over 24 hours. After the seedlings were transplanted, foliar treatments of the same concentrations at various intervals were applied. Seeds soaked in distilled water for 34 hours were considered the control treatment. The results revealed that the seeds of Vinca treated with 1 mM $ZnSO_4$ presented the

greatest degree of germination, and the seeds of Zinnia treated with 2 mM $ZnSO_4$ presented the greatest degree of germination. Moreover, foliar application of $ZnSO_4$ significantly increased the plant growth, yield, and number of flowers, shoot, and root weight of Vinca and Zinnia and can potentially mitigate environmental stresses.

Mitigation of Salt Stress with Foliar Application of Potassium on Lettuce (*Lactuca sativa*)

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Floriculture is a growing sector in Pakistan, with a high demand for cut flowers, seasonal flowers, and landscape plants in major cities. However, environmental stresses are a significant hurdle to the floriculture industry, affecting seed germination and flower production. A research trial was performed at the Department of Horticulture, Bahauddin Zakariya University Multan, Pakistan, from 2021--2023 to study the effects of nutri-priming with zinc sulfate (ZnSO4) on the seed germination, growth quality, and vase life of two summer flowers, viz. Zinnia (*Zinnia elegans*) and Vinca (*Catharanthus roseus*). Three concentrations of ZnSO4, viz. Seeds (1 mM, 1.5 mM, and 2 mM) were used for nutri-priming over 24 hours. After the seedlings were transplanted, foliar treatments of the same concentrations at various intervals were applied. Seeds soaked in distilled water for 24 h were considered the control treatment. The results revealed that the seeds of Vinca treated with 1 mM ZnSO4 presented the greatest degree of germination, and the seeds of Zinnia treated with 2 mM ZnSO4 presented the greatest degree of germination. Moreover, foliar application of ZnSO4 significantly increased the plant growth, yield, and number of flowers, shoot, and root weight of Vinca and Zinnia and can potentially mitigate environmental stresses.

Non-Thermal Processing Postharvest Technologies to Enhance Shelf Life of Citrus Fruit

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Citrus is one of the major fruit crop species worldwide and is grown in more than 140 countries worldwide. Quality losses in citrus produce throughout the postharvest phase are often due to the inappropriate use of preservation technologies and the loss of quality due to ripening and senescence processes, which are often associated with the development of spoilage microorganisms and other undesirable phenomena, which must be controlled to preserve the quality and increase the shelf-life of the product during storage. Furthermore, high water activity and the presence of nutritional factors associated with these matrices can also favor the growth of pathogens. Citrus fruits with better sensory and nutritional attributes have relevant economic value. Consequently, inadequate preservation practices, in addition to causing important losses in nutritional and quality characteristics, can have a detrimental economic impact throughout the entire supply chain, from growers to consumers. The conventional methods (sensory evaluations and analytical methods) used to evaluate citrus fruit quality are destructive, time-consuming and cost-intensive. Moreover, these techniques are not suitable for in-line applications in industrial or market settings to provide real-time information to consumers on the quality of the product at hand. Among the emerging technologies, contactless and nondestructive techniques for quality monitoring present numerous advantages over traditional, destructive methods such as nanotechnology, edible coatings, cold plasma treatment, ozone treatment, smart packaging, ultrasound technology, high-pressure processing (HPP), image analysis, electronic noses, and near-infrared spectroscopy. Intelligent packaging can include indicators, sensors, RFID tags, QR codes, or smart labels that can provide information such as temperature, pH, gas composition, microbial load, ripeness, freshness, shelf life, origin, or traceability of food. Intelligent packaging can help advanced postharvest and biocontrol techniques preserve the high nutritional value and safety of fresh citrus produce after harvesting.

Optimization of Indigenous Soilless Substrate for High-Quality Cut Flower Production of *Celosia argentea* in Punjab, Pakistan

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Celosia (*Celosia argentea*), a member of the family Amaranthacea, is a summer annual that is cultivated in open fields or high tunnels. Celosia is used for both fresh and dry arrangements. A study was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2023--24 to optimize indigenous soilless substrates to produce high-quality cut celosia. There were ten treatments in this experiment: control (soil + silt + farmyard manure, 1:1:1; v/v/v), sugarcane bagasse + composted peanut hulls + sugarcane pressmud

(50:30:20; v/v/v), UAF Gro + coco-coir (50:50; v/v), sugarcane bagasse + rice hull ash + sugarcane pressmud (50:30:20; v/v/v), coco-coir + rice hulls ash + sugarcane pressmud (50:30:20; v/v/v), sugarcane bagasse + composted peanut hulls + composted farmyard manure (50:30:20; v/v/v), coco-coir + composted peanthulls + sugarcane pressmud (50:30:20; v/v/v) and sugarcane bagasse + coco-coir + composted farmyard manure (50:30:20; v/v/v). The experiment was carried out according to a randomized complete block design (RCBD) with three replications of 18 plants each, and treatments were applied to lily crates 45×60 cm in size. The following data were collected: plant height, flower quality, leaf area, total chlorophyll content, survival percentage, production time, flower diameter and stem diameter. The results revealed that the tallest plants (35.8 cm) with the greatest flower diameter (6.6 cm) were those growing in sugarcane bagasse + composted peanut hulls + sugarcane pressmud (50:30:20; v/v/v). The largest leaf area (12.1 cm2) along with the highest leaf total chlorophyll content (60.6 SPAD), greatest stem diameter (4.4 mm) and best flower quality (7.8) were recorded for the plants growing in sugarcane bagasse + composted peanut hulls + sugarcane pressmud. Similarly, the highest production time (44.4 d) was recorded for plants grown in sugarcane bagasse + coco-coir + composted farmyard manure (50:30:20; v/v/v). The shortest plant height (9.3 cm) and flower diameter (3.1 cm), minimum leaf chlorophyll content (38.5 SPAD), smallest leaf area (5.1 cm2) and shortest production time (47.6 d) were recorded for the plants in the control treatment (soil + silt + FYM). In summary, the substrate compositions (sugarcane bagasse + composted peanut hulls + sugarcane pressmud, 50:30:20; v/v/v) and (sugarcane bagasse + coco-coir + composted farmyard manure 50:30:20; v/v/v) were the best and may be used instead of peatmoss or any other expensive imported soilless substrate for the production of the best quality cut celosia.

Effect of Foliar Application of Silicon and Seaweed Extract on Growth and Productivity of Chinese Cabbage

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Chinese cabbage (*Brassica rapa* L.) is a leafy vegetable crop that has major economic importance in many countries. The problem of increasing production via synthetic fertilizers, i.e., urea, DAP, etc., is hazardous for humans, soil, and the environment. A possible solution would be the use of organic fertilizer to increase Chinese cabbage production. To address this issue, seaweed extract and silicon are used to increase the growth and yield of Chinese cabbage. A field experiment was conducted to investigate the effects of foliar application of silicon and seaweed extracts on the productivity and quality of fine Chinese cabbage (*Brassica rapa*). This research was carried out in a randomized complete block design (RCBD) with four

replications. Foliar applications of seaweed extract aqueous solution were used as treatments comprising T0 (control), T1 (1%), T2 (2%), T3 (1 mmol/L), and T4 (2 mmol/L) silicon solutions. The other combined solutions included T5 (1% seaweed extract + 1 mmol/L silicon), T6 (1% seaweed extract + 2 mmol/L silicon), T7 (2% seaweed extract + 1 mmol/L silicon) and T8 (2% seaweed extract + 2 mmol/L silicon). The data from the field and laboratory analyses (quality parameters) were recorded according to standard procedures. The results revealed that the combined effect of seaweed extract and silicon improved these attributes. The plant height, leaf length, leaf width, number of leaves and chlorophyll content significantly increased with the combined application of 2% seaweed extract + 1 mmol/L silicon. The 2% seaweed extract + 2 mmol/L silicon mixture also produced the maximum carotenoid content, root fresh weight and root dry weight. The minimum results were obtained from T0 (control). Hence, seaweed extract and silicon are useful growth promoters, have considerable effects on the growth and development of Chinese cabbage, and are thus recommended to produce Chinese cabbage crops.

Postharvest Application of Edible Coating to Improve the Shelf Life and Quality of Cucumber (*Cucumis sativus* L.)

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The cucumber (*Cucumis sativus L.*) is an important plant worldwide, the fruit of which can be used fresh or cooked in many countries. Owing to the perishable nature of cucumber, edible coating is a simple and inexpensive concept for extending the postharvest life of cucumber. The use of edible films and coatings is an environmentally friendly natural method to increase the postharvest storage life of fresh fruits and vegetables. To address this issue, an edible coating is used to increase the postharvest life of cucumber. An experiment was conducted to observe the effects of almond and Arabic gum. This experiment was carried out in a completely randomized design (CRD) with three treatments and three replications, each consisting of nine fruits. The treatments were T_0 (control), T_1 (10% Arabic gum), and T_2 (10% almong gum), and the data were taken at intervals of 5 d up to 15 d. The obtained results showed that almond gum improved the attributes. On the 15th day, color; texture; and the activities of SOD, POD, CAT, protein and proline significantly increased with the application of 10% almond gum. The results of T_1 (10% Arabic gum) were also predominantly improved. The minimum results were obtained from T_0 (control). Hence, surface coatings of edible gum are useful and have a considerable effect on the postharvest life of cucumber.

Metabolic Study of Carbohydrates of Pak choi (*Brassica rapa ssp. chinensis*) and Health Benefits

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Chinese Pak choi (*Brassica rapa ssp. chinensis*) is a vegetable with a loose head of leaves that mainly originates from China and has substantial economic and nutritional value. Our study focused mainly on nutrition, morphology, and physiology, which can all be affected by metabolites. Therefore, studying a metabolic profile is important for comprehending these many processes. The 24 groupings contained 513 metabolites categorized by comprehensive metabolome technology. Organic acids, flavonoids, anthocyanins, and carbohydrates are noteworthy primary and secondary metabolites. The outcomes of the analysis of the sixteen carbohydrate compounds were primarily composed of mono-, dis-, and polysaccharides. Phenology greatly influences the profiling of metabolites, as the carbohydrate cultivars with the greatest contribution are Xiangqingcai (6%), Aijiaohuang (8%), Ziluolan (9%), Wutacai (13%), Yellow Rose (20%), Zicaitai (21%), and Suzhouqing (23%) in ascending order, and most quantitative differences are observed in Xiangqingcai, Suzhouqing and Aijiaohuang. The specific carbohydrate content in pak choi and its effects on and implications for human health must be completely understood. Thus, this study aimed to investigate how carbohydrates are metabolized in various pak choi cultivars and how they are related to other metabolites, which may impact the potential health benefits of these plants.

Optimizing Nutritional Regimes and Postharvest Preservatives for Amaranthus

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Amaranthus (*Amaranthus cruentus L.*), a member of the family Amaranthaceae, is a type of foliage that is beautiful because its vibrant foliage surpasses its blooms, thereby increasing its appeal in large arrangements. Its high-quality cut stem production and postharvest longevity are pivotal for its use in floral arrangements. However, limited literature is available regarding its nutritional requirements and postharvest preservatives to maintain quality and extend vase life under local conditions. Therefore, a study was conducted at the Floriculture Research Area,

Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, during 2023 to develop tailored nutritional regimes and optimal postharvest preservatives to increase postharvest longevity. The first field experiment was conducted in a randomized complete block design (RCBD) with three replications of 20 plants each. The treatments included no nutrient application (control), N @ 50 kg ha^{-1}, NPK @ 50:25:25 kg ha^{-1}, NPK @ 50:25:25 kg ha^{-1} + micronutrients, *viz*., Zn, Fe, and B @ 1% each, NPK @ 50:25:25 kg ha^{-1} + isabion @ 0.4% and NPK @ 50:25:25 kg ha^{-1} + humic acid @ 0.4%. The application of NPK (50:25:25) + micronutrients (Zn, Fe and B) @ 1% resulted in a peak plant height of 97.27 cm and a leaf area of 64.2 cm^2. This treatment resulted in superior quality stems (8.6), the highest fresh weight (361.6 g), the longest vase life (5.5 d) and a leaf total chlorophyll content of 69.09 SPAD. In contrast, NPK (50:25:25) + 0.4% isabion yielded the highest dry weight (58.83 g) and a greater number of marketable stems per plant (5). Additionally, two postharvest experiments were conducted on Amaranthus, which included pulsing and vase solutions, to extend its vase life. The stems were grown at the Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, following standard procedures. The stems were harvested before 09:00 AM via sharp secateurs and promptly transported to the commercial floriculture laboratory (IHS, UAF) within two hours of harvest. Both experiments were performed individually in a completely randomized design (CRD) consisting of five replicates of two stems each. The results indicated that stems pulsed with a solution containing 2% sucrose, 100 mg/L gibberellic acid (GA), 100 mg/L 6-benzylamino purine (BA) and 300 mg/L citric acid presented the longest vase life (7.5 d), highest quality (8.1) and significant changes in fresh weight (25.5 g). With respect to the vase solutions, distilled water + 7 UP (66:33) was the most effective, resulting in the longest vase life (8.3 d), highest stem quality (9) and the most significant water uptake (150 ml). Chrysal showed the most significant pH change (1.4). In summary, optimal field results were achieved with NPK @ 50:25:25 kg ha^{-1} + micronutrients, followed by NPK @ 50:25:25 kg ha^{-1} + isabion @ 0.4%. For postharvest care, pulse stems were incubated overnight with 2% sucrose + 100 mg L^{-1} GA + 100 mg L^{-1} BA + 300 mg $L^{-1\ \text{citric acid}}$. Distilled water + 7 Up (2:1) was the optimal vase preservative for the longest vase life and maintenance of cut stem quality.

Fresh Flower Shop Business: Case Study of Flower Market, Islamabad

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The flower business in Pakistan is gaining importance because of its increasing demand in the consumer market for its wide use as cut flowers and for car and event decorations at social, cultural, and religious festivals such as weddings, birthdays, and eid celebrations. The trend is most popular in large cities where different flower retail centers have emerged. One such floral market in Islamabad was surveyed to analyze the flower business. Flowers were brought from different cities, such as Pattoki, Lahore, Mansehra, Peshawar, and Hyderabad, while also being imported from countries such as Kenya and Dubai. Locally produced flowers include roses, jasmine, gladiolus, tulip, and sunflower, whereas imported flowers include gerbera, lily, tuberose, and daisy. The price per stick varied between Rs. 10-30 for roses, Rs. 40-80 for gladiolus, Rs. 15−30 for lilies, and Rs. 100--150 for sunflowers. Bouquets were sold at a price range of Rs. 1000−3500, in which fillers such as statice and baby's breath were also used. Other aspects of the business were also analyzed. The lack of refrigerated transport facilities is a major issue in the postharvest value chain of flowers. Local vehicles and sometimes even passenger buses, which do not maintain the freshness of flowers and cause quality loss, are used for the transport of these flowers. These flowers often accumulate during storage and transport without protective or specific packaging to prevent mechanical damage to the flowers. The business is also affected by sociopolitical instability and unrest where the supply chain is disrupted and sales decline. The flower enterprise provides a lucrative opportunity for horticulture graduates to enter the business and scale it to more professional standards. It can potentially create employment opportunities and benefit the economy of the country.

Effect of Different Concentrations of Indole Butyric Acid for Root Development on Rose (*Rosa indica*) Cuttings

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Rose is the best-known and most popular garden flower throughout the world. Propagation through cuttings is the simplest way to increase desirable rose cultivars, but the success rate is limited to many types because of failure in terms of root formation. Different growth regulators are currently in use to promote the rooting of many ornamental plants. This study aimed to evaluate the effects of growth regulators (IBA at 1000, 1500, and 200 ppm) on the rooting of rose cuttings. A field experiment was planned according to a randomized complete block design with four treatments and three replications. The treatments, viz. T0 = control (distilled water), T_1 = IBA 1000 ppm, T_2 = IBA 1500 ppm, and T_3 = IBA 2000 ppm were applied, and 15 cuttings per treatment were evaluated. The main effect of IBA was significant for the majority of rooting characteristics. The results revealed that, compared with the control, the 1500 ppm concentration of indole butyric acid significantly affected the studied parameters. Among the different concentrations of IBA, 1500 ppm had the greatest effect on bud sprouting, the number of buds, the number of days taken for bud emergence, the number of branches, the length of the roots, and the dry weight of the roots. The shoot length, shoot fresh weight, shoot

dry weight and number of leaves also increased with the application of 1500 ppm IBA. These findings suggest that IBA may promote the rooting of rose cuttings and sustainable production.

Comprehensive Genomic Exploration of Class III Peroxidase Genes in Guava Unravels Physiology, Evolution, and Postharvest Storage Responses

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Peroxidases (PRXs) have diverse functions in plant growth, development, and response to stress. This study conducted a thorough analysis of the PRX gene family in guava, a globally significant fruit. Within the guava genome, 37 PRX genes were identified, a count lower than that in Arabidopsis, indicating a unique gene family expansion pattern. Phylogenetic analysis revealed close relationships with Arabidopsis PRXs, with 12 PgPRX genes forming ortholog pairs, indicating a specific expansion pattern. Most PRX proteins are predicted to localize in the chloroplast and extracellular regions. Structural analysis of PgPRX proteins revealed similarities in domain structure and motif organization. Synteny analysis emphasized the impact of segmental duplication on the evolution of guava PRX genes. The dynamic expression of PgPRX genes across guava tissues revealed functional diversity. Additionally, changes in peroxidase levels and gene expression during postharvest fruit storage were examined, offering insights for preserving fruit quality. This study provides the initial genome-wide identification and characterization of class III peroxidases in guava, laying the groundwork for future functional analyses.

Optimizing Planting Methods and Planting Densities for Cut Stock (*Matthiola incana* L.) Production

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The stock (*Matthiola incana* L.) is a popular specialty cut flower grown across the globe. The global cut flower market is large, and floral production demand is increasing rapidly. Optimal production protocols are important for the production of high-quality cut stems. Therefore, a study aimed at evaluating different planting methods and planting densities for cut stock was conducted at the Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, from 2022--23. The experiment was conducted in a randomized complete block design with two factorial arrangements. Data were collected on production time (d), plant height (cm), leaf area (cm^2), leaf total chlorophyll content (SPAD), raceme diameter (mm), stem diameter (mm), stem fresh weight (g), stem dry weight (g), flower

quality (1--9), and vase life (d). In this experiment, the shortest production time (117.5 d) was recorded when the stock was planted on ridges at a spacing of 15 cm × 15 cm. The tallest plant height (51.9 cm) was recorded when the stock was planted on flat beds with 22.5 cm × 22.5 cm spacing. The greatest leaf area (44.3 cm2), raceme diameter (57.4 mm) and stem diameter (12.9 mm) were recorded when the plants were planted on flat beds with a 22.5 cm × 30 cm planting density. The leaf total chlorophyll content (126.9 SPAD) was highest when the stock was planted at ridges with 22.5 cm × 30 cm spacing. The stem fresh weight (43.8 g), stem dry weight (5.2 g) and longest vase life (10.7 d) were recorded when the plants were planted on flat beds with 22.5 cm × 22.5 cm spacing. In summary, the stock planted on flat beds with 22.5 cm × 22.5 cm spacing had the best quality cut stem production.

Impact of Foliar Application of Moringa Leaf Extract on Vegetative and Reproductive Growth of Hoary Stock (*Matthiola incana*)

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Matthiola incana, which is commonly known as the hoary stock flower and evening scented stock, has great value in the flower industry as a cut flower. Preharvest losses of cut flowers are major threats to the floriculture industry. To address this issue, moringa leaf extract (MLE) is used to increase the vegetative and reproductive growth of the hoary stock. A pot experiment was conducted to observe the effect of the foliar application of moringa leaf extract on the hoary stock plant. Seeds of hoary stock flowers were sown in plug trays. After reaching a suitable height, the seedlings were transferred to clay pots (12 inches in size) filled with soil. Each pot contained a single plant. This experiment was carried out in a completely randomized design (CRD) with five treatments and three replications, each consisting of three pots. The treatments used were T0 (control), T1 (0.25% MLE), T2 (0.50% MLE), T3 (1% MLE), and T4 (2% MLE). The MLE was applied at 15-day intervals three times during the whole course of production. The results showed that a 1% MLE improved the attributes. The number of leaves per plant, number of florets per plant, plant height, chlorophyll content, flower length, root length, shoot fresh weight, shoot dry weight, root fresh weight, and root dry weight significantly increased with the application of 1% MLE. The results of T1 (0.25% MLE), T2 (0.50% MLE), and T4 (2% MLE) were also predominantly improved. The minimum results were obtained from T0 (control). Hence, moringa leaf extract is a useful growth promoter, has a considerable effect on the growth and development of a hoary stock plant, and is thus recommended for the production of the hoary stock plant.

The Developing Trend of Frozen Vegetables: Enhancing Profitability and Reducing Losses in the Value Chain

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Postharvest losses in the vegetable value chain in Pakistan are significantly high because of the perishable nature of the product. These losses can be reduced via different value addition techniques. Freezing is one such technique that is used for preserving vegetables for a longer period of time while maintaining the nutritional value of the product. A growing trend toward the value addition of vegetables can be observed, especially in large cities, where consumers increasingly prefer frozen vegetables for their convenience. A survey was conducted at supermarkets in twin cities to analyze this trend. Many frozen vegetable products, such as peas, okra, broccoli, carrots, cauliflower, and potatoes, are available. These frozen vegetables are packed without the use of any preservatives and are certified for food safety and quality standards such as Bureau Veritas, ensuring hygienic food and superior quality products to customers. It also extends the window of availability of these vegetables throughout the year. The growing frozen vegetable business also provides an opportunity for farmers to earn a greater share of profit from vegetables by selling their produce directly to such companies, bypassing the involvement of middlemen in the value chain. Compared with fresh vegetables, frozen vegetables are sold at higher prices on the market, ensuring greater profits for farmers and processors. For example, fresh peas sold for Rs. 50–60/- per kg while frozen peas are priced at Rs. 250/- per kg. Similarly, okra are sold at Rs. A total of 70–80/- per kg fresh vegetables are used, and the price of frozen okra is Rs. 225/- per kg. These value-added products can also be exported, especially to developed countries with higher demand, potentially earning valuable foreign exchange for the country.

Impact of Moringa Leaf Extract and Commercial GA_3 Formulation on Coriander Growth, Yield, and Biochemical Traits

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The nutritional makeup of coriander makes it a valuable food resource. A research trial was carried out to evaluate the impact of commercial GA_3, formulation and moringa leaf extract on the growth, yield and biochemical traits of two coriander varieties, Washington and Evergreen. Different concentrations of *GA3,* i.e.*, gibafar* (10 and 20 ppm), gulabo (10 and 20 ppm), moringa leaf extract (3%) and distilled water (control), were sprayed on the coriander plants. The experiment was conducted according to the CRD under a factorial arrangement with four replications. A technique called analysis of variance was used to examine the data that were gathered. At the 5% probability level, Tukey's test was used to compare the means of the treatments. The data concerning plant height, plant dry weight and SOD activity were enhanced by treatment *with gibafar* (Gc), 10 ppm and 20 ppm (T_2 and T_3). The number of leaves, plant fresh weight, yield, number of stems, and DPPH and total flavonoid contents were greatest in response to moringa leaf extract (MLE). The chlorophyll content, total soluble solids (TSS), and titratable acidity (TA) were increased by Gulabo (Gu) at both 10 ppm and 20 ppm (T_4 and T_5). However, POD, CAT, and TPC were greater in T_1 (control). These results suggest that moringa leaf extract can be used as a substitute for GA_3 for increasing yield-related traits in coriander.

Effect of Grafting Combinations and Grafting Time on the Growth of Mango (*Mangifera indica* L.) Varieties

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The present research was carried out from 2021--22 at Horticulture Garden, Sindh Agriculture University, Tandojam, to assess the effects of grafting combinations and grafting times on the growth of mango varieties. The experimental trial was carried out in a randomized complete block design (RCBD) with four replications. The rootstocks of the Langro and Dasheri varieties were grown in the nursery field. Langer and Dasheri scions of uniform size were used and attached to the rootstock via saddle grafting. There were ten grafts for each grafting combination and 160 grafts for the whole experiment. The grafting combinations were GC1= Langro x Langro, GC2 =Langro x Dasheri, GC3 =Dasheri x Dasheri and GC4= Dasheri x Langro. The two grafting times, i.e., February and March, were followed. Substantial variation was found among the grafting combinations for all the studied traits. The maximum results for plant height (73.53 cm), length of leaves (13.39 cm), chlorophyll content (24.43 SPAD), fresh weight of shoot (2.05 g), dry weight of shoot (0.57 g), diameter of shoot (6.05 mm), sprouting (62.43%), and sprouting sapling-1 (2.16) were observed in the grafting combinations of T3 and Dasheri × Dasheri. The number of grafting events also had a notable effect on all the scored traits. Compared with the plants grafted in March, those grafted in February were better. On the basis of these findings, mango may be grafted in February by applying a combination of Dasheri and Dasheri.

Collection and Optimization of Fungal and Bacterial Endophytes to Manage the Soil-Borne Pathogens of Vegetables

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Endophytes refer to microorganisms, including fungi and bacteria that reside within the tissues of plants and exhibit a commensal relationship with the host plant, devoid of any discernible detrimental effects. These organisms develop symbiotic relationships with their hosts, which results in a variety of benefits, such as defense against plant pathogens. The importance of these endophytes has increased, as they exhibit potential as biological control agents and can assist plants in combating pathogens and improving overall plant health. Soil-borne pathogens encompass a range of microorganisms, including bacteria, fungi, nematodes, and viruses, which inhibit the soil environment and have the potential to induce diseases in vegetable plants. The main purpose of this project is to find alternative and innovative ways to manage the devastating soil-borne pathogens associated with vegetables. The endophytes will be collected from plant species and grown in a suitable culture medium. These endophytes are subsequently purified and identified at the species level. The identified species of endophytes were tested via the mean inhibition zone technique against the collected soil-borne pathogens under *in vitro* conditions. The potential efficacy of such endophytes will be measured and later tested under greenhouse conditions against soil-borne pathogens. The successful endophytes will be molecularly characterized and sequenced. The obtained sequences will be submitted to the NCBI database. Preliminary investigations or initial experiments on these endophytes have yielded encouraging outcomes with respect to disease regulation and enhanced plant growth. However, additional experiments and verification are underway to ascertain the complete capabilities of endophytes in the management of soil-borne pathogens.

Biochemical Properties in Leaves of Different Olive Cultivars

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Olive is a miraculous fruit crop with high nutritive and medicinal properties; however, little is known about the biochemical properties of its leaves. The aim of this study was to evaluate the variability of physiological and biochemical properties in two leaf age groups (LA1: fresh leaves; LA2: mature leaves) of five different olive cultivars (V1: Koroneiki; V2: BARI Zaitoon 1; V3: BARI Zaitoon-2; V4: Arbequina; V5: Gemlik) under agroclimatic conditions in the pothowar region.

The study followed a two-factor (variety and leaf age) factorial design with a randomized complete block design. The data were collected for various biochemical, proximate, and mineral properties. The biochemical parameters included total phenolic content (TPC), total flavonoid content (TFC), and total antioxidant capacity (TAC); the proximate parameters included moisture, protein, ash, fiber, fat and nitrogen-free extract (NFE); and the studied minerals included sodium (Na), calcium (Ca), nitrogen (N), phosphorus (P), potassium (K), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn). The findings of this study revealed significant differences in various biochemical activities (TPC, TFC), proximate attributes (moisture, protein, ash, fiber, and NFE) and mineral contents (Na, Ca, N, P, Zn, Fe, Cu, and Mn) in the leaves of the studied varieties. Arbequina (V4) had more nutrients because of its significantly greater TFC, moisture, protein content, NFE, and Na, N and P contents. The impact of leaf age was also significant for the various studied attributes of olive, including TPC, TFC, TAC, protein, ash, Ca, Fe, Cu and Mn. The fresh leaves presented increased TPC, TFC, protein, Fe and Cu contents, whereas the mature leaves presented increased TAC, ash, Ca, and Mn contents. In conclusion, olive leaves have significant potential for supplementing human nutrition; however, their pharmacological effects need to be investigated before any recommendation is given. Moreover, research and development are also needed to develop different products from olive leaves.

Influence of Sulphate-Based Postharvest Chemical Applications on Physico-Chemical Attributes in Peel and Pulp of Banana Fruit

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Banana is a climacteric fruit with a limited postharvest shelf-life and fast deterioration quality because of its perishability and losses caused by a high respiratory rate, ethylene production and microbial contamination. For better quality and shelf-life, the preharvest application of nutrients is common; however, the role of postharvest nutritional applications has not been studied thus far. This study was conducted to explore the impact of the postharvest application of different sulfate-based nutrients on the shelf-life and quality of bananas. This experiment was carried out under a completely randomized design (CRD) with three-factor factorial arrangements (sulfate-based nutrient solutions, fungicide and shelf duration) and three replications. Sulfate-based nutrients (T_0: control; T_1=$CuSO_4$; T_2=$FeSO_4$; T_3= $MgSO_4$; T_4=$MnSO_4$; T5= $ZnSO_4$) were applied at 1 g/100 ml without fungicide (F0) or with 0.7 g/L thiophenate

methyl fungicide (F1), and the physicochemical quality was assessed at 0 d and 9 d on the ambient shelf (25±1°C; 60–65% RH). Among the sulfate-based treatments, the banana fruits subjected to MnSO4 (T4) and ZnSO4 (T5) with thiophenate methyl fungicide on the 9^{th} day after treatment had better quality attributes of less weight loss, softening, shriveling and disease severity. Significant changes in different physicochemical attributes, including TA, TSS/TA, antioxidant, catalase, protein, SOD, total phenolic, peroxidase, total soluble solids, and vitamin C contents, were recorded under posttreatment ambient shelf conditions, with significant increases from day 1 to day 9; however, significant changes in different physical attributes were recorded, and after treatment ambient shelf conditions, significant increases in weight loss, fruit peel color, softness, shriveling and disease severity were detected.

Postharvest Quality Changes in the Fruit of Different Olives Cultivars under Ambient Conditions

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Olive (*Olea europaea* L.) is a widely expanding fruit crop in Pakistan. A study was conducted to evaluate the physicochemical attributes of ten olive cultivars, namely, Arbequina, Arbosana, BARI Zaitoon-1, Gemlik, Koroneiki, Leccino, Manzanillo, Nabali, Oliana, and Ottobratica. Ripe fruit samples were collected and assessed for various physicochemical parameters, including total soluble solids (TSS), titratable acidity (TA), ripening index (RI), pH, vitamin C, total phenolic content (TPC), total antioxidant capacity (TAC), proteins, and antioxidative enzymes, such as superoxide dismutase (SOD), catalase (CAT) and peroxidase (POX), at 1, 4 and 7 d of ambient shelf (25°C ± 2°C; 60–65% RH). The study was laid out under a randomized complete block design (RCBD) with two factor (cultivars and shelf intervals) factorial arrangements. The results revealed significant variability among the cultivars for all the studied parameters. The TSS ranged from 8.56°Brix in Ottobratica to 16.67°Brix in Arbequina. TA was highest in Arbequina (0.4%) and lowest in Manzanillo (0.22%). The ripening index values varied from 31.39 in Ottobratica to 60.40 in Leccino. The pH of olive fruit ranged from 4.47 in Leccino to 5.50 in Oliana. The vitamin C content was maximal in Nabali (100.73 mg/100 g) and minimal in Gemlik (64.6 mg/100 g). The total phenolic content was highest in BARI Zaitoon-1 (567.49 mg GAE/100 g) and lowest in Arbequina (464.12 mg GAE/100 g). The antioxidant capacity reached a maximum at BARI Zaitoon-1 (62.07 mg GAE/100 g) and reached a minimum at Manzanillo (29.29 mg GAE/100 g). The protein content ranged from 9.42 mg/g in Koroneiki to 42.80 mg/g

in Oliana. Among the antioxidative enzymes, SOD activity was highest in Arbequina (25.78 U/mg protein) and lowest in Gemlik (17.96 U/mg protein). The catalase activity was highest in Nabali (10.34 U/mg protein) and lowest in Gemlik (0.289 U/mg protein), whereas the POX activity was highest in Nabali (7.07 U/mg protein) and lowest in BARI Zaitoon-1 (2.45 U/mg protein). Shelf duration also had a significant effect on physicochemical attributes. Progressive decreases were observed in the TSS, TA, TPC, antioxidant, protein, SOD and POX contents from day 1 to day 3, whereas the pH, RI and catalase content tended to increase. A significant interaction was found between cultivar and shelf interval for most of the studied parameters. In conclusion, significant variability was observed among the ten olive cultivars studied for all the assessed physicochemical parameters, including TSS, TA, pH, RI, vitamin C, TPC, TAC, proteins, and antioxidative enzymes, at 1, 2, and 3 d of ambient shelf storage. The nutritional composition of the cultivars differed considerably. Shelf duration also impacted attributes with progressive declines in TSS, TA, TPC, antioxidants, proteins, SOD and POX over time, whereas increases in pH, RI, and catalase occurred. Interactions between cultivar and shelf duration influenced quality. The findings demonstrate that physicochemical properties differ substantially between olive cultivars and are affected by postharvest storage conditions. These data provide valuable information regarding the biochemical nutritional composition of different olive varieties, which significantly vary during postharvest storage. The investigations need to be focused on the storage potential of different olive varieties for optimal quality, nutrition and oil content.

Optimizing Growth and Yield of Various Aromatic Plants for Essential Oil Production

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Aromatic plants have long been valued by humans for their enticing aroma and many industrial applications. Compounds that are abundant in essential oils enhance our sensory perceptions and have a variety of uses in the medical, cosmetic and therapeutic fields. Lemongrass (*Cymbopogon citratus*) is a perennial species of oil grass in the family Poaceae. Niazbo (*Ocimum basilicum*), a sweet basil, a popular herbaceous plant from the Lamiaceae family, and *Ocimum tenuiflorum*, a holy basil or tulsi, an aromatic perennial plant in the Lamiaceae family, are widely used aromatic plants for the extraction of various compounds. An experiment was conducted to optimize the growth and yield of three aromatic plant species, viz. lemon grass, niazbo and tulsi. The experiment was performed according to a randomized complete block design (RCBD) with three replications containing 10 plants each. The findings demonstrated that the tallest plant (99 cm) with the greatest canopy diameter (92 cm), lowest essential oil percentage (0.19%) and production time (78 d) was recorded in Tulsi. Lemon grass had the

longest production time (97 cm) and the shortest plant height (65 cm). The longest production time (145 d), greatest plant height (64 cm), smallest canopy diameter (60 cm), and highest percentage of oil (1%) were observed in the niazbo plants. The highest percentage of oil was recorded for the niazbo plants, followed by the lemon grass plants, which are suitable aromatic plants for commercial cultivation in the plains of Punjab, Pakistan.

Postharvest Quality Maintenance of Tomatoes and Jamun Fruit Using a Microporous Membrane Patch

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A microporous membrane patch (BreatheWay®) is a newly adopted technology used to maintain the quality and improve the shelf life of horticultural commodities. Therefore, this study was carried out to evaluate the ability of microporous patches to maintain the postharvest shelf-life and quality of cherry tomatoes and jamun fruits. For this purpose, fruits for experiment I (jamun) and experiment II (cherry tomatoes) were packed in plastic zipper bags with T_0 (no hole), T_1 (6 mm hole), T_2 (3 mm hole) and T_3 (1 mm hole), where the microporous membrane patch was pasted on it and placed under ambient conditions (25 ± 2°C, 60–65% RH) and cold storage (5 ± 1°C and 80–90% RH). In experiment I, the fruit stored under ambient conditions presented the lowest weight loss (1.5%), respiration rate (1.5 mmol $^{kg-1}$) and ethylene gas content (1.5 µmol kg−1) at T2, whereas a relatively high TSS (17.65°Brix) and low TA (0.48%) were recorded at T_0. However, jamun fruit stored at a low level presented no weight loss, with lower ethylene gas (0.29 µmol $^{kg-1}$) and TA (0.44%) contents in T_1 and the lowest respiration rates (1.5 mmol kg-1) and vitamin C (282.25 mg/100 ml of juice) contents in T_0. In experiment II, cherry tomato fruit kept under ambient conditions presented the lowest respiration rate (1.93 mmol $^{kg-1}$) with a relatively high TSS (8.4°Brix) in T_1. The lowest levels of ethylene gas (0.63 µmol $^{kg-1}$ h^{-1}) and vitamin C (485.9 mg/100 ml of juice) were recorded at T0. The lowest respiration rates (1.76 mmol kg-1), ethylene gas (0.54 µmol $^{kg-1}$) and TA (0.06%) were noted in T_2, T_0, and $T_{3,}$ respectively, during cold storage. In conclusion, jaman and cherry tomato fruits placed in plastic zipper bags under T_1 (paper punch with a 6 mm hole) with microporous membrane patches presented better fruit quality under ambient conditions as well as during cold storage.

Physicochemical Diversity in Acid Lime Cultivars and Hybrids

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In acid limes, only two varieties, viz. The Mexican lime 'ML' (*Citrus aurantifolia* L.) and *Eustis limequat* 'EL' (X Citrofortunella) are commercially cultivated, indicating the existence of a narrow gene pool. In the last few years, the use and demand of limes have increased. Hence, there is a dire need to explore the potential of available germplasms for diversification and utilization in breeding programs. Five acid limes, namely, ML, EL, Tahiti lime 'TL' (*C. latifolia*), Seedless lime 'SL', and Tavares limequat 'Tav L' (X Citrofortunella), were collected from Institute gardens and commercial sources for physicochemical analysis. The leaf lamina shape ranged from elliptic (ML and EL) to obcordate (TL, SL and Tav L). SL had large leaves and a relatively large leaf area (0.33 cm^2), whereas Tav L had the heaviest fruit (74.55 g), oblong shape and longer fruit length (63.40 mm). The fruit diameter was greater in the SLs (43.84 mm). The juice weight (28 g) and content were greatest in SL lime (54%) and lowest in EL (8.9 g, 31.33%). The cultivars TL, SL and ML were seedless. In terms of chemical traits, the TSS content was greater in TL (9.25 °Brix), the acidity was greater in EL (7%), and the juice pH was the lowest (1.8), whereas the TSS:TA ratio was greater in Tav L (2.82). The ascorbic acid content was greater in the MLs (38.31 mg/100 ml), and the anthocyanin content was greater in the SLs (0.39 mg/100 ml). These findings reveal the great diversity of acid lime germplasms, which should be further explored to identify potential candidates for commercial cultivation and crop improvement programs.

Ginger Substrate Regulates Soil Microbial Community Structure and Diversity in Replanted Disturbed Soil to Promote Chilli Growth and Reduce Fusarium Wilt

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Ginger substrate may affect plant growth by changing the soil microbiota. The technique by which soil microbial populations reduce disease and promote plant development is unknown, particularly in deteriorated soil. In this study, damaged soil from a long-term chili monoculture (an annual double-cropping system in a greenhouse) was replanted with ginger substrates at 2,

4, and 7 g/100 g. An increased proportion of C-amended ginger substrate suppressed foliar infections 35% more than did the control (C). The chili plants produced 20% more fruit and grew 20% better in this inhibitory soil. Adding ginger substrate temporarily increased the soil organic matter (SOM) content, nutrient availability, and enzyme activity. The microbial and fungal communities of the control and ginger-amended soil samples differed greatly according to Illumina MiSeq sequencing. In the treated soil, the stock species richness and diversity indices increased significantly. Soil organic matter (SOM), nutrient concentrations, and biological activators changed the microbial community structure, according to correlation heatmaps. By preventing Fusarium development and lowering its quantity, the use of ginger as a substrate increased crop production. The host plant attracted beneficial microorganisms that may prevent plant diseases and increase crop biomass after substrate addition. The monocropped chili soil contained microbial taxa that may have inhibited Fusarium wilt, Firmicutes, Actinobacteria, Bacteroidetes, Basidiomycota, and Glomeromycota taxa.

Foliar Silver Nanoparticles Modulate Antioxidant Defense and Osmolytes to Reduce Drought Stress in Tomato Seedlings

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Among the most significant environmental threats, drought stress affects plant development and decreases crop yields. We are now evaluating potential strategies to lessen the negative effects on plants. Nanotechnology is regarded as an excellent tool for addressing a variety of issues by providing unique and practical solutions. The effectiveness of applying silver nanoparticles (Ag NPs) as a foliar treatment (25 mg L^{-1} and 100 mg L^{-1}) on the growth performance of tomato plants exposed to drought stress was investigated in a laboratory experiment. Under normal circumstances, the application of Ag NPs reduced drought-induced decreases and increased growth and biomass. The development and biomass accumulation of tomato seedlings are stunted due to drought stress, which increases reactive oxygen species (ROS) and peroxidation and reduces membrane function. Reduced ROS accumulation and lipid peroxidation were observed in the plants treated with Ag NPs. The improvement of antioxidant components, both enzymatic and nonenzymatic, led to a significant decrease in oxidative damage. Drought stress caused a decrease in the mineral and phenol concentrations. Additionally, both normal and drought conditions resulted in increases in proline, free amino acid, and sugar contents as a result of Ag NPs. Foliar applications of Ag NPs also reduced the

loss of phenol and mineral nutrients caused by drying. These results show that applying exogenous Ag NPs to tomato seedlings suffering from drought stress can be a practical solution.

Effect of Nitrogen on Biochemical Attributes of Tomato (*Solanum lycopersicum* L.) Plants under Drought Conditions

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Tomato (*Solanum lycopersicum* L.) is an important vegetable crop of the Solanaceae family that is cultivated worldwide because of its culinary and nutritional importance. Nitrogen is an essential nutrient for plant growth and development. Its overuse has damaging effects on the growth and development of tomato plants. The main objective of this study was to estimate the effects of nitrogen on the biochemical features of tomato plants. The results revealed that the negative impacts of an overdose of nitrogen cause poor growth and poor fruit quality in tomato plants and decrease the pH level and organic matter in the soil, whereas total dissolved salts (TDS) and electrical conductivity (EC) are amplified at high doses of nitrogen. Compared with those in the control plants, the levels of peroxidase (POD), catalase (CAT) and phenolic enzymes increased, whereas the activities of superoxide dismutase (SOD), antioxidant and protein enzymes decreased under nitrogen stress. The tomato plant leaves were resistant to a greater dose of nitrogen. The present study will ultimately be helpful for designing nutrient calendars for balanced nutrient management in tomato and other vegetable crops.

Cytological, Biochemical and Physiological Responses of Colchiploid Germplasm in Guava

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Polyploidization in guava is highly desirable for the development of plant materials with superior agronomic attributes, such as increased vigor and climate change resilience. Leaves of the polyploid germplasm of guava cultivars Round and Pyriform, which were developed via colchicine treatments, were subjected to stomatal studies and leaf biochemical and physiological analyses for evaluation. The application of a relatively high level of colchicine (0.1%) reduced seed germination (51.80%), plant height (21.10 cm), stomatal frequency (103.52/unit area), stomatal density (796.3 mm²), transpiration rate (0.63 µmol H_2O m^{-2} s^{-1}), leaf temperature (20.59°C) and superoxide dismutase 'SOD' (5.94 IU/mg of protein). However, compared with the control treatment, the colchicine treatment increased the leaf size (3.32 cm^2), stomatal size (355.30 μ^2), photosynthetic rate (19.70 µmol CO_2 m^{-2} s^{-1}), water use efficiency (34.22), substomatal CO_2 concentration (1480.7 µmol mol^{-1}), and stomatal conductance in response to water vapor (0.04 C, µmol m^{-2} s^{-1}). Similarly, compared with the control, colchicine application also increased the total chlorophyll content (35.65 µg/ml), carotenoid content (12.52 µg/ml), peroxidase 'POD' activity (0.865 IU/mg of protein), catalase 'CAT' activity (0.816 IU/mg of protein), malondialdehyde 'MDA' activity (0.24 nmol/g FWT), proline content (41.68 µg/g FWT) and antioxidant capacity (92%) under 0.1% colchicine. The presence of these promising attributes can greatly increase plant vigor, crop productivity and quality. These findings reveal the potential of colchiploid germplasms for greater biochemical activity and photosynthetic efficiency. Further investigations of the genetic polymorphisms and molecular pathways involved in the reported physiological and biochemical alterations may reveal the key regulators for genetic improvements.

Nanotechnology for Sustainable Horticulture Amidst Abiotic Challenges in Pakistan

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Horticulture has emerged as Pakistan's prominent industry, accounting for 12% of the country's agricultural GDP (22.9%). It contributes significantly to the country's expanding demand for fruits and vegetables, which are essential for the growing population. Crops grown for human consumption are high in essential nutrients such as carbohydrates, proteins, organic acids, vitamins, and minerals. However, growth methods, genetic attributes, and climatic conditions significantly affect the quality and yield of horticultural crops. Abiotic stressors (variations in light intensities, exposure to UV radiation, extreme temperatures (cold and heat), drought, excessive water, salinity, etc.) significantly impair crop production, leading to agricultural output losses ranging from 50% to 70%. These abiotic stressors affect various physiological and

biochemical systems in plants. Addressing abiotic stress in horticultural crops is not only essential but also a means to achieve sustainable and resilient agriculture. Thus, exploring alternative methodologies for cultivating stress-tolerant crops is highly important. Through the cultivation of stress-tolerant crops and the implementation of advanced agricultural techniques, we can ensure not only high crop yields but also a more sustainable and ecologically aware future. The incorporation of cutting-edge technologies, such as nanotechnology, has the potential to significantly alter the present situation of the country. The endeavour to achieve these solutions demonstrates a dedication to ensuring access to sufficient food, promoting economic growth, and enhancing the welfare of both agricultural producers and consumers. The key to a resilient agricultural environment that can withstand unpredictable factors of nature lies in the simultaneous adoption of these technologies alongside conventional approaches.

Morpho-physical and Biochemical Attributes of a Biannual Mango Accession

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This research aimed to study the differences between the morphological attributes of vegetative and floral parts as well as the physicochemical attributes of the summer and winter fruits of a biannual mango accession. The morphological attributes were studied via the IPGRI plant descriptor. The fruits were harvested during two different seasons (S1: summer and S2: winter) at an anticipated mature stage, packed in corrugated cardboard boxes, and kept at room temperature (25±1°C°C; 60–65% RH). The studied parameters included qualitative and quantitative morphological parameters, biochemical parameters, physical parameters, sensory parameters, and soil properties. The findings of this study were that the summer fruit was better in terms of attractiveness, diameter, weight, and eating quality, having a coarse texture and stronger turpentine aroma, inflorescence size and flowering percentage. However, qualitative visual parameters such as fruit shape, fruit color, fruit beak type, fruit sinus type, fruit apex shape, fruit ventral shoulder, neck prominence, stalk attachment type, stone texture, seed shape, inflorescence color, and inflorescence shape were similar in both seasons. With respect to the biochemical attributes, significant differences were detected in the TSS, TA, ripening index, vitamin C content, antioxidant capacity, total phenolic content, catalase, and peroxidase between the summer and winter fruits. In terms of physical parameters, a

significant difference was found in average fruit weight and weight loss %. The sensory properties were significant in terms of texture and aroma.

Dormancy Breaking and Enhancement of Sprouting of Lilium (*Lilium* L. hybrids) Bulbs through Magnetic Treated Water

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Geophytes have great value in the world floriculture industry, and Lilium is prominent among them. The increased demand for Lilium cut flowers requires continuous cultivation to meet the market demand throughout the year, but the postharvest problem of bulbs is due to the occurrence of dormancy, which limits Lilium cultivation to only one growing season. Breaking the dormancy and enhancing the sprouting of Lilium bulbs through magnetically treated water. The magnetically treated bulbs presented the maximum sprouting percentage, number of flowers, plant height, flower diameter, total leaf chlorophyll content (SPAD), production time (days), sprouting energy (%), sprouting index and mean sprouting time for all Lilium cultivars, viz., 'Sorbonne', 'Zambesi' and 'Caesars'. Among the cultivars, the minimum time to 50% sprouting, number of flowers, plant height, flower diameter, total leaf chlorophyll content (SPAD), production time (days), sprouting energy (%), and sprouting index were lower in 'Caesars' than in 'Sorbonne' and 'Zambesi' when the bulbs were dipped in 60 mint magnetically treated water for 48 hr. In conclusion, magnetically treating Lilium bulbs with water for 60 min is best for breaking dormancy.

Gum Arabic as a Novel Organic Edible Coating for Conservation of Postharvest Quality and Storage Life of Fruits and Vegetables

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Acacia gum, also commonly referred to as gum arabic (GA), belongs to the family Leguminosae and is a polymeric gelling agent that is chiefly composed of polysaccharides. It is an extract obtained from the woody parts of two distinct species of Acacia trees, namely, *Acacia senegal*

and *Acacia seyal*. Recent studies have revealed multiple pharmacological and medical advantages linked to the consumption of GA, such as weight loss; the ability to manage hypertension and diabetes; and antihyperlipidemic, anticoagulant, antibacterial, antidiabetic, anti-inflammatory, and nephroprotective effects, among other qualities. GA has broad utility in the food industry because of its edibility, vigorous water solubility, generally recognized as safe (GRAS) status, lack of aftertaste, and other desirable traits. The use of a GA coating for the postharvest preservation of fresh and processed commodities during the storage and transportation stages has led to a substantial increase in global demand. The application of a GA coating as a thin layer on the food surface acts as a replacement for natural protective waxy coatings by providing a barrier to oxygen, moisture and solute movement across the surface of fruits and vegetables. Numerous studies have suggested that GA causes significant delays in physical and biochemical changes in fruits and vegetables during different phases in the postharvest supply chain. The use of GA as an edible coating during postharvest treatment has also demonstrated notable results in protecting the phytochemical and enzymatic characteristics of different fruits and vegetables. This leads to an extended storage life and maintenance of postharvest quality. As it is inert in nature and has a palatable taste, the application of GA has promising results as an edible coating for the preservation of the postharvest storability and quality attributes of fruits and vegetables.

Postharvest Application of Tragacanth Gum for the Preservation of Quality and Storability of Fruits and Vegetables

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Tragacanth gum (TG), generally referred to as Shiraz Gum or Dragon Gum, is the dried sap extract of various species of the genus *Astragulas,* which belongs to the family Leguminosae. *A. adscendens, A. gummifer, A. brachycalyx and A. tracanth* are the commonly known species in this genus, sometimes collectively referred to as the “Goat’s thorn” or “Locoweed”. TG is a versatile polysaccharide with various applications in food, pharmaceuticals and cosmetics. It forms colloidal solutions, suspensions, or gels and has been used as a thickener, stabilizer, and dietary fiber. Iran is a major producer, supplying more than 70% of its share of the world market. TG also shows potential in biomedical fields, such as drug delivery and wound healing, making it a promising biobased polymer. TG is a complex mixture of acidic heteropolysaccharides containing D-galacturonic acid. It exhibits pseudoplastic behavior, with high viscosity at pH 5--6, and forms a gel with bassorin as the insoluble fraction. TG has been widely utilized as an edible coating for various fruits and vegetables to increase their quality and shelf-life. Its anionic properties allow it to stabilize, thicken, and emulsify food systems. TG coatings effectively reduce water loss, enzymatic activity, texture deterioration, microbial growth, and the browning index in fruits and vegetables. Moreover, TG coatings have been found to preserve the firmness, ascorbic acid content, antioxidant activity, and overall sensory quality of produce such as apples, bananas, apricots, mushrooms, and pomegranates. These findings highlight the potential of TG as a natural and effective alternative for postharvest interventions in the preservation of fruits and vegetables.

Sustainable Foodscape Management: Key Opportunities and Challenges

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Sustainable foodscape management is an innovative and holistic approach that seeks to integrate biodiversity, productivity, and environmental stewardship in the design and maintenance of landscapes. This systematic review explores the principles and practices associated with sustainable foodscape management, emphasizing the coexistence of diverse plant species, optimal land utilization for high-yield crop production, and the promotion of ecological resilience. The analysis delves into key components such as organic soil management, water conservation strategies, integrated pest management and opportunities in creating edible landscapes. The expansion of urban edible landscapes may be restricted by factors such as policies, land contamination, and management techniques in various nations. Despite these difficulties, edible landscapes have the ability to alleviate socioecological crises and support human–nature partnerships that are sustainable. Additionally, the idea of edible landscapes can be used in a variety of urban settings, such as subterranean farming, home food gardens, roof gardens, and controlled-environment farms, providing creative solutions. Overall, this review underscores the critical role of sustainable foodscape management in coping with all the challenges associated with fostering resilient, biodiverse, and productive landscapes that contribute to environmental health, community well-being and the future challenges of food security.

Establishment of Micropropagation in Cucumber Cultivars

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Cucumber (*Cucumis sativus* L.) is an important summer vegetable in Pakistan. The current study aimed to establish efficient micropropagation protocols for selected cucumber germplasms. In the present study, BAP+NAA and KIN+NAA were used for the micropropagation of cucumber germplasm. Different explants, such as hypocotyls, single nodes, shoot tips and axillary buds, were cultured. However, cultivar Champion presented the greatest percentage of germination (92.33%), followed by CP 001 (83.00%) and Local Khera (71.33%). Three cucumber cultivars, Champion, CP.001, and Local Khera, presented significant results in terms of micropropagation from a single node, hypocotyl, shoot tip, and axillary bud. Compared with shoot tips (57.41%), axillary buds (41.27%), and nodes (22.96%) developed more roots (82.87%) at higher levels of KIN+NAA. However, cv. Local Khera presented significant results for hypocotyls and shoot tips, whereas CP.001 performed well for axillary buds and nodal cultures. All concentrations of BAP+NAA enhanced root induction when axillary buds, hypocotyls, shoot tips, and single nodes were used as explants.

Performance of Different Date Palm Cultivars at Fruiting Stage

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This study was conducted to assess the performance of different date cultivars in terms of production and other characteristics in the major date palm-growing regions of Dera Ghazi Khan, Punjab, Pakistan. However, different cultivars are grown in the climate of Dera Ghazi Khan; their yield is quite low and varies among different cultivars under agroclimatic conditions. This experiment investigated the yield performance of different date palm cultivars in a subtropical climate at the Department of Horticulture, Ghazi University, Dera Ghazi Khan. For this research, ten different cultivars of date palm (Gulshan, Kashowari, Barri, Bareemi, Dakki, Khuzrawi, Halawi, Shamran, Lolo, and Safawi) were selected from commercial orchards of progressive growers of Dera Ghazi Khan, with three replications. The maximum number of spikes per bunch was observed in Khuzrawi (56.00). While the maximum spike length was observed in Safawi and Halawi (53.00 cm and 51.00 cm, respectively), the maximum fruit weight was also observed in Safawi (24.00 g), and the maximum fruit length was observed in cultivar Bareemi (48.00 mm).

Ethanolic Filtrate of Streptomyces spp.: Antifungal Efficacy against *Penicillium digitatum*, a Post-harvest Pathogen of Citrus Fruits

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Fruit postharvest infections continue to be a significant issue affecting many different areas worldwide due to the many losses they cause. Microorganism culture filtrates are among the many options used to manage phytopathogenic fungi, which are the primary cause of fruit postharvest disease. Numerous studies have shown the effectiveness of these filtrates. This study sought to determine whether *Streptomyces* spp. ethanolic filtrate might prevent *Penicillium digitatum* from growing and regulate postharvest deterioration in citrus fruits (oranges and lemons) while they are being stored. The actinomycete isolate exhibited antagonistic activity against *Penicillium digitatum*, as demonstrated by an *in vitro* assay utilizing the agar cylinder technique, with an inhibition rate of 68.68±2.46%. Conversely, via the radial growth method, the strain's ethanolic filtrate was obtained from a culture on starch casein agar medium and showed a very high level of activity against the phytopathogen, with an inhibition rate of 78.29±4.85%. With the disc approach, a 21 mm inhibition zone value was obtained. Through precipitation and coloration experiments, the ethanolic filtrate was chemically screened to identify the presence of leucoanthocyans, flavonoids, polyphenols, alkaloids, and saponins. An *in vivo* test using oranges and lemons demonstrated the antifungal product's preventative impact. Compared with untreated fruits, whose shelf lives were 2 d for lemons and 4 d for oranges, the shelf life of the two tested fruits treated with the ethanolic filtrate improved during artificial infection experimentation (5 d for both fruits) and storage assays (11 d for lemons and over 21 d for oranges) at room temperature.

Biochemical Quality Attributes in Different Maturity stages of Strawberry Fruit with Respect to Different Preservation Methods

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Strawberry is a very nutritious fruit but has a limited postharvest shelf life because of its perishable nature and susceptibility to postharvest quality defects and infections. The objective of this study was to evaluate the biochemical changes in strawberry fruits in relation to harvest maturity and preservation techniques. The experiment was conducted under a completely randomized design (CRD) with a factorial arrangement. The fruits of strawberry cv. Chandler were picked at three distinct color-based maturity stages (M1: 0% red, M2: 50% red, and M3: 100% red), subjected to two different preservation techniques (P1: frozen, P2: freeze-dried), and subjected to quality analysis at 0 d or after 7 months of dry storage under ambient conditions. The different biochemical attributes, including total soluble solids (%), pH, titratable acidity (◦Brix), vitamin C (mg), total phenolic content (mgGAE/100 g), total antioxidant capacity (%), superoxide dismutase (U mg-1 protein), catalase (U mg-1 protein), peroxidase (U mg-1 protein), protein (mg/g) and organoleptic characteristics (aroma, color, flavor, texture, and taste), were investigated. The results regarding the impact of fruit harvest maturity revealed that fully ripe strawberry plants had significantly better biochemical attributes, including total soluble solids (TSS), pH, titratable acidity (TA), and the TSS/TA, than did 50% and 0% red strawberry plants. Moreover, the total phenolic content (TPC) and peroxidase (POX) content were also significantly greater in the 100% red strawberry treatment group than in the control group. The organoleptic attributes (aroma, color, flavor and taste) were significantly better in the fruits harvested at 100% and 50% red color than in the strawberries harvested at the green stage (0% red color). With respect to preservation techniques, freeze-dried strawberry had significantly better attributes than did frozen strawberry in terms of the TSS, TSS/TA, vitamin C, antioxidant, total phenolic content (TPC), and peroxidase (POX) contents. The consumer preference for frozen strawberry was better than that for freeze-dried strawberry because of the significantly higher rating for fruit aroma and color. The assessment of several attributes, including TA, TSS/TA, and vitamin C, was performed at 0 d and at 7 months of storage, and the preserved fruit maintained these attributes well for up to 7 months of dry storage. Overall, the findings of this study indicated that, for commercial harvest and preservation, strawberry fruits should be preferably harvested on the basis of a 100% red color and preserved by employing freeze-drying technology for up to seven months, which results in well-maintained nutrition and quality as well as consumer acceptability.

Community Development Framework Through Smart Technology for Climate Change Adaptation in the Urban Landscape of Punjab, Pakistan

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A landscape is an emergent field through which a healthy and aesthetically pleasing environment is created throughout the globe. In Pakistan, the landscape is a significant area, as it is a country that is working and progressing in every line of work. There is a need for appropriate horticulture and landscapes wherever possible, especially in the province of Punjab. Punjab is an agricultural and industrial province and a hub of related activities in Pakistan. It is on the way for development through industrial growth, with ever-increasing urbanization and deteriorated environments, which adversely impact overall ambience. The province also has one of the severely polluted cities as its capital, i.e., Lahore. Consequently, the landscape of the province of Punjab is required to provide its people with a good environment. This research is based on a community development framework through smart technology for urban landscapes. Community engagement and innovative solutions for current problems related to climate change have been addressed in this study. Contemporary landscape sites, heritage gardens and residential green areas were analyzed. The quality function deployment (QFD) method was used to gather information from the identified community. This information was translated into technical specifications through a planning matrix also known as the HOQ-House of quality. After the current conditions and requirements are analyzed, strategies have been developed accordingly to address the current issue in the region.

Enhancing Dahlia Tubers Longevity through Various Handling and Storage Techniques

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Dahlias are herbaceous perennials in the aster family (Asteraceae) that are native to Mexico and Central America. Dahlia tubers constitute the underground storage component of Dahlia plants, which serve as an energy source for the next year's growth. The present study aimed to obtain more precise information about the storage conditions of Dahlia tubers. A total of four packaging materials (polythene wrapping, coco coir, sawdust, and gunny bags) were examined at both ambient temperature and under cold storage for storing Dahlia tubers for 12 weeks. Minimum changes in tuber weight (1.59 g), ion leakage (20%), mortality rate (0%), respiration rate (13.6%) and disease incidence (0%) were recorded in the treatment where tubers were wrapped in polythene sheets. A significant result was shown by the treatment in which polythene-wrapped tubers were placed in a cold store, followed by the tubers, which were stored in coco coir and placed in a cold store. In conclusion, placing tubers in cold storage via polythene wrapping can reduce the chance of mortality, and the tubers can be stored until sowing.

Application of Spermidine and L-arginine to Extend the Shelf Life of Papaya cv. Red Lady

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Papaya (*Carica papaya* L.) is a member of the family Caricaceae. It is a tropical fruit that is highly important because of its high nutritional value and medicinal uses. There has been a considerable increase in the demand for papaya due to consumer awareness. A large proportion of total papaya production is affected by postharvest losses and the quality of fruit. The main factors contributing to the decline in postharvest quality are related to physical, physiological and biochemical changes in fruits. The present study was conducted to evaluate the quality attributes of papaya fruits through two trials. In the first experiment, "spermidine" at concentrations of 1 mM, 3 mM, and 5 mM was applied via the immersion method. The 5 mM spermidine concentration maximizes fruit aroma, pulp texture, fruit firmness, and ascorbic acid content; minimizes papaya fruit weight loss; and is the best treatment. The 5 mM Spd concentration also maintained the total acidity and total soluble solids and increased the total phenolic content and the activities of the SOD, POD and CAT enzymes in addition to the oxidative stress mechanism in papaya fruit. For the second experiment, the papaya fruits were immersed in L-arginine dilutions of 1 mM, 5 mM or 7 mM. Among all the treatments, the 5 mM L-arginine concentration was the most effective treatment, as it maintained the fruit aroma, pulp texture, and fruit firmness and reduced fruit weight loss. Moreover, it also maintained the titratable acidity and total soluble solids and increased the ascorbic acid, total phenolic, and activity of the SOD, POD and CAT enzymes compared with those of the control.

Induction of Polyploidy in Chrysanthemum by Colchicine

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Chrysanthemum has been cultivated as an ornamental garden plant owing to the beauty of its flower and its broad use as a cut flower. The induction of polyploidy and increase in the ornamental value of chrysanthemum are major concerns. Therefore, the application of different concentrations of colchicine (500, 1000, 1500 and 2000 mg/L) compared with the control was performed to induce polyploidy in chrysanthemum. The study sample comprised pots and experimental units, was carried out in a complete randomized design (CRD), and was replicated three times, with a total of five treatments. The reproductive and vegetative

parameters of chrysanthemum plants were examined by applying different concentrations of colchicine, and the results were subjected to statistical analysis. Statistical analysis revealed highly significant differences between the control and treated plants. The findings showed that the maximum results for the number of lateral buds (7.22 buds), chlorophyll content (46.36 SPAD), stomatal length (51.22 µm), stem width (3.93 mm), and flower diameter (10.3 cm) were observed in the 1000 mg/L colchicine treatment, which was the highest among all the treatments. Thus, the findings revealed that 1000 mg/L colchicine was the best treatment for inducing polyploidy and developing the ornamental characteristics of chrysanthemum.

Value Addition and Quality Preservation of *Helichrysum bracteatum* and *Limonium sinuatum* through Various Drying Techniques

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Value addition is a process of increasing the economic value of any floricultural commodity. When preserved and processed, flowers with beauty as well as an everlasting value can be cherished throughout the year at any occasion. A study was conducted to optimize drying techniques for preserving the flower quality of H. helichrysum and L. limonium. There were five drying procedures, viz. (air drying, sun drying, silica gel, sand and dehydrator drying at 30°C). The experiment was conducted in a completely randomized design (CRD) with five replications. Both flower species were harvested at the full bloom stage with five stems in each treatment and dried via air drying (bunches of five stems were tied with rubber bands and hung at room temperature, viz. The samples were held at 15–20°C for two weeks at room temperature or under sun drying (the stems were tied with rubber bands and hung in an open place that received direct sunlight). Silica gel and sand were poured separately into beakers, and many of the five stems whose flower heads were downward were immersed into them until complete moisture loss occurred. Dehydration of stems at 30°C in a dehydrator. A reduction in dry weight (2.5 g) for helichrysum and (3.4 g) for limonium was recorded when the stems were kept in a dehydrator, followed by silica gel (2.7 g and 3.7 g), respectively. The percentage moisture loss on a fresh weight basis was highest (92.1%) in silica gel for H. helichrysum, followed by (90.3%) in L. limonium with the dehydration method. The least mean drying time (11.4 h) was recorded for H. helichrysum, and 121.8 h was recorded for L. limonium in the dehydrator. The color of the L. oleifera flowers was 100%, followed by that of the H. helichrysum flowers (80%), with the lowest change in flower quality (2.5) for both tested flowers. The sand drying method resulted in the lowest color retention percentage (20%) and the greatest change in flower quality (5.1). It was concluded that controlled temperature drying in a dehydrator of 30°C is best among the tested techniques for both helichrysum and limonium because it results in the best color

retention and the least change in flower quality and may be used for commercial dehydration for dry flower arrangements and the use of floral stems for extended periods.

Optimizing Planting Densities and Planting Methods for High Quality Flower and Seed Yield of Rudbeckia (*Rudbeckia hirta* L.) - A Novel Annual Flower in Punjab, Pakistan

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Rudbeckia (*Rudbeckia hirta* L.), a member of the Asteraceae family, commonly known as black eyed susan, is a novel winter annual flower introduced as an ornamental bedding plant in Pakistan. In addition to its visual appeal, it also has significant ornamental and medicinal importance. A study was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab, Pakistan, from 2022--23 to optimize the planting methods and planting densities of rudbeckia in the agroclimatic conditions of Faisalabad by optimizing the planting density along with the planting methods. Three treatments were selected for planting density (22.5×22.5 cm^2, 22.5×30 cm^2 and 30×30 cm^2), along with three planting methods (flat beds, raised beds and ridges). The experiment was conducted according to a randomized complete block design (RCBD) with two factorial arrangements along with three replications of 30 plants each. The following data were collected: plant height, plant canopy, number of flowers, flower diameter, leaf area, leaf total chlorophyll content, production time, harvest index, seed yield per plant, seed moisture content and 1000-seed weight. The tallest plants (28.4 cm) were recorded when the plants were planted on ridges with a spacing of 30×30 cm. Similarly, the greatest plant canopy (32.8 cm) was recorded when the plants were planted in flat beds with a spacing of 30×30 cm. The largest leaf area (2.4 cm^2) was recorded when the plants were planted in raised beds with a spacing of 30×30 cm. Similarly, the greatest number of flowers (5.0) was observed when the plants were planted at ridges with a spacing of 30×30 cm. The highest chlorophyll content (19.2 SPAD) was recorded when Rudbeckia was planted at ridges with a spacing of 22.5×30 cm. However, the maximum production time (138.2 d) was observed when the plants were planted in flat beds with a spacing of 22.5×30 cm. The maximum flower diameter (14.03 mm) was recorded when the plants were planted in raised beds with a spacing of 22.5×30 cm. The highest seed yield/plant (2.10 g) was recorded when the plants were planted at ridges at a spacing of 30×30 cm. The optimum seed moisture content (10.2%) was recorded when the plants were planted at ridges with a spacing of 30×30 cm. The highest harvest index (10.5%) was recorded when the plants were planted on flat beds at a spacing of 30×30 cm. However, the shortest production time (125.8 d) was recorded when the plants were planted at ridges with a spacing of 22.5 × 22.5 cm. In summary, for high-quality

rudbeckia flowers and seed yield, ridge plantations with plant spacings of 22.5× 22.5 cm and 30×30 cm presented the best flower quality and seed yield.

Biochemical Activities in Pomace of Different Olive Cultivars

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Olive (*Olea europaea*) is a fruit crop with significant nutritional and medicinal value. It is cultivated globally for oil production and table purposes. During oil production, the waste material 'olive pomace' is also produced, which may possess significant biological and chemical activities, thereby having potential for industrial use. This research aimed to study the biochemical activities of pomace from different olive cultivars. The study was laid out under a randomized complete block design (RCBD) with two factor (cultivars and storage) factorial arrangements and three replications. The pomace of four olive cultivars (C_1: Arbequina, C_2: Coratina, C_3: Frantoio and C_4: Manzanilla) was subjected to frozen storage for different durations (S_0: 0 months, S_1: 1 month, S_2: 2 months, S_3: 3 months, S_4: 4 months). After each storage duration, biochemical assessments were performed for different parameters, including total soluble solids (TSS), pH, titratable acidity (TA), vitamin C, TSS/TA, superoxide dismutase (SOD), peroxidase (POX), catalase (CAT), protein content, total phenolic content (TPC) and total antioxidant content (TAC). The results revealed significant biochemical activities in the pomace of the studied olive cultivars. The storage duration also had a significant effect on the biochemical activities of olive pomace. These activities were greater in fresh pomace than in frozen pomace. The interaction effect of cultivar and storage was also significant for different biochemical activities except pH. Arbequina presented significant decreases in TSS and TA during all storage durations and in POX until S3. Coratina presented an increase in vitamin C content during all storage durations and in TPC during S3. Frantoio increased in SOD and protein activity until S3 and increased in TAC until S2. Manzanilla presented the highest CAT activity, TSS/TA ratio until S2 and pH until S4. In conclusion, olive pomace has significant biochemical properties. Hence, instead of being wasted, it should be used to extract different biochemical constituents. Compared with frozen pomace, fresh pomace has better biochemical properties. Future research can focus on evaluating mineral properties, developing novel value-added products from olive pomace and determining the impact of ultralow temperatures on biochemical activities.

Assessing the Potential of Nitric Oxide for Improving the Vase Life Performance of Cut *Gladiolus grandiflora* "Purple Flora"

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Increasing the vase life (VL) of cut flowers is important for improving profitability in the floriculture sector. Gladiolus is an important cut flower crop, but the major issue is its short VL. Various approaches have been developed by floriculturists to improve the VL of cut flowers. The application of signaling molecules such as nitric oxide (NO), hydrogen sulfide or carbon monoxide is a novel approach because of their multifunctional nature in plants, including the enhancement of the postharvest performance of horticultural produce. To increase the postharvest performance of *Gladiolus grandiflora* cv. 'Purple Flora', an experiment was conducted in which different concentrations (distilled water, 2 mL, 4 mL, 6 mL, and 8 mL) of sodium nitroprusside (SNP) were used as sources of NO to address various physiological and biochemical changes in the cut spikes of gladiolus during the postharvest period. The effects of different concentrations of SNP on the VL, spike relative fresh weight (RFW), spike moisture content, number of opened florets, number of unopened florets, flower moisture content, total protein content, catalase (CAT), peroxidase (POD), and superoxide dismutase (SOD) activities, total phenolic content (TPCs), and total antioxidant activity (TA) in the florets of gladiolus before the end of the experiment were recorded. The results revealed that 6 mL of SNP resulted in a significantly high VL (10.83 d), followed by 8 mL and 4 ml, with VLs of 7.8 and 7.3 d, respectively, and the lowest VL (5.33 d) occurred in response to gladiolus spikes treated with distilled water as the vase solution. Similarly, in terms of enhancing the VL, the 6 mL SNPs presented a significantly high RFW, followed by the 4 ml and 2 ml SNPs, whereas the lowest RFW was associated with the 8 mL SNPs. For the spike moisture content, distilled water was used, followed by 8 ml, 2 ml and 6 ml, and the lowest amount of SNP was used in 4 ml. High numbers of open florets were recorded in 6 mL of SNP, followed by 2 ml, 4 ml, and 8 ml, and the lowest number of open florets was recorded in distilled water. Distilled water resulted in a high number of closed florets, followed by 8 ml, 4 ml, 2 ml and, finally, 6 ml of SNP. However, 8 ml of SNP resulted in a significantly high flower moisture content, followed by 4 ml, 2 ml, distilled water and, finally, 6 ml of SNP. The protein content was significantly high in the 4 ml sample, followed by the 2 ml, 6 ml and 8 ml SNP samples. CAT, POD, SOD and total antioxidant activities were greater in 8 mL (SNP)-treated flowers than in control flowers. The 6 mL SNP mixture had a relatively high phenolic content, and the lowest phenolic content was detected in the 4 mL sample. Overall, the addition of 6 ml of SNP effectively increased the VL of gladiolus flowers according to the tested parameters.

Comparative Analysis of Bioactive Compounds in Fresh and Stored Citrus Peel Extracts

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Pakistan is one of the largest producers of citrus, with an annual production of approximately 2,549 thousand tons. However, the peel of citrus fruits is often wasted or discarded and can be utilized for several purposes, such as cosmetics, perfumes, baking, and medicine, due to its potential bioactive compounds. The composition of these compounds can vary significantly among different citrus cultivars. This research aims to conduct a comparative analysis of the bioactive compounds present in the peels of various citrus cultivars to explore the effects of the centrifuge extraction technique. This study included peel extracts of four citrus cultivars, namely, Kinnow (*Citrus nobilis* Loureiro × *C. deliciosa* Tenore), Musambi (*C. sinensis*), Lemon (*C. limon* L.), and grapefruit (*C. paradisi*), which were analyzed at three different storage periods, namely, 0, 7, and 14 d. The experiment consisted of quadruplicates and was conducted in accordance with a completely randomized design with two-factor factorial settings. The results revealed significant ($P \leq 0.05$) differences in phenolic, 2,2-diphenyl-1-picrylhydrazyl-radical scavenging (DPPH-RSA), and peroxidase (POD) enzyme activities among the cultivars. However, the storage period had a significant ($P \leq 0.05$) effect on the catalase (CAT), POD, and DPPH-RSA activities. The interactive effect was significant ($P \leq 0.05$) for only phenolics and DPPH-RSA. The phenolic content was the highest (1.68 mg GAE kg^{-1}) in the peel of musambi and the lowest (1.40 mg GAE kg^{-1}) in the peel of kinnow. The DPPH-RSA was highest (0.67%) in grapefruit peel and lowest (0.49%) in lemon peel. The POD activity was greatest (0.62 $U^{/mg}$ protein) in the peel of lemon and lowest (0.34 $U^{/mg}$ protein) in that of grapefruit. From 1 to 14 d of storage, the DPPH-RSA and enzymatic activities of CAT and POD decreased in the aqueous extracts of the citrus peels. Under the interaction, the phenolic content and DPPH-RSA decreased with increasing storage period; however, the decrease was slightly lower in Kinnow peel than in grape fruit.

Efficacy of Various Macro and Micronutrients on Growth, Yield and Quality of *Antirrhinum majus* L.

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Antirrhinum majus L. (snapdragon) plays a key role in landscape and is gaining popularity as a specialty cut flower. A study was conducted to evaluate the effects of various macro- and micronutrients on the growth, yield and quality of antirrhinum. Macronutrients, viz. N, P and K and micronutrients, viz. Fe, Zn and B, along with biostimulants, viz. Isabion and Ticamin Max were used in the study. Micronutrients were applied as foliar sprays three times at 15-day intervals, while a full dose of potassium and phosphorus and a half dose of nitrogen were applied to the soil at the second irrigation after transplanting, and the remaining nitrogen dose was applied at the fourth irrigation. The experiment was performed according to a randomized complete block design (RCBD) with three replications. The experimental treatments included no fertilizer application (control), N @ 90 kg ha^{-1}, NPK @ 90:45:45 kg ha^{-1}, NPK @ 90:45:45 kg ha^{-1} + micronutrients, *viz.*, Fe, Zn and B @ 0.5%, 0.5% and 0.3%, NPK @ 90:45:45 kg ha + Isabion @ 2 mL L^{-1} and NPK @ 90:45:45 kg ha^{-1} + Ticamin Max @ 2 mL L^{-1}. The results revealed that plant height, production time, flower diameter, flower quality, stem length, stem fresh weight, stem dry weight, number of marketable stems per plant, life, leaf nitrogen content, leaf phosphorus content and leaf potassium content were greatest in the plants fertilized with NPK @ 90:45:45 kg ha + Isabion @ 2 mL L^{-1}, whereas the leaf total chlorophyll content and stem diameter were greatest in those fertilized with NPK @ 90:45:45 kg ha^{-1} + micronutrients, viz. Fe, Zn and B @ 0.5%, 0.5% and 0.3%, respectively. NPK @ 90:45:45 kg ha^{-1} + Isabion @ 2 mL L^{-1} was the best combination compared with the other treatments, whereas all the other treatments performed better than the control. It was concluded that the application of macronutrients along with biostimulants could improve the flower yield and quality of snapdragon.

Exploiting Rhizospheric Bacteria for Enhanced Biocontrol of Early Blight (*Alternaria solani*) in Tomato Cultivation

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The cultivation of tomatoes (*Solanum lycopersicum*) is seriously threatened by *Alternaria solani*-induced early blight, which affects Pakistan as well as other countries. The main tool used to treat diseases is conventional fungicides; however, concerns about pathogen resistance, health risks, and environmental pollution have prompted researchers to look into other approaches. The utilization of rhizospheric bacteria for improved biocontrol has shown promise in reducing the incidence of early blight and advancing sustainable agricultural methods. In Pakistan, where growing tomatoes is a major industry, finding efficient biocontrol agents to prevent early blight is critical. *Pseudomonas* species, *Bacillus* species, and *Streptomyces* species are examples of rhizospheric bacteria that naturally have antagonistic qualities against phytopathogens such as *A. solani*. Through a variety of methods, such as competition for resources and space, the synthesis of antimicrobial chemicals, the development of systemic resistance, and the modification of characteristics that promote plant growth, these bacteria can colonize the rhizosphere of tomato plants and perform biocontrol. In addition, Pakistan's distinct environmental conditions—which include a variety of climatic zones and soil types—provide chances for the screening and selection of native rhizospheric bacteria with specialized biocontrol abilities against early blight. There is a significant chance that using these indigenous bacterial strains in sustainable disease control plans would increase tomato yield while lowering reliance on chemical fungicides. This abstract provides a broad overview of what is currently known about the use of rhizospheric bacteria for the biocontrol of early blight in tomato agriculture, with an emphasis on developments in science and applications that are pertinent to Pakistan. The difficulties of using biocontrol techniques in the field and potential paths for future studies are also discussed.

Harnessing Indigenous Microbial Solutions for Precision Management of Anthracnose Disease in Onion Cultivation Across Pakistan

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Onion farming in Pakistan is severely hampered by anthracnose disease, which is caused by fungi such as *Colletotrichum* species. The extensive reliance on conventional management strategies involving chemical fungicides has raised concerns about resistance development and environmental effects. Investigating other tactics, especially those that make use of locally available microbiological remedies, has gained more attention in the past several years. This study investigated how well-suited native microbes are for controlling anthracnose in Pakistani onion farming. Through the use of naturally occurring soil microorganisms such as fungi and bacteria as biocontrol agents, this method provides a sustainable and eco-friendly substitute for

conventional chemical treatments. Experiments carried out in Pakistan's onion-growing regions have shown encouraging outcomes. Native microbiological solutions have demonstrated efficacy in mitigating the occurrence of anthracnose and lessening the intensity of illness when used as soil supplements or seed treatments. Furthermore, by inducing plant defense responses and competing for resources, these microbial agents show promise for long-term disease control. Using native microbial solutions to control anthracnose helps preserve soil biodiversity and maintain the health of ecosystems while also addressing concerns about the build-up of chemical residues. Additionally, the use of locally produced microbial agents makes farming more affordable and accessible for farmers, especially smallholders, who support rural communities' socioeconomic growth and sustainable agricultural practices. In summary, this study underscores the feasibility of utilizing native microbiological remedies as an effective approach for accurate handling of anthracnose illness in onion production, providing enduring solutions to the problems encountered by onion cultivators throughout Pakistan.

Grafting Enhances Cucumber Growth and Productivity under Protected Cultivation in Semi-Arid Climate

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Vegetables, including cucumber, are essential sources of food and energy. The continuous cultivation of cucumber on the same land, particularly in arid to semiarid climates, leads to a reduction in growth, productivity, and quality due to various biotic and abiotic stresses. However, cucumber productivity can be sustained and enhanced by the adoption of different techniques, including grafting. Therefore, a study was planned to evaluate the impact of grafting on cucumber growth and productivity under a protected cultivation system in a semiarid climate. Cucumber (cv. Yalla F1) was grafted onto four indigenous cucurbit landraces, Sponge gourd (*Luffa aegyptiaca*), Bottle gourd (*Lagenaria siceraria*), Pumpkin (*Cucurbit pepo* L) and Ridge gourd (*Luffa acutangula*), and one exotic rootstock, Korean bottle gourd (*Lagenaria siceraria*), along with nongrafted cucumbers, was used as a control. Grafting was carried out at the 1st true leaf stage, followed by shifting to a healing chamber (with a relative humidity and temperature of 85–95% and 21–23°C, respectively) along with low light for the first 72 hours, followed by a reduction in relative humidity and an increase in light to regulate the healing process of the plants. Later, the grafted cucumber plants were transplanted (plant-to-plant

distance of 1 ft) in the field with a manual hand transplanter under the walk-in tunnel system. The study was conducted under a randomized complete block design (RCBD). Overall, statistically significant ($P \leq 0.05$) results were observed for different morpho-physio-biochemical and yield traits. The morphological (shoot and root length, shoot and root fresh and dry weight), physio-chemical (antioxidant, total phenolic, SOD, CAT, and POX), gaseous exchange (transpiration, photosynthesis, water use efficiency, stomatal conductance and substomatal conductance) and nutritive (phosphorous and potassium) parameters were recorded when the cucumber was grafted onto the Korean bottle gourd rootstock. The yield and related parameters (fruit diameter and fruit length) also reached a maximum when cucumber was grafted onto the Korean bottle gourd rootstock. In conclusion, the use of cucumber plants grafted onto Korean bottle gourd rootstock may be an effective approach for improving cucumber growth, yield, and quality under the protected growing conditions of a semiarid environment.

1-MCP Cards–An Innovative Environment Friendly Approach to Mitigate Ethylene Sensitivity and Extend Postharvest Longevity of Cut Chrysanthemum

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Dendranthema grandiflorum, a member of the family Asteraceae, is one of the three best-selling cut flowers in the world. The market value of any cut flower is dependent upon its visual appearance, which further depends upon flower wilting or leaf discoloration. The postharvest life of chrysanthemum stems is affected by leaf yellowing prior to petal senescence, which might be induced by internal hormonal imbalance and long and dark storage or transport conditions. Therefore, the prime concern in improving the commercial significance of chrysanthemum is postharvest management, which could improve its postharvest performance and commercial appeal. A study was conducted to evaluate the ability of various commercial 1-MCP cards to inhibit the adverse effects of ethylene and extend the vase life of cut chrysanthemum during storage and transportation to markets. The cut chrysanthemum stems were harvested at commercial maturity and shipped to the Commercial Floriculture Laboratory, University of Agriculture, Faisalabad, Pakistan, during 2023, within 6 hours of harvest. The treatments included 1-MCP cards or no 1-MCP card (control) at ambient temperature (25±2°C) or cold storage (4±2°C) for 7, 10 or 14 days, respectively, to mimic transportation. The results demonstrated that the change in fresh weight (g) for evaluating the vase life of chrysanthemum stems was statistically independent of the 1-MCP card. The

Chrysanthemum stems were terminated immediately after storage at 25±2°C and after 7, 10 and 14 days of storage. However, the stems stored at 4±2°C for 7 and 10 days were fresh and marketable (6). Water uptake was independent of all the treatments. The carotenoid and anthocyanin contents were highest at 4±2°C for 7 days with 1-MCP card I (4.11 mg mL^{-1}**)** (0.94 mg 100 g^{-1} FW) and lowest at 10 days (1.53 mg mL^{-1}) (0.02 mg 100 g^{-1} FW). The TPC was highest at 4±2°C for 7 days with 1-MCP cards I and II (633.96 and 589.93 mg GAE $^{100–1}$ g) and lowest at 4±2°C for a storage duration of 10 days (157.91 mg GAE $^{100–1}$ g). Antioxidants were more common at 4±2°C for 7 days when 1-MCP cards were used (4643.30). Antioxidants were lower at 10 days with no 1-MCP cards (1562.84). The Vase life of chrysanthemum stems was not significantly affected by the 1-MCP card II. However, the Vase life of chrysanthemum stems was significantly affected by the 1-MCP card I when they were stored at 4±2°C (8.5 days). In summary, chrysanthemum stems may be stored for 7 days at 4±2°C along with the placement of 1-MCP card I in the sealed packaging box.

Optimizing Postharvest Handling Protocols for Cut Gerbera Stems

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Gerbera (*Gerbera jamesonii* L.), also known as gerbera daisy, transvaal daisy, or barberton daisy, is a member of the Asteraceae family. Because it is highly perishable, it needs to be handled carefully from harvest to market, and its postharvest handling protocols need to be optimized. Therefore, a series of experiments were conducted to optimize postharvest handling protocols for cut *Gerbera jamesonii* stems. In Experiment I, different harvest stages, viz. bud stage, partially open bloom, and fully open bloom were compared. In Experiment II, the handling procedure, viz. wet–wet, wet–dry, dry–dry, and dry–wet samples were compared. In Experiment III, different vase water qualities, viz. Water, canal water, and distilled water were used to determine the best suited water to handle cut gerbera stems. In Experiment IV, different pulsing preservatives, viz. Control (distilled water), 2% sucrose + citric acid, 7up + distilled water (50:50), 2% sucrose + aspirin, 2% sucrose + salicylic acid, 2% sucrose + aluminum sulfate, 2% sucrose + lemon juice, 2% sucrose + vinegar, 2% sucrose + bleach and Chrysal Clear Flower Food were compared. In Experiment V, different vase preservatives, viz. Control (distilled water), 2% sucrose, 2% sucrose + salicylic acid, 2% sucrose + citric acid, 5% sucrose, 2% sucrose + aluminum sulfate, distilled water + 7 up (66:33), 2% sucrose + lemon juice, 2% sucrose + vinegar, 2% sucrose + 2 Aspirin tablets, 2% sucrose + bleach, 2% sucrose + gibberellic acid (GA) + benzoic 3-aminopurine (BA) + citric acid (CA), 2% sucrose + citric acid + aluminum sulfate and Chrysal Clear Flower Food were used until termination to determine the best preservative for extending the longevity of cut stems. The experiments were carried out according to a completely randomized design (CRD) with five replications individually and evaluated in a vase life evaluation room set at 25 ± 2°C°C and 50 ± 10% relative humidity along with a 12 h photoperiod from white florescent tubes. The results revealed that gerbera stems harvested at the bud stage and partial bloom opening stage presented the longest vase life (16.6 and 15.2 days, respectively). The wet handling of gerbera stems maintained flower quality along with postharvest longevity when the stems were subjected to wet–wet conditions, with a vase life of 13 days, and the flower quality changed the least. The gerbera stems held with distilled water during processing and handling presented the longest vase life (8.4 days) and the highest water uptake (73 mL). Compared with commercial preservatives, gerbera stems pulsed with 7up + distilled water (50:50) performed best in terms of vase life, followed by those pulsed with 2% sucrose + aluminum sulfate, with vase lifetimes of 14 and 12.5 days, respectively. For vase preservatives, 2% sucrose + aluminum sulfate, distilled water plus 7-up (66:33) and Chrysal Clear Flower Food had similar effects on increasing the vase life of cut gerbera stems (15.5, 14.1 and 14.5 days, respectively). In conclusion, gerbera stems should be harvested at the 25–50% open floret stage, handled in wet (water) conditions from harvest to marketing, kept in distilled water rather than tap water and treated with lemon/lime soda and water or 2% sucrose plus aluminum sulfate for the longest postharvest longevity of cut stems.

Standardization of Pruning Intensity of Pomegranate for its Quality Production

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Pomegranates, hardy fruit plants, can grow well climatically in tropical to temperate regions. The training of pomegranates is practiced to train the frame of the plant as single- or multistemmed and to subsequently increase productivity. The current study was conducted on 3-stemmed trained plants aged 5 years to determine the best pruning intensity for better quality and yield of pomegranate (cv. Golden) from 2020–21 and 2021–22 at Horticultural Research Station, Bahawalpur, Pakistan. The four treatments, with T_1 as the control (unpruned) and the other containing pruning of side branches from the tip to the base up to 20 cm (T_2), 40 cm (T_3) and 60 cm (T_4), were carried out during the 2nd fortnight of November. All pruning levels (20–60 cm) significantly affected fruit productivity, quality and biochemical parameters.

However, 60 cm pruning (T_4) yielded maximum values for average yield per plant (56 kg), fruit size (50 cm^2), fruit weight (253 g), number of arils per fruit (319), aril weight (170.4 g), rind weight (79.9 g), rind thickness (2.4 mm), total sugars (14.5%), total soluble solids (15.3 °Brix), and juice (39.9%), with a minimum number of fruits per plant (186) and minimum fruit acidity (0.23%) from means calculated over two years of data. Unpruned plants (T_1) had minimum values for yield per plant (42 kg), fruit size (39 cm^2), weight of single fruit (172 gram), arils in single fruit (262), aril weight (118.6 g), rind weight (52.5 g), rind thickness (1.9 mm), total sugars (13.2%), total soluble solids (14.1°Brix), juice (36.1%) with maximum fruits on a single plant (238) and the highest acidity of fruit (0.28%). Hence, 60 cm pruning (T_4) of side branches from tip to base can be used to increase the fruit production and quality parameters of the golden variety of pomegranate in the semiarid region of southern Punjab, Pakistan.

Potting Mix Standardization will help the Ber Rootstock Germinate More Easily and Grow Faster

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Ber/Jujube (*Zizyphus mauritiana* Lamk.) fruit is a popular minor fruit due to its high economic returns, low cost of cultivation, and wide ability to withstand drought conditions. The ripe fruits are mostly consumed fresh or crushed and mixed with water and sugar to form a ready-to-severe drink. Dried fruits are also eaten or used in candy. Seed germination and subsequent growth are influenced by physical interactions with soil particles in dense and compact soils, but root–soil contact is essential for optimal growth and the uptake of water and nutrients. To improve the germination and growth of Ber rootstock in pots because of its rapid growth and extended storage of nursery plants under a lath house, an experiment was conducted at Horticultural Research Substation, Dera Ghazi Khan, from 2020–22. Seeds of desi ber were soaked in water for 03 days prior to sowing in polythene bags filled with soil media by volume as follows: 5 treatments, i.e., 100% silt (T_1), 80% silt+ 20% peat moss (T_2), 60% silt + 40% peat moss (T_3), 40% silt + 60% peat moss (T_4) and 20% silt +80% peat moss (T_5), to raise seedling stocks for grafting in CRD formations, with 3 replications. The results obtained indicate that the maximum germination (63.56%), grafting success (55%) and length of the scion (9.21 cm) were obtained by the combination of 80% silt + 20% peat moss (T_2), and the same treatment required a minimum of 133.56 days to achieve budable thickness and a minimum of 76 days by which the grafted plants were transplanted. The maximum stem thickness (8.73 mm) was

achieved by the combination of 60% silt + 40% peat moss (T_3), and the same treatment resulted in the maximum number of days (20.91 d) on which the scion sprouted. Both combinations are useful for raising Ber nursey in polythene bags.

Standardization of Technique to Enhance Shelf Life of Jujube

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Jujube (*Zizyphus mauritiana* Lamk**.**) Locally known as Ber, it is considered an underutilized fruit crop in semiarid regions of the world and can be successfully cultivated in the marginal ecosystem of the subtropics and tropics. Ber fruit is generally eaten fresh and is a rich source of ascorbic acid, essential minerals and carbohydrates. Standardized storage conditions are not available for commercial recommendations. Ber fruits exhibit climacteric respiration behavior. The postharvest quality and shelf-life of Ber fruits are influenced by both pre- and postharvest factors. The storage life of Ber fruits is extremely short because of their rapid perishability and heavy postharvest losses, and they cannot be delivered to distant markets. Profits could be enhanced by increasing shelf-life and minimizing postharvest losses. Therefore, a standardized technique for enhancing shelf-life is urgently needed. Hence, an experiment was conducted at Horticultural Research Sub Station, Dera Ghazi Khan, from 2020--2022 to increase the shelf life of Ber for distant marketing. Semiripe fresh fruits of the Pak White variety at full maturity were rinsed with 5 concentrations of $CaCl_2$ solution ranging from 1 to 5% (T_1--T_5), and untreated fruits dipped in distilled water (T_6) were used as controls, with 3 replications in the CRD. One hundred fruits were used per treatment per replication. The treated fruits were kept at room temperature. The results clearly revealed that the maximum average loss of fruit weight on a daily basis (15.2 g) was associated with 3% $CaCl_{2,}$ with maximum shriveling (7%) and senescence (5%). The maximum fruit TSS (16.6°Brix) was recorded in response to 2% $CaCl_2$ (T_2), and the minimum degree of senescence (2%) occurred on a daily basis. The minimum loss of fruit weight (5.3 g) on a daily basis was noted by 1% $CaCl_2$ (T_1).

Evaluation of Scent Attributes and Floral Essential Oils in Different Rosa Species

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Rose is the most prevalent and renowned flower in the entire horticulture sector. These plants have been intentionally cultivated and refined over the course of 5000 years in the ancient civilizations of China, Western Asia, and Northern Africa. They consistently held a leading position in the floriculture trade and have expanded into a diverse industry that specializes in fresh flowers and value-added goods. The Netherlands is a leading exporter alongside other significant contributors, such as Ecuador, Kenya, Germany, and China. Pakistan contributes little to the import and export of fresh and dry roses. *Rosa damascena*, *R. centifolia*, "Gruss a Teplitz," *R. chinensis*, and *R. hybrida* are well versed for their commercial attributes, graceful aesthetics, and strong aroma. Rosa extracts and essential oils include several bioactive components, such as phenols, flavonoids, carotenoids, and anthocyanins, which have potent antibacterial and antioxidant properties. The extraction of rose essential oils is often performed via a CO2 supercritical extraction process. The evaluation of these oils involves techniques such as the Folin–Ciocalteu reagent method, colorimetric assays, the sulphur dioxide bleaching method, high-performance liquid chromatography (HPLC) and gas chromatography–mass spectrometry (GC–MS). This paper explores the commercial potential of rose, its essential oil and quality evaluation via modern and conventional techniques and compares their robustness efficiency. It can be a highly lucrative business if it is performed properly on a commercial basis.

Application of Seaweed Extract and Chemical Compounds Enhanced the Resistance against Early Blight (*Alternaria solani*) in Tomatoes

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Early blight is the most destructive fungal disease of tomatoes caused by *Alternaria solani*. It affects both the yield and quality of tomatoes in all growing regions of the world. Fungicides are primarily used to control early blight; however, fungicide applications have residual effects on agricultural commodities, posing a threat to human health and the environment. Thus, it is necessary to develop ecofriendly alternative disease control methods that have minimum residual toxicity in harvested tomatoes. An experimental trial was conducted to evaluate the ability of seaweed extract and other chemical compounds (salicylic acid and imidacloprid) as elicitors to induce resistance in tomato against early blight. Different concentrations of seaweed extract, imidacloprid, salicylic acid and azoxystrobin (check) were evaluated under laboratory and greenhouse conditions. The experiment was repeated twice, and data were recorded for mycelial growth, disease severity and plant growth parameters, along with an assessment of defense-related enzymes. The results revealed a significant ($P \leq 0.01$) reduction in the mycelial growth of *Alternaria solani* treated with the seaweed extract and salicylic acid. Compared with those in the control treatment, the growth of the tomato plants in the seaweed extract treatment was greater. The results also revealed increased enzymatic activity in treated plants, which indicates the possible role of the listed enzymes in inducing resistance against early blight in tomatoes. The introduction of elicitors into tomato crop production will reduce the application of fungicides and thus contribute to the development of sustainable and safe agriculture.

Optimizing Guava Seedling Growth: Impact of Diverse Potting Media on Physiochemical Composition and Vegetative Parameters

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The choice of potting media significantly influences the growth and development of fruit plant seedlings. Given the importance of potting media, an experiment was conducted under controlled conditions to evaluate the impact of different potting media on Guava seedling growth and development. Approximately nine growing media (i.e., sand, silt, clay, garden soil, compost, rice husk, cotton ginning material, wheat straw and farmyard manure) were used to make different growing mixes. The experiment was conducted at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad. The trial followed the CRD design, the data were analyzed via ANOVA, and the means were compared via the least significant difference (LSD) test at the 5% significance level. Physiochemical analysis of the pot mixtures was performed along with determination of seedling vegetative growth and physiological parameters. The outcomes highly significantly varied among the physicochemical contents of the pot mixtures. Among the pot mixtures, the combination of FYM + silt + compost and silt + wheat straw + compost resulted in relatively high nutritional values, along with the optimum pH and EC values. Similarly, the pot mixture strongly influenced the growth of guava seedlings, with the highest results obtained from the silt + sand + wheat straw mixture, which had a prominent impact on the vegetative and physiological parameters. The results revealed that the maximum

germination percentage (73%), root length (0.4 cm), fresh weight (73 mg) and highest number of leaves per seedling (7) were recorded in the silt + sand + wheat straw treatment. Similar outcomes were observed for the physiological parameters, in which different growing mixes affected the chlorophyll content, photosynthetic rate, stomatal conductance and transpiration rate of guava seedlings. These findings emphasize the importance of careful potting media selection for optimizing guava seedling establishment and growth, paving the way for future research on tailoring mixes for specific needs and environments.

Sequestration of Arsenic Using Cuo-Modified Biochar: Kinetics and Modeling

Muhammad Shafique Khalid[1*], Aiman Saddique[1], Muhammad Imran[1], Behzad Murtaza[1], Samina Khalid[2], Muhammad Amjad[1], Muhammad Asif Naeem[1], Hafiz Faiq Siddique Gul Bakht[1] and Atyab Amjad[3]

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Elevated levels of arsenic (As) in water pose a significant threat to human health, soil, plants and ecosystems. Biochar-based sorbents offer an efficient and eco-friendly solution for removing As from contaminated aqueous systems. The current study investigated the effectiveness of biochar prepared from carrot pulp (CPB) and its nanocomposite with copper oxide nanoparticles (CPB/CuO) for removing As from polluted water via batch-scale experiments. The effects of various parameters on As removal from water, including adsorbent dose (0.5–2 g/L), contact time (0–180 min), initial As concentration (1–10 mg/L), solution pH (3, 5, 8), and temperature (25, 30, 45°C), were evaluated. The results revealed that CPB (92% to 97%) and CPB/CuO (96–98%) demonstrated high As removal efficiencies when the As concentration was varied from 1–10 mg/L. The performance of the CPB/CuO process was better because of its enhanced surface characteristics. The experimental adsorption data were well described with the Freundlich and pseudo-second-order adsorption models. Overall, this study demonstrated that the CPB/CuO nanocomposite is a promising biochar-based composite for As removal from water. Further investigations are needed to increase the potential of nanocomposites for the sequestration of As and other contaminants from water.

Multivariate Analysis of Arsenic Accumulation and Associated Risks in District Vehari Orchards, Pakistan

Muhammad Shafique Khalid[1*], Nimra Farooq[1], Muhammad Imran[1], Behzad Murtaza[1], Samina Khalid[2], Muhammad Amjad[1], Muhammad Asif Naeem[1], Hafiz Faiq Siddique Gul Bakht[1] and Atyab Amjad[3]

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Food security and contamination of natural resources have become the most critical concerns across the globe, especially in low-income countries such as Pakistan. The contamination of water, soil, and plants adversely affects human health. In the present study, 60 orchards (20 from each tehsil, i.e., Burewala, Mailsi and Vehari) in District Vehari were selected, and soil, plant and irrigation water samples were collected. This study aims to assess heavy metal (loid) (As) contamination in irrigation water, soil, and plant leaves (mango, Kinnow mandrin, guava and falsa). The physicochemical parameters of the irrigation water samples, such as pH, electrical conductivity (EC), total dissolved solids (TDS), carbonates (CO3), bicarbonates (HCO3), chloride (Cl), and sulfate (SO4), were analyzed. The results revealed that the As concentration in the irrigation water ranged from 0.2–69.9 µg/L, with a mean concentration of 16.2 µg/L. In the soil, the As concentration ranged from 0.1–83.6 µg/L, with an average concentration of 44.6 µg/L. Moreover, in the plants, it ranged from 0–50.6 µg/L, with an average concentration of 9.18 µg/L. Overall, 40% of the irrigation water samples, 91.6% of the soil samples and 28.3% of the plant samples presented As levels higher than the WHO limit (10 µg/L). Furthermore, 11.6% of the irrigation water samples, 45% of the soil samples and 1.67% of the plant samples presented higher As levels than the permissible limit notified by Pak-EPA (50 µg/L). The possible potential human health risks due to As in contaminated water and soil were evaluated by calculating the hazard quotient (HQ), average daily dose (ADD), estimated daily intake (EDI), and cancer risk (CR). The mean values of hazard HQ, ADD, EDI and CR were 1.5, 0.0005, 0.0000 and 0.01 for As, respectively. On the basis of the current findings, As in the water and soil of orchards in Vehari is relatively high, which demands attention from policy makers to minimize human health risks.

Advances in Citriculture Industry of Afghanistan

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The citrus industry in Afghanistan faces development challenges in response to a local unsatisfied fresh citrus demand of two hundred thousand tons (200,000 tons). The eastern region of Afghanistan has favorable climatic conditions for growing citrus. To respond to this demand, the Afghan government, with the support of the EU, has implemented the Perennial Horticulture Development Project – Afghanistan (www.afghanhorticulture.org); this project was employed to support the Ministry for Agriculture of Afghanistan. The main goal was to strengthen perennial horticulture through the development of a highly standardized nursery sector and the adoption of local genetic resources. Citrus has been surveyed in a wide area of East Africa, and germplasms have been collected. The current GPU holds 70 different labeled and recorded varieties, among which 50 varieties are imported from abroad, mainly from Italy. Then, mother stock nurseries (MSNs) are established from the best performing varieties, and the registered nursery growers take certified bud wood from these MSNs and produce certified plants. Citrus growers transplant certified citrus plants in their orchards to ensure the health and authenticity of the trees. Recently, citrus orchards have been established with drip irrigation systems, the results of which are promising; thus, more growers want to grow with drip irrigation in the future in Afghanistan.

Embracing Climate-Smart Horticulture through Climate-Resilient Crop Varieties and Precision Agriculture

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This abstract explores the imperative shift toward climate-smart horticulture and the pivotal role played by climate-resilient crop varieties and precision agriculture in achieving sustainability and adaptability in the face of climate change. This paper delves into the importance of selecting and breeding crops with enhanced resilience to climatic extremes, outlining the tangible benefits of such varieties. Furthermore, it discusses the transformative impact of precision agriculture, leveraging advanced technologies to optimize resource management, minimize environmental impact, and ensure the resilience of horticultural practices. The synthesis of climate-resilient crop varieties and precision agriculture has emerged as a synergistic approach, offering a pathway to sustainable food production and

agricultural systems resilient to the challenges imposed by a changing climate. The author underscores the importance of embracing these innovations as a holistic strategy to manage the complexities of climate change in the realm of horticulture.

Two *Bactrocera* Species Preference and Performance on Three Different Fruits

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Across the world, but particularly in Asia, *Bactrocera dorsalis* and *B. correcta* (Diptera: Tephritidae) are infamous fruit crop flies. After *B. dorsalis*, *B. correcta* is currently the second most infamous fruit fly in China. Understanding their olfactory and ovipositional behavior is vital for designing reliable control strategies. Most *Bactrocera* species prefer to lay their eggs inside fruits with soft skin. There are few detailed studies on the predilection of B. correcta for oviposition on different fruits or the growth of its offspring. As a result, this study presents for the first time how *B. correcta* behaves on banana, guava, and mango in contrast to *B. dorsalis*. The findings revealed that there were fewer male *B. correcta* and *B. dorsalis* flies on each fruit. Compared with the other two fruits, mango fruit attracted more female *B. dorsalis* and *B. correcta* flies. Compared with the other two fruits, the mango fruits produced substantially more oviposition punctures from female *B. dorsalis* flies. The number of oviposition punctures made by female *B. correcta* flies was markedly greater on guava fruits than on the other two fruits. Mangoes were most favorable for the development and survival of both species, e.g., *B. dorsalis and B. correcta*. β-Caryophyllene and 3-carene were the major volatile components among the three fruits. This study might be helpful for bait application to female adults of *B. dorsalis* and *B. correcta* on farms and in orchards.

In Vitro Callus Induction and Assessment of Physicochemical Attributes in *Stevia rebaudiana* by Standardizing MS Media Protocols

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The cultivation and sustainable use of medicinal plants are critical for human health, especially in developing nations with a rich legacy of such medicine. However, the increasing demand for medicinal plants, driven by their commercial value, has led to environmental and geopolitical challenges, putting several species at risk of extinction. This study focused on *Stevia rebaudiana*, a plant known for its therapeutic and commercial importance, which is native to Paraguay and cultivated globally. The unique properties of stevia, including its sweetness derived from stevioside, make it a valuable alternative to sugar, particularly beneficial for individuals with diabetes and those who are conscious of their diet. This paper discusses the challenges in stevia cultivation, such as the slow germination of seeds and limitations in traditional propagation methods. Micropropagation has emerged as a potential solution for addressing issues related to seed germination and uniformity. This study explored the impact of plant growth regulators, specifically 2,4-D, on callus induction from stevia leaf explants. The callus weight also increased with increasing 2,4-D concentration, reaching a maximum at $^{2\ mg/L}$. Total phenolic content (TPC) in calli induced with different 2,4-D concentrations. A significantly high TPC was observed at 2.0 $^{mg/L}$ 2,4-D, suggesting its potential as an effective concentration for phenolic compound production. In conclusion, this research optimizes culture conditions for *in vitro* callus induction in stevia, providing insights into the physical and biochemical attributes of the induced callus. These findings contribute to the understanding of sustainable cultivation practices for medicinal plants, address challenges in propagation and emphasize the potential for *in vitro* methods to increase the production of bioactive compounds to address food security issues worldwide.

Beyond Taste: Genetic Determinants of Organic Acids in Chinese Plum Revealed by Integrative Omics Analysis

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The Chinese plum (*Prunus salicina* Lindl.) is an important commercially produced stone fruit that accumulates high amounts of organic acids with numerous health benefits. Organic acids are key components for determining the flavor of any fruit. Here, to identify potential genes involved in organic acid accumulation in plums, metabolomic and transcriptomic analyses of plum fruits were performed at four developmental stages (fruitlet, green, veraison, and mature). The results suggest that malic acid was predominant among the eight organic acids analyzed. RNA-Seq analysis revealed a total of 26,547 unigenes, of which 7,584 represented 28.56% differentially expressed genes (DEGs). In addition, 11 enzyme-encoding genes, 21 transporter genes and 5 MYB transcription factor genes involved in malic acid accumulation were identified. Our combined transcriptomic and targeted metabolomic analyses provide new comprehensive insights into the genetic control of fruit acidity in plums, which will be useful for future breeding.

Comprehensive Genomic Exploration of Class III Peroxidase Genes in Guava Unravels Physiology, Evolution, and Postharvest Storage Responses

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[†]These authors contributed equally to this work.

Peroxidases (PRXs) have diverse functions in plant growth, development, and response to stress. This study conducted a thorough analysis of the *PRX* gene family in guava, a globally significant fruit. Within the guava genome, 37 *PRX* genes were identified, a count lower than that in Arabidopsis, indicating a unique gene family expansion pattern. Phylogenetic analysis revealed close relationships with Arabidopsis *PRXs*, with 12 *PgPRX* genes forming ortholog pairs, indicating a specific expansion pattern. Most PRX proteins are predicted to localize in the chloroplast and extracellular regions. Structural analysis of PgPRX proteins revealed similarities in domain structure and motif organization. Synteny analysis emphasized the impact of segmental duplication on the evolution of guava *PRX* genes. The dynamic expression of *PgPRX* genes across guava tissues revealed functional diversity. Additionally, changes in peroxidase levels and gene expression during postharvest fruit storage were examined, offering insights for preserving fruit quality. This study provides the initial genome-wide identification and characterization of class III peroxidases in guava, laying the groundwork for future functional analyses.

Other Abstracts

Thiamine Helps to Regulate the Morphological and Phsio-Chemical Process in Sunflower (*Helianthus annuus* L.) Cultivars under Heat Stress

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High temperatures resulting from anthropogenic activities present significant ecological stress for plants. Heat stress adversely affects various morphological and physio-biochemical processes in plants, posing a threat to the productivity of essential crops such as sunflower, which contributes 8% of global oilseed production. This study aimed to explore the protective effects of foliar application of thiamine (vitamin B_1) at different concentrations (0, 80, and 100 mL^{-1}) on the morphophysiological growth, yield, fatty acid composition, and oxidative metabolism of two sunflower (*Helianthus annuus* L.) cultivars, namely, Hysun-39 and Gulshan, under normal (25°C) and heat stress (45°C) conditions. The heat stress applied to the plants one month after germination induced oxidative stress by promoting the overproduction of reactive oxygen species (ROS), such as H_2O_2 and OH, leading to an increase in the malondialdehyde content. Consequently, this oxidative stress resulted in diminished photosynthetic components, growth, and yield attributes. However, foliar application of thiamine, particularly at concentrations of 80 and 100 mL^{-1}, mitigated the impact of heat stress, increasing these parameters. Thiamine application also significantly increased the activities of antioxidants, specifically catalase and peroxidase. Additionally, the cultivar Hysun-39 performed better under both control and heat stress conditions than did the Gulshan cultivar. In conclusion, the exogenous application of thiamine (100 mL^{-1}) effectively enables plants to withstand heat stress by regulating various physiological and biochemical mechanisms. This agricultural approach holds great potential for alleviating the detrimental effects of heat stress on crops through the foliar application of thiamine.

Role of Riboflavin to Mitigate Chromium Toxicity in Maize (*Zea mays* L.) Cultivars

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Chromium (Cr) stress poses a serious threat to ecosystems and drastically affects crop production and food security. The goal of this study was to determine the impact of foliar application of riboflavin (RF) on several *Z. mays* cultivars grown under Cr contamination. This study was carried out in the botanical garden of Government College University, Faisalabad, Punjab, Pakistan. Seeds from two *Z. mays* cultivars, Pearl (Cr tolerant) and Sadaf (Cr sensitive), were grown under Cr stress (0 and 200 µM). Our results revealed that Cr stress markedly decreased plant growth, dry mass, chlorophyll pigments, and photosynthetic efficiency and essential nutrients in *Z. mays* plants. However, Cr stress increases ROS production by increasing the MDA content and H_2O_2 initiation in membrane-bound organelles. However, the enzymatic and nonenzymatic performance increased with increasing Cr stress in the sand. Although the uptake of Cr in plants and its translocation from roots to shoots increased under Cr stress, roots accumulated more Cr than did shoots. The reduction in the growth parameters of *Z. mays* plants caused by chromium was lower in the tolerant cultivar than in the sensitive cultivar. The foliar application of riboflavin (0, 50 and 60 mg/L) mitigated the toxic effects of Cr by increasing the plant fresh and dry weights, rate of photosynthesis and nutrient production. It also enhances the antioxidant machinery of plants by reducing the MDA content and H_2O_2 initiation in *Z. mays*. These findings suggest the use of riboflavin application to reduce the toxic effects of chromium stress.

Conference Summary

The Department of Horticultural Sciences (DHS), Faculty of Agriculture and Environment, The Islamia University of Bahawalpur (IUB) organized the 8th International Horticulture Conference of Pakistan Society for Horticultural Science (PSHS) and first ever Horti-Expo of South Punjab (IHCE-2024) on February 26-28, 2024, at the Khawja Ghulam Farid Auditorium, IUB. The theme of the event was 'Innovations in Sustainable Horticulture'. Approximately 500 registered professionals, including academics, researchers, extension workers, government officials and leaders, together with horticultural crop growers, traders, exporters, input suppliers and service providers, participated in the event, along with approximately 10,000 walk-in visitors of Horti-Expo. The exhibitors of Horti-Expo included growers and nursery businesses, traders (exporters, importers, domestic businesses, online traders), input suppliers (fertilizers, pesticides, seeds), service providers (processors, logistic & storage companies, advisory/extension services), food industries, machinery and equipment businesses, academic and research institutions, regulatory/certification bodies, social enterprises and other relevant organizations. The key activities included inaugural ceremonies, expos, technical sessions (presentations by scientists, researchers and other stakeholders), poster presentations, annual general body meetings of PSHS, cultural evenings, closing ceremonies and field visits. Overall, approximately 205 abstracts were received from various national and international scientists. Among these abstracts, 74 abstracts were accepted for oral presentation and were arranged in 8 different technical sessions. Among the submitted abstracts, 131 were accepted for poster presentation at IHCE-2024. The scientists highlighted their research work as flex posters in the poster gallery. The evaluation of posters was independently performed by a panel of experts, and awards and appreciation certificates were provided to the winners. Overall, IHCE-2024 provided valuable opportunities for awareness, branding and networking for stakeholders and led to the establishment of future R&D and outreach goals to improve the role of the horticulture sector in achieving global sustainability.

Conference Recommendations

Prof. Rtd. Dr. Muhammad Akbar Anjum, Former Chairman Department of Horticulture, Bahauddin Zakariya University, Multan presented the conference recommendations, which are provided below.

- Fertilizer and water use efficiency need to be improved through the adaptation of high-efficiency irrigation systems.
- Vegetable grafting has been adopted in more than 28 countries across the world; Pakistan needs a special focus on this topic.
- Ornamental Horticulture and Landscaping require special attention as an industry.
- Protected cultivation needs to be utilized for diverse crops.
- Alternative crops, such as dragon fruit and papaya, need to be explored.
- Development and promotion of climate smart technologies for improving the yield and quality of horticultural crops.
- The use of breeding and biotechnological approaches for horticultural crop improvement is needed.
- Genetic diversity and the diversification of products, markets and value addition are needed over time.
- Food safety, quality and reduced postharvest losses are the key criteria for sustainable and profitable supply chains.
- The transformation of horticulture waste materials to useable products should be a focus.
- Focus should be placed on seed sector development to reduce the number of seed imports.
- Sustainable introduction of corporate sector and cooperatives in agricultural production, trade and logistics.
- Joint ventures with potential national and international organizations for research, technology and processing in horticulture.
- Consumer-focused product development.
- International supermarket access.
- Focus on worker’s health, education and well-being.
- Strengthening of academia–industry linkages and private sector involvement in policy development and execution.
- A private sector-led horticulture development and marketing initiative is needed.
- Needs-based R&D and solutions are needed for the horticulture industry.
- There is a dire need for technical, financial, and capacity-building support in horticulture.

Poster Award Winners

Position Holders*	
1st position	1-MCP Cards – An Innovative Environment Friendly Approach to Mitigate Ethylene Sensitivity and Extend Postharvest Longevity of Cut Chrysanthemum **Amina Zulfiqar**, Iftikhar Ahmad, Tazkia Hussain, Ahmad Sattar Khan and Mehmood Ul Hassan Institute of horticultural sciences, University of Agriculture, Faisalabad, Pakistan
2nd position	Biotic stress resilience in passion fruit exploring the role of gene in molecular defense against Fusarium species **Xiaobo Hu** and Muhamamd Moaz Ali College of Horticulture, Fujian Agriculture University, China
3rd position	Sustainable Vertical Gardening in Urban Spaces using IoT based Technologies **Aneeqa Sahar Janjua,** Basit Shehzad, Umer Habib, Shoaib Saleem and Muhammad Azam Khan PMAS Arid Agriculture University Rawalpindi, Pakistan
Best Poster Awards**	
1	Effect of Grafting Combinations and Grafting Time on the Growth of Mango Varieties **Ali Raza Jamali,** Niaz Ahmed Wahocho, Noor-Un-Nisa Memon, Shamshad Jamali and Adeel Ahmed Khaskheli Sindh Agriculture University Tandojam, Sindh, Pakistan
2	Assessing the Potential of Nitric Oxide for Improving the Vase Life Performance of Cut Gladiolus grandiflora "Purple Flora" **Asma,** Faisal Zulfiqar, Muhammad Nafees, Muhammad Wasim Haider and Ruqayya Department of Horticultural Sciences, The Islamia University Bahawalpur, Paksitan
3	Nanotechnology for Sustainable Horticulture amidst Abiotic Challenges in Pakistan **Syeda Anum Masood Bokhari**, Tanveer Ahmad, Roqia Nazir, Alishba Shahid, Asia Bibi, Hafiz Nazar Faried and Bilal Ahmad Department of Horticulture, MNS-Agriculture University Multan, Pakistan
4	Sustainable Foodscape management, key opportunities and challenges **Arooba Abbas** Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Paksitan
5	Impact of Octanoic Acid on Food-Borne Pathogens and Quality of the Mabroom Dates (*Phoenix dactylifera* L.) **Ali Hamid Mohammed** Agricultural Research Corporation, Integrated Pest Management Center, Sudan

*These winners received the shields as tokens of appreciation.

** These winners received certificates as tokens of appreciation.

Exhibiting Organizations (Horti-Expo South Punjab 2024)

1. Bazargankala Co. Tehran, Iran
2. Engro Fertilizers Ltd., Pakistan
3. ACIAR/Australian Aid-funded Citrus Value Chain Project (HORT/2020/129)
4. MG Agri. Foods, Multan
5. Moon Star Seeds Pvt. Ltd, Hyderabad
6. FB Exporters, Multan
7. The Mango Company, Jalalpur Pirwala
8. Mehar Landscaping Company, Pattoki
9. Green Circle, Lahore
10. Al-Hadi Impex Pvt. Ltd, Multan
11. Al-Qasim Bagh, Dera Ghazi Khan
12. Food For Life, Dera Ghazi Khan
13. Alif Khan Afridi Drip Irrigation Parts Suppliers, Rawalpindi
14. Pak Diamond Food Factory, Bahawalpur
15. ASARI Water Solutions, Bahawalpur
16. Pakistan Horticulture Development and Export Company (PHDEC)
17. Institute of Horticultural Sciences, University of Agriculture Faisalabad
18. PMAS Arid Agriculture University, Rawalpindi
19. Mango Research Institute, Multan
20. Citrus Research Institute, Sargodha
21. Fruit Research Institute, RARI, Bahawalpur
22. Department of Plant Protection (DPP), Government of Pakistan
23. Department of Horticultural Sciences, FA&E, The Islamia University of Bahawalpur

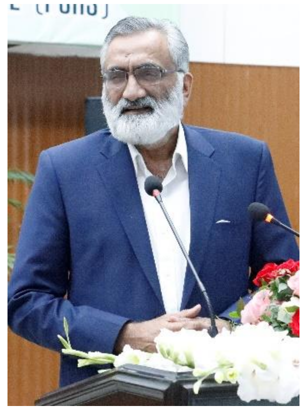
Sponsoring Organizations (IHCE & Horti-Expo South Punjab 2024)

1. Australian Aid/Australian Centre for International Agricultural Research (ACIAR)
2. Engro Fertilizers Limited, Pakistan
3. Punjab Higher Education Commission (PHEC), Lahore, Pakistan
4. Pakistan Science Foundation (PSF), Islamabad, Pakistan
5. Shamim Ghee Industries Pvt Ltd., Bahawalpur, Pakistan
6. Croplands Chemicals & Seed Services, Bahawalpur, Pakistan
7. Nutricles, Pakistan
8. MOBI Paints, Pakistan
9. ECS Pakistan, Pakistan
10. Vital Tea, Pakistan

Glimpses of the IHCE-2024

Inaugural Session of IHCE-2024








Horti-Expo South Punjab 2024


ONION
PROCESS
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Technical Sessions of IHCE- 2024


Annual General Meeting of PSHS 2024

Cultural Activities during IHCE-2024









Closing Session of IHCE-2024


8th INTERNATIONAL
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SOUTH PUNJAB
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DEPARTMENT OF HORTICULTURAL SCIENCES
FEBRUARY 26-28, 2024
PAKISTAN SOCIETY FOR HORTICULTURAL SCIENCE (PSHS)

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