6th International Horticulture Conference- 2022

17 – 19 May 2022

Book of Abstracts

DEPARTMENT OF HORTICULTURE
Faculty of Agriculture, Gomal University, D.I.Khan
KP, Pakistan

ABSTRACT BOOK

INTERNATIONAL HORTICULTURE CONFERENCE 2022

(May 17-19, 2022)

Organized by:

Department of Horticulture,
Faculty of Agriculture, Gomal University,
Dera Ismail Khan, Khyber Pakhtunkhwa,
Pakistan

In collaboration with

Pakistan Society for Horticultural Science (PSHS)

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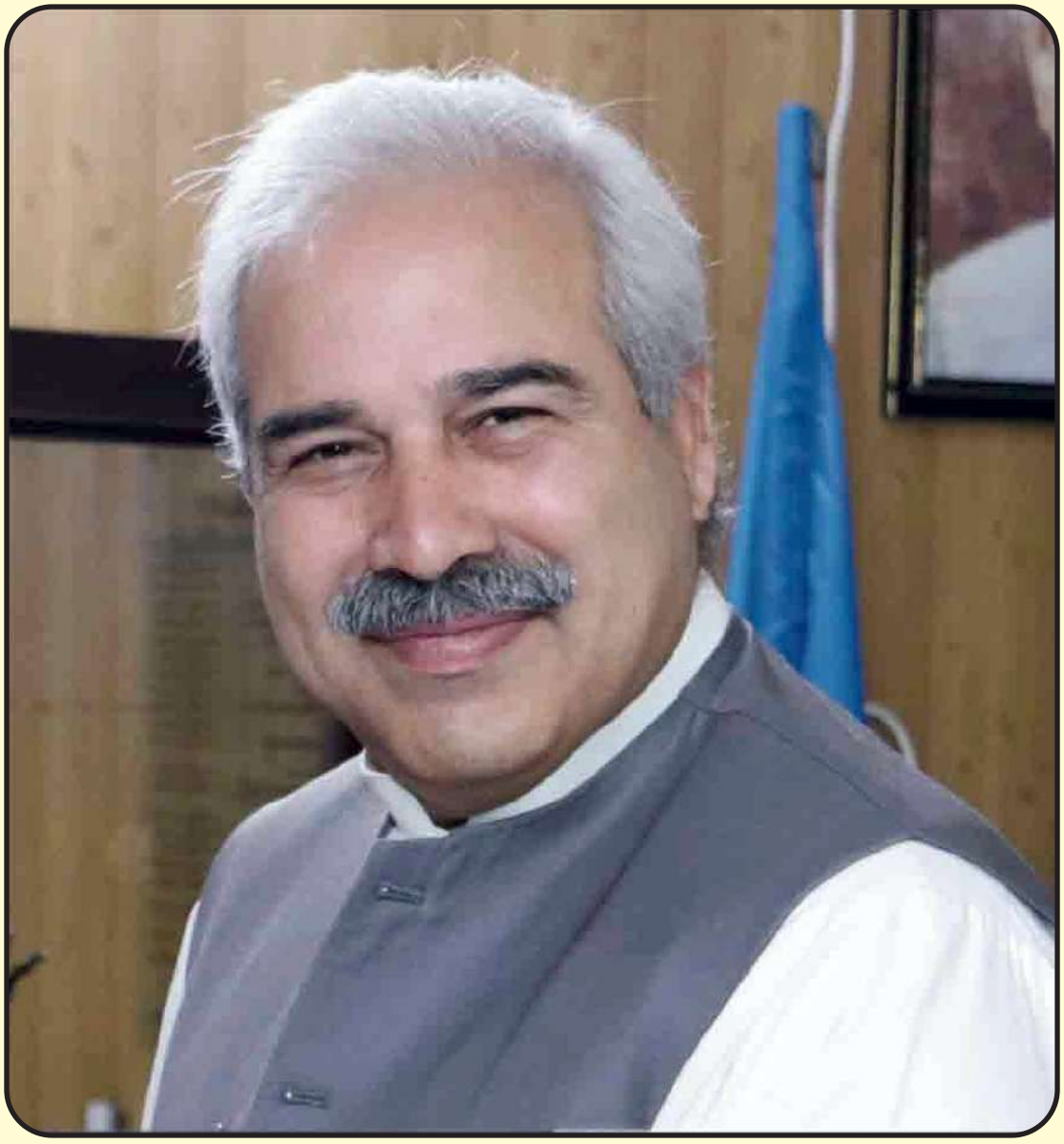

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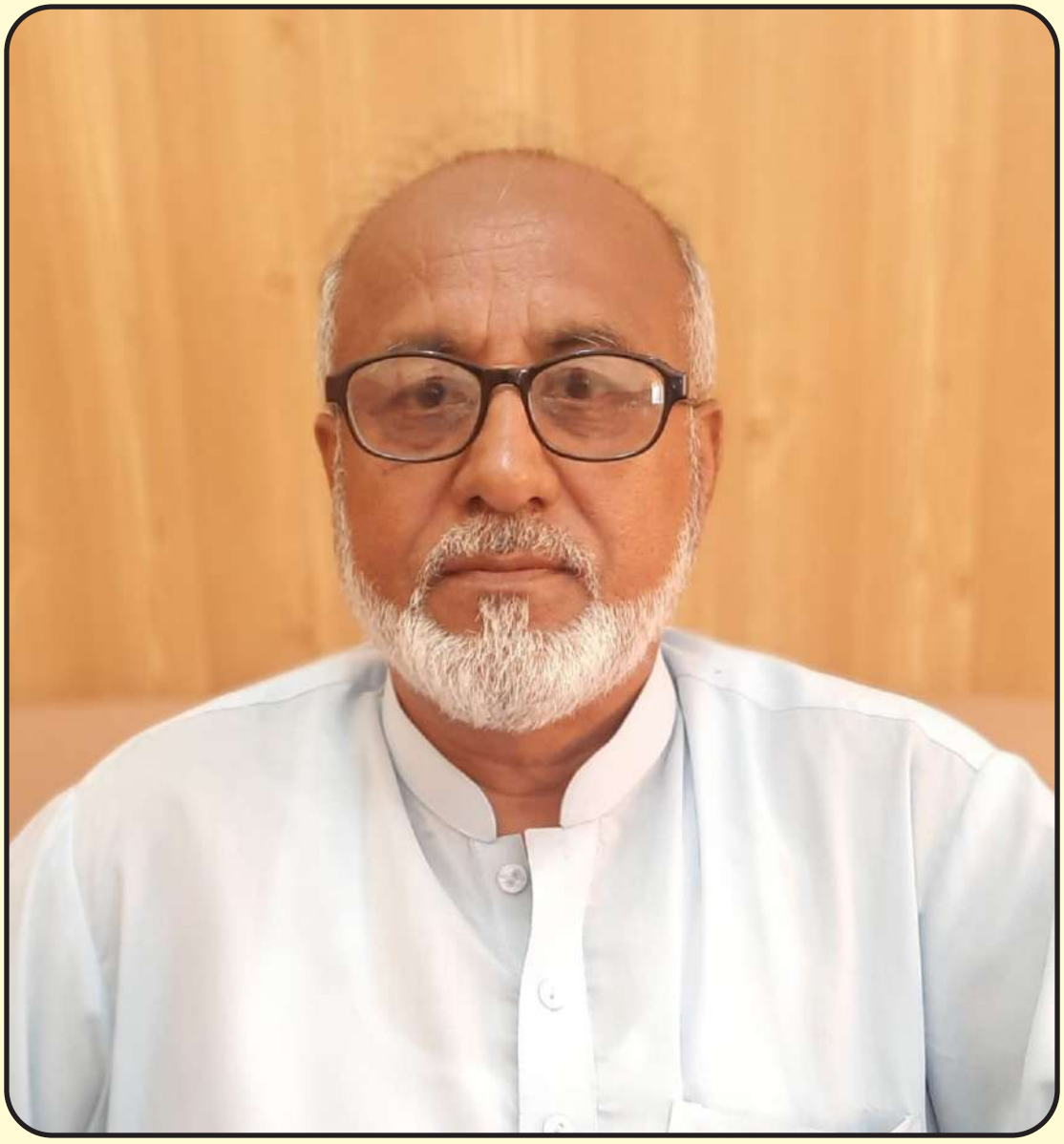
(*Tamgha-e-Imtiaz*)
Vice Chancellor
Gomal University, D.I.Khan, Khyber Pakhtunkhwa, Pakistan

CHIEF ORGANIZER



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Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

TITLE

Abstract Book of the International Horticulture Conference (IHC-2022) 17th to 19th May 2022

COMPOSER

Dr. Muhammad Sohail Khan, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

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- Dr. Sujata Upadhyay, Assistant Professor, Department of Horticulture, Sikkim University, India

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- Dr. Samina Khalid, Assistant Professor, Department of Environmental Sciences, COMSATS University Islamabad, Vehari Campus, Pakistan

Keynote Speakers

Foreign Speakers:

- Dr. Gerrit Hoogenboom, Professor and Preeminent Scholar, University of Florida, USA
- Dr. Holger Meinke, Strategic Research Professor for Global Food Sustainability, Research Division, University of Tasmania, Australia
- Dr. Jean W. H. Yong, Professor, Swedish University of Agricultural Sciences, Sweden
- Dr. Mehmet Emin Çalişkan, Professor, Niğde Ömer Halisdemir Üniversitesi, Türkiye
- Dr. Adel Ahmed Abul-Soad, Professor, Agricultural Research Centre, Egypt
- Dr. Sujata Upadhyay, Assistant Professor, Department of Horticulture, Sikkim University, India
- Mr. Afzal Khalid Chughtai, Technical Manager, Rapido Pest Control, Doha, Qatar

National Speakers:

- Mr. Fazli Wahab, Director Agriculture Research, Merged Areas, Khyber Pakhtunkhwa, Pakistan
- Dr. Muhammad Jafar Jaskani, Professor and Director, Institute of Horticultural Sciences, University of Agriculture, Faisalabad
- Dr. Ghulam Sarwar Markhand, Meritorious Professor and Ex-Director, Date Palm Research Institute, Shah Abdul Latif University, Khairpur, Sindh, Pakistan
- Dr. Raheel Anwar, Assistant Professor/IT Secretary (PSHS), Institute of Horticultural Sciences, University of Agriculture, Faisalabad
- Dr. Syed Waseem-ul-Hassan, Food Security Commissioner, Ministry of National Food Security and Research, Islamabad

Forward

Pakistan is one of the few countries blessed with a diversity of agro-ecological conditions and fertile soils, which facilitate the production of almost all crops. With resources becoming scarcer and the population growing, it is more important than ever to concentrate on more efficient agricultural production methods. There is enormous potential for intensifying agricultural production in Pakistan through technological advancement. Also, attempts to close the wide gaps between potential (controlled-experimental) yields, actual (progressive-farmer) yields, and national crop yield averages can generate fruitful results.

What other agriculture sector offers a more lucrative and high pay-off opportunity than the horticulture! The right combination of technology and resources ensures the highest income from horticultural crops. Production and marketing of these crops is a year-round operation that employs labour and helps generate economic activities throughout the year. Moreover, preserving surpluses can bring stability to prices for the farmers and consumers, besides ensuring food security. Hence, horticulture can offer broad socio-economic development with many rural and urban populations year-round employment opportunities. However, the horticulture sector remained a low-priority area in our agriculture development strategies. The result is that the yields of our horticultural crops are among the lowest in the world.

Along with deficits in R&D, the majority of the barriers to the productivity of horticulture in Pakistan are due to inadequate communication and a lack of coordinated contact among researchers, farmers, traders, and processors. In this respect, I commend and congratulate the teaching staff of the Department of Horticulture, Faculty of Agriculture, Gomal University Dera Ismail Khan, for organizing this first-ever International Horticulture Conference in the Khyber Pakhtunkhwa and particularly at Gomal University, Dera Ismail Khan in collaboration with Pakistan Society for Horticultural Science (PSHS).

This conference created a great opportunity to bring together a vast array of national and international scientists, faculty members, scientists, experts, students, and industry personnel actively working in the vast discipline of Horticultural Science. I am sure the deliberations during this conference will be most beneficial in formulating specific recommendations on different aspects of the horticultural sector. The efforts made by the organizers in successfully conducting this mega international event rightly deserve appreciation.

Finally, I would also like to congratulate the editors of the conference abstract book for a job very well accomplished. I am very impressed by the range and quality of material covering almost every aspect of research and development in horticulture. I am confident the successful conduct of this "International Conference" would set the pace and direction of horticulture development in Pakistan.

Prof. Dr. Iftikhar Ahmad (*Tamgha-e-Imtiaz*)
Vice Chancellor
Gomal University, D.I.Khan, Khyber Pakhtunkhwa, Pakistan

Preface

The Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan (D.I.Khan), Khyber Pakhtunkhwa, Pakistan, in collaboration with the Pakistan Society for Horticultural Science (PSHS), successfully organized the "International Horticulture Conference 2022 (IHC-2022)" during May 17–19, 2022. This was the first-ever International Horticulture Conference in Khyber Pakhtunkhwa, particularly at Gomal University, D.I.Khan. The conference was offered and organized in a hybrid mode (i.e., both physical and online).

The theme of the conference was *Horticulture for Stronger Economy*. Around 270 participants attended the conference. Among these, 45.6% were faculty members and scientists, 53.7% were students, and 0.7% were industry personnel. Around 76.9% of participants physically attended the conference, whereas 23.1% attended the conference via online mode. Around 161 abstracts were submitted to the conference, out of which 55 abstracts were selected for oral presentations, and 49 were found suitable for scientific posters by the IHC-2022 Scientific Committee comprising national experts across the academic institutions of Pakistan as well as a team of renowned international experts including Prof. Dr. Paul C. Struik (Wageningen University, The Netherlands), Dr. Şahane Funda Arslanoğlu (University of Ondokuz Mayis, Türkiye), Dr. Murat Deveci (Namık Kemal University, Türkiye), Dr. Fatih Öner (Ordu University, Türkiye), and Dr. Sujata Upadhyay (Department of Horticulture, Sikkim University, India).

The conference presenters delivered presentations in six technical sessions covering a wide array of key horticultural research disciplines, including plant physiology and ecology, *in vivo* and *in vitro* plant propagation, growing media and nursery management, genotype-by-environment (G×E) interaction, fruit and vegetable production and quality, and post-harvest physiology and management. Several international experts also presented their keynote lectures during the conference. Among these included Prof. Dr. Gerrit Hoogenboom (University of Florida, USA), Prof. Dr. Holger Meinke (University of Tasmania, Australia), Prof. Dr. Jean W. H. Yong (Swedish University of Agricultural Sciences, Sweden), Prof. Dr. Mehmet Emin Çalişkan (Niğde Ömer Halisdemir Üniversitesi, Türkiye), Prof. Dr. Adel Ahmed Abul-Soad (Agricultural Research Centre, Egypt), Dr. Sujata Upadhyay (Department of Horticulture, Sikkim University, India), and Mr. Afzal Khalid Chughtai (Rapido Pest Control, Doha, Qatar). Besides, various national keynote speakers also presented their work during the conference. Several companies took a keen interest in the conference and ensured their presence through stalls and seminars.

This *Abstract Book* comprises the research contributions of the participants to this conference. The outcomes of this conference on horticultural crop research, production, processing, marketing, etc., will significantly contribute to the development of Pakistan's horticulture industry.

Dr. Atiq Ahmad Alizai **Dr. Muhammad Sohail Khan**

Department of Horticulture, Faculty of Agriculture,
Gomal University, D.I.Khan, Khyber Pakhtunkhwa, Pakistan

Acknowledgments

International events demand well-coordinated teamwork to be successful. In this respect, I would like to thank all the members of the scientific and organizing committees for their tremendous work, sacrifice, and contribution.

Special thanks are extended to the foreign experts: Prof. Dr. Paul C. Struik (The Netherlands), Prof. Dr. Gerrit Hoogenboom (USA), Prof. Dr. Holger Meinke (Australia), Prof. Dr. Jean W. H. Yong (Sweden), Prof. Dr. Adel Ahmed Abul-Soad (Egypt), Prof. Dr. Mehmet Emin Çalişkan (Türkiye), Dr. Şahane Funda Arslanoğlu (Türkiye), Dr. Murat Deveci (Türkiye), Dr. Fatih Öner (Türkiye), Dr. Sujata Upadhyay (India), and Mr. Afzal Khalid Chughtai (Qatar) for their outstanding technical support, time, and valuable contribution to the International Horticulture Conference 2022.

I owe great gratitude to Prof. Dr. Iftikhar Ahmad (*Tamgha-e-Imtiaz*), Vice Chancellor, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, for his unwavering confidence in, support of, and encouragement during the planning of this significant event. Without his assistance, it would not have been able to hold this mega event and see it through to a successful conclusion.

In addition, I would like to express my gratitude to Prof. Dr. Niamat Ullah Babar, Registrar, Gomal University, Dera Ismail Khan, Pakistan, for his administrative assistance in making this conference a success.

I sincerely thank the Pakistan Society for Horticultural Science (PSHS) for giving us the chance to host this international event effectively and for offering a great platform and collaborative effort.

The gratitude is also extended to the Agriculture Research Institute (ARI), Dera Ismail Khan, Pakistan, and distinguished companies like CropLife Pakistan, Evyol Group, Fatima Group, and Suncrop Group for their generous support during the conference.

Last but not least, I want to express my gratitude to the faculty and staff of the Department of Horticulture, Gomal University, Dera Ismail Khan, Pakistan, for their tireless efforts from the beginning to the successful conclusion of this wonderful event. Sincere thanks are also extended to the Department of Horticulture students for their timely assistance and support throughout the conference.

I am much thankful to Dr. Muhammad Sohail Khan, Dr. Atiq Ahmad Alizai, and Dr. Kashif Waseem from the Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, for their hard work and dedication during the preparation of the conference abstract book.

Finally, I would like to thank everyone who participated in the conference, including the keynote speakers, for their invaluable support in making it a success.

Prof. Dr. Muhammad Saleem Jilani
Chairperson, Department of Horticulture
Gomal University, D.I.Khan, Khyber Pakhtunkhwa, Pakistan

Inaugural Session

Venue: Dr. A.Q. KhanAuditorium, Gomal University, Dera Ismail Khan, Pakistan

Moderator: Dr. Muhammad Sohail Khan, Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Pakistan

Time	Event
8:00 AM	Guests Registration
9:00 AM	Recitation from the Holy Quran Mr. Muhammad Raza
9:05 AM	Recitation from the Holy Quran Mr. Toqir Hassan
9:10 AM	Welcome Remarks *Prof. Dr. Muhammad Saleem Jilani, President PSHS and Convener IHC 2022*
9:20 AM	**Overview of Pakistan Society for Horticultural Science** *Dr. Raheel Anwar, Assistant Professor/IT Secretary (PSHS), Institute of Horticultural Sciences, University of Agriculture, Faisalabad*
9:30 AM	**Enhancing of Potato, Onion and Tomato (POT) Production, Issues, Challenges, and Way Forward** *Dr. Syed Waseem-ul-Hassan, Food Security Commissioner, Islamabad*
9:40 AM	**Status and Potential of Horticulture in Khyber Pakhtunkhwa** *Mr. Fazli Wahab, Director Agriculture Research, Merged Areas, Khyber Pakhtunkhwa, Pakistan*
9:50 AM	**Remarks by the Chief Guest** *Prof. Dr. Iftikhar Ahmad (Tamgha-e- Imtiaz), Vice Chancellor, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan*
10:15 AM	Opening Ceremony of Stalls
10:20 AM	Group
10:30 AM	**Tea Break**

Technical Sessions

SESSION I: PLANT PHYSIOLOGY AND ECOLOGY

Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Muhammad Jafar Jaskani (Director, Institute of Horticultural Sciences (IHS), University of Agriculture, Faisalabad, Pakistan)
Co-Chair: Prof. Dr. Ahmad Sattar Khan (IHS, University of Agriculture, Faisalabad, Pakistan) and Dr. Muhammad Shah Zaman (Deputy Director, Agriculture Research, Gilgit Baltistan)

Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
11:00 AM	Sustainable Horticulture Development for Food Security	Prof. Dr. Muhammad Jafar Jaskani
11:15 AM	Nutritional Importance of Underutilized Horticultural Species	Dr. Sujata Upadhyay
11:30 AM	Towards Quality Seed Potato Production: Impact of Genotype and Physiological Status of Seed-tuber	Dr. Muhammad Sohail Khan
11:45 AM	Comparative Morphological Responses of Different Varieties of African Marigold (*Tagetes erecta* L.) to water stress	Ms. Nudrat Ali
12:00 AM	Mitigation of Cadmium Toxicity through Basal Application of Melatonin in Pepper Seedlings	Dr. Muhammad Saqib
12:15 AM	Spermidine Counters Salt Stress by Limiting Reactive-Oxygen Species (ROS) and Alleviating Antioxidant Defence System in Strawberry	Dr. Muhammad Salman Haider
12:30 PM	Impact of the Soilless Growing System and Greenhouse Environment on Tomato Growth and Productivity	Dr. Nazar Faried
12:45 PM	Field Evaluation of Turf Grass Species Korean (*Zoysia japonica*) and Tifway (*Cynodon transvaalensis* × *Cynodon dactylon*) in Response to Herbicide Treatments	Dr. Ahsan Akram
01:00 PM	**Lunch and Prayer Break**	

SESSION II: *IN VIVO* AND *IN VITRO* PLANT PROPAGATION

Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Ghulam Sarwar Markhand (Ex-Director, Date Palm Research Institute, Shah Abdul Latif University, Khairpur, Sindh, Pakistan)
Co-Chair: Dr. Kashif Waseem (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan) and
Dr. Syed Noor Muhammad Shah (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
2:00 PM	Pumpkin Rootstocks Improve the Growth of Watermelon under Less Available Boron Conditions	Dr. Fareeha Shireen
2:15 PM	Role of Plant Growth Regulators on the In vitro Regeneration of Chrysanthemum (*Dendranthema morifolium* L.)	Dr. Kashif Waseem
2:30 PM	Micropropagation in Cyclamen: Multiple Shoot Induction through Corms	Ms. Syeda Anum Masood Bokhari
2:45 PM	Micropropagation of Turmeric as an Alternative to a Seed-derived Method for Clean Planting Material	Ms. Mamonila Jahandad
3:00 PM	*In vitro* Regeneration and Characterization of Colchiploid Germplasm in Acid Lime Cultivars	Dr. Bilquees Fatima
3:15 PM	Influence of Various PGRS on the *In Vitro* Propagation of Two Potato Cultivars	Dr. Kashif Waseem
3:30 PM	**Tea Break**	

SESSION III: GROWING MEDIA AND NURSERY MANAGEMENT

Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Ahmad Sattar Khan (IHS, University of Agriculture, Faisalabad, Pakistan)
Co-Chair: Prof. Dr. Niamat Ullah Babar (Director, Institute of Social Sciences, Gomal University, Dera Ismail Khan, Pakistan) and Dr. Summar Abbas Naqvi (Assistant Professor, IHS, University of Agriculture, Faisalabad, Pakistan)

Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
4:00 PM	Understanding the Role of Biostimulants in Cultivation	Prof. Dr. Jean W. H. Yong
4:15 PM	Impact of Humic Acid Amended Growing Media and IBA on Propagation of Lemon (Cv. Singhar) via Stem Cuttings	Dr. Muhammad Sohail Khan
4:30 PM	Standardization of Growing Media and Propagation Time Using Air Layerage Technique for Lemon	Dr. Atiq Ahmad Alizai
4:45 PM	Effect of Different Substrate Disinfection Methods on the Performance of King Oyster Mushroom (*Pleurotus eryngii*)	Dr. Hasan Sardar
5:00 PM	Comparative Effect of Seed Priming and Growing Media on Seed Germination and Seedling Growth of Papaya (*Carica papaya* L.)	Mr. Muzamil Farooque Jamali
5:15 PM	Sugarcane Pressmud: A Potential Agricultural Waste for Containerized Nursery Production of Marigold	Ms. Shaiza Rasool
5:30 PM	Annual General Meeting 2022 Pakistan Society for Horticulture Science (PSHS) **Convener:** Prof. Dr. Muhammad Saleem Jilani, President, PSHS **Moderator:** Dr. Raheel Anwar, IT Secretary (PSHS)/ Assistant Professo, IHS, University of Agriculture, Faisalabad, Pakistan	
6:30 PM	**END OF DAY-1**	

May 18, 2022

SESSION IV: GENOTYPE-BY-ENVIRONMENT (G×E) INTERACTION
Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Ahmad Sattar Khan (IHS, University of Agriculture, Faisalabad, Pakistan)
Co-Chair: Dr. Nazar Faried (Assistant Professor, Department of Horticulture, MNS University of Agriculture, Multan, Pakistan) and Dr. Muhammad Azher Nawaz (Assistant Professor, Department of Horticulture, College of Agriculture, University of Sargodha, Sargodha, Pakistan)
Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
8:30 AM	Adaptability Performance of Various Exotic Potato Varieties at Multilocations of Gilgit Baltistan	Dr. Muhammad Shah Zaman
8:40 AM	Genotype-by-Environment (G×E) Interaction on the Dynamics of Yield Formation in Okra	Dr. Muhammad Sohail Khan
8:55 AM	Genetic Evaluation for Yield and Quality Attributes in Spinach (*Spinacia oleracea*) Under Heavy Metals Stress	Mr. Muhammad Adnan Raza
9:05 AM	Assessing Causes and Effects of Declining Chilgoza (*Pinus gerardiana*) Forests Nuts Yield in South Waziristan Agency, Pakistan	Mr. Imran Khan
9:15 AM	An Overview of Germ Plasm Unit (Tropical), Agriculture Research Institute, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan	Mr. Sheheryar Hafeez
9:30 AM	True Potato Seed Breeding: History, Progress and Prospects	Dr. Muhammad Abdul Rehman Rashid
9:40 AM	Physiological Responses of Grapevine Cultivars at Key Phenological Stages under Varying Environmental Conditions	Mr. Rizwan Rafique
9:50 AM	Impact of Irradiated Pollens on Compatibility and Fruit Traits in Intervarietal Crosses of Guava	Ms. Syeda Anum Masood Bokhari
10:00 AM	Phenotypic Evaluation and Genetic Analysis of Reproductive Phase in F1 Transgenics of Chrysanthemum Plants: A Case Study	Dr. Saba Haider
10:10 AM	Zeolite Amendment to Mitigate Pb Stress in Chili Pepper Plants Irrigated by Sewerage Water	Dr. Shaghef Ejaz
10:20 AM	Effect of Foliar Applications of Chitosan and Salicylic Acid on Tomato Genotypes under Heat Stress Conditions	Prof. Dr. Chaudhary M. Ayyub
10:30 AM	**Tea Break**	

SESSION V: FRUIT AND VEGETABLE PRODUCTION AND QUALITY

Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Ahmad Sattar Khan (IHS, University of Agriculture, Faisalabad, Pakistan)
Co-Chair: Dr. Nazar Faried (Assistant Professor, Department of Horticulture, MNS University of Agriculture, Multan, Pakistan) and Dr. Muhammad Azher Nawaz (Assistant Professor, Department of Horticulture, College of Agriculture, University of Sargodha, Sargodha, Pakistan)

Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
11:00 AM	Key Insights From "Labour Productivity: The Forgotten Yield Gap"	Prof. Dr. Holger Meinke
11:15 AM	Date Palm Status in Pakistan: Opportunities and Threats	Prof. Dr. Ghulam Sarwar Markhand
11:30 AM	Overview of Horticulture in Balochistan	Dr. Muhammad Javed Tareen
11:40 AM	Fruit Cultivation for Improving Climate Change Resilience	Prof. Dr. Adel Ahmed Abul-Soad
11:55 AM	Pest Management in Landscape Areas in Qatar	Mr. Afzal Khalid Chughtai
12:05 PM	Influence of Transplant Time, Foliar Applications and Maturity Stage on Strawberry Plant Health, Yield and Fruit Quality	Dr. Raheel Anwar
12:15 PM	Phenological Response of Red Palm Weevil (*Rhynchophorus ferrugineus*, Olivier) (Coleoptera: Curculionidae) On Six Different Varieties of Date Palm	Mr. Gul Rehman
12:25 PM	The Role of Plant Breeding On Food Security and Sustainability	Prof. Dr. Mehmet Emin Çalişkan
12:40 PM	Mitigation of Cadmium Toxicity through Melatonin Application in Strawberry Plants at the Fruiting Stage	Dr. Umbreen Shahzad
12:50 PM	Role of CropLife Pakistan Association in Horticultural Crops	Mr. M. Shoaib & Mr. Murtaza Quddusi
01:00 PM	**Lunch and Prayer Break**	

2:00 PM	Identifying and Characterizing the Value Chain Coordination Structures in the Potato Industry of Pakistan	Mr. Hafiz Azhar Rasool
2:10 PM	Does Value Chain Approach Enhance the Profitability of Small Potato Farmers in Punjab?	Dr. Hafiz Mahmood ur Rehman
2:20 PM	Empowering Smallholder Onion Farmers through Value Chain Approach	Dr. Habat Ullah Asad
2:30 PM	Yield and Quality Response of Potato to Split Application of Nitrogen and Phosphorous Fertilizers	Prof. Dr. Chaudhary Muhammad Ayyub
2:40 PM	A Case Study on Value Addition Business Led By Rural Women in District Khairpur, Pakistan	Mr. Syed Azeem Hayder
2:50 PM	A Whole Family Approach Improves Gender Inclusion in Onion Value Chain in Rural Sindh	Ms. Iqra Sultan Rajput
3:00 PM	Computer Modeling of Horticultural Crops	Prof. Dr. Gerrit Hoogenboom
3:20 PM	Role of Minor Fruits in the Economy of Pakistan	Prof. Dr. Ishtiaq Ahmad Rajwana
3:30 PM	**Tea Break**	

SESSION VI: POST-HARVEST PHYSIOLOGY AND MANAGEMENT

Venue: New Senate Hall, Gomal University, Dera Ismail Khan, Pakistan

Chair: Prof. Dr. Ghulam Sarwar Markhand (Ex-Director, Date Palm Research Institute, Shah Abdul Latif University, Khairpur, Sindh, Pakistan)

Co-Chair: Dr. Muhammad Hussain Soomro (Associate Professor, Department of Botany, Shah Abdul Latif University, Khairpur, Sindh, Pakistan) and Dr. Zahoor Hussain (Chairperson/Associate Professor, Department of Horticulture, Ghazi University, Dera Ghazi Khan, Pakistan)

Moderator: Dr. Muhammad Sohail Khan (Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan)

Time	Title	Presenter
3:40 PM	Postharvest Quality Management of Jamun (*Syzigium cumini* Skeels.) Fruit by Combined Pre- and Postharvest Oxalic Acid Treatment	Dr. Sami Ullah
3:50 PM	Impact of Oxalic Acid on Post-Harvest Shelf Life and Quality of Bell Pepper at Cold Storage	Mr. Rana Muhammad Ateeq Ahmad
4:00 PM	Postharvest L-Cysteine Application on Storage Life and Quality of Commercial Table Grapes Cultivars of Balochistan	Prof. Dr. Ahmad Sattar Khan
4:10 PM	Standardization of Optimum Temperature for Dehydration of Whole Banana	Dr. Mateen Sajid
4:20 PM	Effect of Different Packaging Materials on Postharvest Quality and Shelf Life Dynamics of Wild Black Raspberry (*Rubus occidentalis* L.) fruits	Dr. Mehdi Maqbool
4:30 PM	Improvement of Quality and Shelf-Life of Strawberries Cv. Chandler with Edible Coatings	Dr. Kashif Razzaq
4:40 PM	Short-term Ultrasound Treatment Preserved Fruit Quality and Extended Storage Life of Fresh Strawberries	Dr. Ayesha Maryam
4:50 PM	Improvement in Chilling Tolerance of Harvested Banana Fruits by Hydrogen Sulfide Regulated γ-Aminobutyric Acid Shunt Pathway and Ascorbate Glutathione Cycle	Dr. Sajid Ali
5:00 PM	Application of Hydrocolloids as Biocomposite Coating Delays Ripening and Senescence by Activating Antioxidant Enzymes and Deactivating Cell Wall Degrading Enzymes in Coated Tomato Fruits	Dr. Shaghef Ejaz

5:10 PM	Carboxymethyl Cellulose Coating Maintains Postharvest Qualities of Chiku Fruit during Storage	Dr. Ghulam Khaliq
5:20 PM	Postharvest Dipping of Grapes in Oxalic Acid Solution Improves Physiological and Biochemical Attributes of Berries	Ms. Shafa Nayab
5:30 PM	Mulching Materials Influence Weed Emergence, Plant Growth and Postharvest Quality of Strawberry at Rawalakot, Azad Kashmir	Dr. Noosheen Zahid

CONCLUDING CEREMONY

Venue: Dr. A.Q. Khan Auditorium, Gomal University, Dera Ismail Khan, Pakistan

5:40 PM	IHC-2022 Recommendations *Dr. Muhammad Sohail Khan, Assistant Professor, Department of Horticulture, Faculty of Agriculture, Gomal University, Dera ismail Khan, Khyber Pakhtunkhwa, Pakistan*
6:00 PM	Poster Awards & Shield Distribution
6:20 PM	Vote of Thanks *Prof. Dr. Muhammad Saleem Jilani, President PSHS and Convener IHC-2022*
6:40 PM	Concluding Remarks *Prof. Dr. Iftikhar Ahmad (Tamgha-e- Imtiaz), Vice Chancellor, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan*
7:00 PM	**END OF CONFERENCE**

May 19, 2022

Tour Program

Time	Activity
8:30 AM	Trip to Germ Plasm Unit (Tropical) & Agriculture Research Institute, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan
12:00 PM	**END OF DAY-3**

Poster Presentations

Venue: Facilitation Center, Gomal University, Dera Ismail Khan, Pakistan

Date: 18 May 2022
Mounting of Posters: 08:00 AM – 09:30 AM
Poster Evaluation: 11:00 AM– 12:00 PM

Poster No.	Abstract Title	Presenter
IHC2022P-1	Interactive Response of Genotype and Rooting Volume on Seed Tuber Production	Mr. Muhammad Awais
IHC2022P-2	Efficacy of Humic Acid in Combination with Multiple N Levels on the growth and yield of Tomato	Mr. Shafqat Ullah
IHC2022P-3	Influence of Different Nitrogen Doses and Seed Rates on the Growth and Production of Purslane	Mr. Atta Ur Rehman
IHC2022P-4	Impact of Humic Acid on the Performance of Exotic Red Radish Genotypes	Mr. Kashif Hussain
IHC2022P-5	Effect of Plant Spacing on the Production of Turmeric (*Curcuma longa* L.) Under the Agro-Climatic Conditions of Dera Ismail Khan	Dr. Mehwish Kiran
IHC2022P-6	Effect of Water Deficit Conditions on Tagetes Varieties in Relation to Bio-chemical Parameters	Ms. Nudrat Ali
IHC2022P-7	Testing the Feasibility of Aquaponics in the Farming Poor Community of Potohar	Dr. Mehwish Liaquat
IHC2022P-8	Vegetable Grafting: Recent Developments in Pakistan	Dr. Muhammad Azher Nawaz
IHC2022P-9	Studies on Phenotypic and Yield Response of Roselle (*Hibiscus sabdariffa* L.) to Different Sowing Times in Agro-Climatic Conditions of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan	Dr. Habib ur Rahman
IHC2022P-10	Interactive Response of Humic Acid and Variable Nitrogen Application on Yield Production in Tomato	Mr. Muhammad Salman
IHC2022P-11	Response of Bottle Gourd to Foliar Application of Iron Sulfate	Ms. Erum Rashid

IHC2022P-12	Influence of Exogenous Silicon on Physiological and Antioxidant Enzyme Activities of Tomato (*Lycopersicon esculentum* L.) Under Salinity	Ms. Erum Rashid
IHC2022P-13	Distinctive Evaluation of Lisianthus (*Eustoma grandiflorum*) On The Basis of Morphological Characteristics	Ms. Sanjeela Sabahat
IHC2022P-14	Precision Horticulture: A Step towards Sustainable Production	Dr. Muhammad Tahir Akram
IHC2022P-15	Comparative Evaluation of Herbicides and Manual Weeding Effects on the Growth and Yield of Summer Crop of Onion CV. Nasarpuri	Dr. Khurram Ziaf
IHC2022P-16	Phosphorus Dose Effects on Growth, Yield and Quality of Different Varieties of Potato	Dr. Khurram Ziaf
IHC2022P-17	Guava Wilt Disease (GWD): A Silent Pandemic	Ms. Syeda Anum Masood Bokhari
IHC2022P-18	Effect of Plant Based Extract on Phytochemicals and Morphological Properties of Calendula (*Calendula officinalis* L.)	Mr. Muhammad Muzamil Ijaz
IHC2022P-19	Breaking Bud Dormancy in Grapevines with Garlic and Onion Paste	Dr. Saba Ambreen Memon
IHC2022P-20	Shellac Wax Coating to Improve the Storage Quality and Shelf Life of Strawberry Fruit (*Fragaria ananassa* L.)	Dr. Saba Ambreen Memon
IHC2022P-21	Pre-Storage Coating of Aloe Vera with Methyl Salicylate Maintained the Quality of Cold Stored Sweet Pepper (*Capsicum annuum* L.)	Dr. Rana Naveed Ur Rehman
IHC2022P-22	Growth and Yield Response of Broccoli to Exogenous Application of Chitosan	Prof. Dr. Chaudhary Muhammad Ayyub
IHC2022P-23	Morphological Variability in Gamma Irradiated Germplasm of Grapefruit	Dr. Muhammad Usman
IHC2022P-24	Diminution of Cadmium Stress in Cucumber Seedlings by Controlling the Photosynthesis and Antioxidant Mechanism by Exogenous Application of Glutamic Acid	Mr. Muhammad Mehran Abbas

IHC2022P-25	Exogenous Application of Glutamic Acid Promoting Cucumber (*Cucumis sativus* L.) Growth under Salt Stress Conditions	Mr. Muhammad Mehran Abbas
IHC2022P-26	Postharvest Hypobaric Treatment Inhibited Fungal Decay, Maintained Cosmetic Quality and Retained Phytonutrient Profile of Jujube During Low Temperature Storage	Mr. Mahmood Ul Hasan
IHC2022P-27	Genome Wide Analysis of Plant Specific YABBY Transcription Factor Gene Family in Carrot (*Daucus carota*) and its Comparison with Arabidopsis	Mr. Mujahid Hussain
IHC2022P-28	Plant Water Relations and Efficiency of Various Commonly Used Houseplants	Dr. Muhammad Asif
IHC2022P-29	Advances in the Environmentally Friendly Management of Red Palm Weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae)	Mr. Farhan Nayyar
IHC2022P-30	Assessment of Stevia (*Stevia rebaudiana* Bertoni) Growth under the Climatic Conditions of Dera Ghazi Khan	Dr. Tehseen Ali Jilani
IHC2022P-31	Influence of Different Levels of Salinity to Check the Growth and Quality of Rose	Mr. Hafiz Muhammad Bilal
IHC2022P-32	Micropropagation of Date palm (*Phoenix dactylifera* L.)	Mr. Ali Ahmad Shah
IHC2022P-33	Steps towards Mitigating the Drastic Hit of Climate Change on Fruit Ripening of Promising Date Palm cv. Dhakki	Dr. Shahzada Arshad Saleem Khan
IHC2022P-34	Assessment of Various Organic Compounds to Hasten the Display Life of Cut Narcissus (*Narcissus tazetta*) Flower	Mr. Muhammad Abu Bakar
IHC2022P-35	Impact of Variable Nitrogen Levels and Seed Rates on the Growth and Yield of Fenugreek	Mr. Sami Ullah
IHC2022P-36	Influence of Pollination Times on the Yield and Fruit Characteristics of 'Muzawati' and 'Kahraba' Date Palm (*Phoenix dactylifera* L.)	Mr. Syed Ameer Hussain Shah
IHC2022P-37	Impact of Liquid Pollination on Fruit Set, Quality, and Yield Of Dhakki and Zahidi Date Palm (*Phoenix Dactylifera* L.)	Mr. Bilal Ahmad Khan
IHC2022P-38	Assessing theWhorl-Wise Spath and Fruit Physiochemical	Mr. Haseeb

	Characteristics of Different Date Palm (*Phoenix dactylifera* L.) Cultivars Grown in Dera Ismail Khan Region	Ahmad
IHC2022P-39	Assessing the Impact of Nitrogen on the Growth and Yield Production in Red Beet	Mr. Muhammad Uzair Hameed
IHC2022P-40	Assessing the Response of Intra-Row Spacing on the Growth and Yield of Onion	Ms. Uzma Khan
IHC2022P-41	Strengthening Horticulture Sector Economy through Production and Cultivation of Certified Fruit Plants of Registered Varieties	Mr. Abdul Qayum Khan
IHC2022P-42	Effect of Transplanting Time on the Yield and Quality of Sugar Beet (*Beta vulgaris* L.)	Dr. Imran Khan
IHC2022P-43	Impact of Salt Stress on Secondary Metabolites and Expression of Selected Genes in Pea	Dr. Sabaz Ali Khan
IHC2022P-44	Postharvest Application of Botanical Extracts to Improve the Storage Life & Quality of Kinnow	Dr. Muhammad Zahid Rashid

Contents

Keynote Presentations

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Overview of Pakistan Society for Horticultural Science

R. Anwar[1*], M.S. Jilani[2] and I. Ahmad[1]

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'Pakistan Society for Horticultural Science' (PSHS) was founded as a student society in 2004 at the Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Competent leadership and vibrant membership helped this society gain popularity not only within the university but also at the national level. So, considering frequent requests from national horticulture institutes, the PSHS was upgraded and registered at the national level back in 2016. The main objective of the PSHS is to encourage interest and involvement of professionals and amateurs in horticulture and related aspects and to sustain the vital connection between people and plants by gathering all professional horticulturists at one platform to enhance their interaction and share their experiences and problems to seek solutions. PSHS invites students, professionals, and entrepreneurs through student, regular, lifetime, and corporate memberships and offers them opportunities to share, interact, collaborate, and develop their skills and help promote society's mission. Society promotes sharing of scientific knowledge with researchers; improve communication and coordination with the farmers and other stakeholders by holding conferences, workshops, and seminars. Journal of Horticultural Science and Technology is an official quarterly publication of PSHS. This open-access journal publishes peer-reviewed original research articles and reviews on all aspects of horticultural crops. 'HortiMag' is another biennial publication of PSHS to disseminate innovative but practical techniques and management strategies for challenging issues in the horticulture industry. Recently, PSHS has also taken the initiative to develop a national 'Pakistan Horticulture Resource Guide' to gather all horticulture related businesses information on one platform, which would be just a click away from the consumers, in order to enhance the visibility of local horticulture-related businesses and to facilitate the consumers for finding horticultural products nearby. Further detail about PSHS and updates about its activities are available at https://www.pshsciences.org/.

Keywords: Overview, PSHS, horticulture, Pakistan, society.

Status and Potential of Horticulture in Khyber Pakhtunkhwa

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The horticultural landscape of the Province of Khyber Pakhtunkhwa (KP) is shaped by its highly diverse agro-climate, ranging from sub-tropical southern plains to severe temperate snow-bound northern mountains. There are several frost-free pockets and isolated valleys, offering niche for opportunities and potential for the cultivation of high-value horticultural crops. Out of the total cultivated area (22.4% of the total reported area) of the Province, fifty percent is irrigated which is most suitable for horticultural crops. The other 20%, classified as culturable wasteland is likely to be available for low moisture requiring fruit trees like olive. Land fragmentation is the highest in Pakistan wherein 89.5% of the farms are classified as small farms (< 12.5 acres), while the rate of further fragmentation, is on the rise. Though home to more than seven rivers and perennial streams, irrigation water availability is becoming scarce over time The Province is also facing the curse of climate change with rising temperatures, higher evapotranspiration rates, erratic rainfall, abrupt extreme weather conditions, and high-velocity dust storms. The Province has suitable land, water for irrigation, and above all a diverse agro-climate, placing this Province in a unique position. Climatic diversity is the most valuable strength for high-value horticultural produce targeting low-supply periods in markets. Currently, 11% of the irrigated area of the Province is dedicated to fruits and vegetables with an estimated farm gate value of around Rs. 70 billion which is providing livelihood to around 0.700 million households. Besides, fruit and vegetable cultivation, floriculture in the Province offers great potential though currently underutilized. The high yield gaps, quality improvement, and reduction in post-harvest losses are the areas, wherein the academician and researchers are to ponder over and dedicate their resources and knowledge for innovative home-grown solutions. The introduction of sequential ripening varieties of fruits (93 varieties approved) and the establishment of fruit plants certification system with seven Germplasm Units are considered the hallmark of the Agriculture Research System of the Province. Likewise, the introduction of off-season vegetables at higher altitudes, virus-free potato seed production, and the establishment of vegetable seed production clusters in isolated valleys, are some of the success stories of the Agriculture Department. The Government of KP has prioritized horticulture development, as one of the three sectors for economic growth and development besides hydel power generation and mineral development. Horticulture being the highest job creator in rural areas has an edge over the other two sectors. Predominantly small landholdings of the Province, offer an incentive for labour-intensive, high-value horticulture over field crops. Specialized production clusters linked to the value addition industry (food processing parks), certification of organic production, and reduction in Maximum Residue Levels (MRL) are the areas that need the attention of policymakers and experts. The shift from the emphasis on production to market-oriented high-value horticulture and built-in value chain approach in all future interventions shall be the

based Soil Fertility Project, Strengthening of Pesticides Residue Surveillance System, Province is positioned on the confluence of CPEC connecting Central Asia with the major routes Establishment of Centers of Excellence for Horticulture and Project for Climate Resilience through Horticultural Promotions, are the precursors to the development of the sector. The to the Arabian Sea; therefore, harnessing the horticultural potential of the Province is synonymous with the economic development of the country.

Keywords: Potential, horticulture, diversity, germplasm, Khyber Pakhtunkhwa.

Date Palm Status in Pakistan: Opportunities and Threats

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Despite having an ancient cultivation trend, rich varietal diversity, and being one of the top dates producing and exporting countries, Pakistan still has not established an advanced date sector and is not getting the rightful price of its product in the international market. Such a poor situation is mainly due to using centuries-old fashioned traditional methods of pre and post-harvesting, dearth of advanced dates processing and preservation units, standardized packaging and presentation, national branding and market diversification, and establishment of modern marketing system facilities. The dates from Pakistan are mainly exported to India, which might establish its date fruit industry in the next few years, urging the importance of finding new markets for our date products. The study aimed to highlight the de facto situation of the date palm industry in Pakistan with a detailed discussion regarding several opportunities such as the availability of abundant land for date palm cultivation, investment opportunities, presence of a wide range of varieties, and future potential of exotic varieties, etc. The threats include international competition, pest and pathogen issues, water shortage problems, etc.

Keywords: Date palm, marketing, postharvest losses, processing, exotic varieties.

Nutritional Importance of Underutilized Horticultural Species

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The underutilized or lesser-known, or underexploited species have been beneficial for us. They have been traditionally utilized for a variety of purposes such as food, medicine, fuel, natural colorants, source of genes, artifacts, shelter, rootstocks, etc. These species generally have limited territorial distribution, and they are generally utilized based on indigenous technical knowledge associated with them. The name underutilized suggests their potential for further utilization. The cultivation of horticultural crops faces various challenges like climatic uncertainty, devastation by pests and diseases, etc. Lack of diversification in farming and dependence on few crops only has caused significant losses to the farming community. The promotion of locally adapted species will help in the conservation of biodiversity and serve as an additional source of income for the farming community. Many of these underutilized horticultural species can be processed, and value addition can be done. Promoting these species will be beneficial as the land resource of any nation is limited. Some annual or biennial underutilized plant species may also be grown in urban horticulture using vertical farming. The underutilized perennial species serve as the most sustainable livelihood sources and nutritional and ecological security. There is a need for joint efforts of researchers, educationists, extension personnel, industry personnel, and policymakers to promote underutilized horticultural species for economic, nutritional, and food security. Efforts are also needed to standardize their production technology to bring them into the mainstream and upgrade their status of valuable species to crop. The diversity of underutilized or wild edible lesser-known plant species is very high (>250 species) in the northeastern state of Sikkim, India. Due to high forest coverage in this state, wild edible plants are highly consumed in the daily diet of the local community. In this context, studies on the determination of nutritional profile, value addition, product diversification, and effect of irradiation on the shelf life of various underutilized and indigenous horticultural species have been conducted at the Department of Horticulture, Sikkim University, Gangtok, Sikkim, India.

Keywords: Underutilized, indigenous, species, nutritional profile, food security.

Understanding the Role of Biostimulants in Cultivation

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Plant cultivation needs a comprehensive overhaul in terms of sustainability, with better approaches to producing safe and healthy food, while leaving little footprint. The reliability of cultivation is also disrupted by increasing extreme weather, attributed in part to climate change. Hence, alternatives to strengthen our plants need to be explored urgently that harness nature's own biological components. From a sustainability perspective, organic cultivation offers an eco-friendly cultivation system that minimizes agrochemicals and producing food with little or no environmental footprint. However, organic cultivation's biggest drawback is the generally lower and variable yield in contrast to conventional cultivation systems. Compatible with organic cultivation, the selective use of biostimulants can close the apparent yield gap between organic and conventional cultivation systems. Biostimulants are defined as natural microorganisms or biologically active substances that are able to improve plant growth and yield through several processes. Biostimulants are derived from a range of natural resources including organic materials (composts, seaweeds, coconut water), manures (earthworms, poultry, fish, insects' frass) and extracts derived from microbes, plant, insect or animal origin. The integration of biostimulants with other compatible substrates into any cultivation represents added environmental and public health benefits of providing a waste management solution (circular bioeconomy). The current trend is indicative that a mixture of biostimulants is generally delivering better growth, yield and quality rather than applying biostimulant individually. When used correctly, biostimulants are known to help plants cope with stressful situations like drought, salinity, extreme temperatures and even certain diseases. More research is needed to understand the different biostimulants, key components, and also to adjust the formulations to improve their reliability in the field. With greater mechanistic clarity, designing purposeful combinations of biostimulants offer a promising, innovative and sustainable strategy to supplement and replace agrochemicals in the near future.

Keywords: Biostimulants, sustainability, of natural resources, eco-friendly cultivation system.

The Role of Plant Breeding On Food Security and Sustainability

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Agriculture offers the basic needs of humanity like food, shelter, and raw materials for various industries (e.g., medicine, cosmetics, etc.). Hence, the agriculture sector is contributing a lot to humanity. *Food security* is a broad concept comprised of three main pillars. The first is food availability, the second is food safety, and the third is food sovereignty. These three dimensions create food security. In other words, all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. Four main factors ensure food security, including food availability, food accessibility, food utilization, and food stability. A *sustainable food system* is a food system that delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised. Almost half of the 17 United Nations (UN) sustainable development goals are directly or indirectly related to agricultural activities and food security. However, there are several future challenges and/or threats to food security, such as population increase, climate change, and diminishing natural resources. According to a recent UN report, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050, and 11.2 billion in 2100. With roughly 83 million people being added to the world's population every year, the upward trend in population size is expected to continue, which may significantly enhance the supplementary demand for food, but will also stress out natural resources amid climate change, which is posing an alarming threat to food production, safety, and security. Any plant breeding effort aims to generate new, improved cultivars or breeding lines for specific target areas and increase agricultural production and quality to meet expected increases in global food demand. In most agricultural species, major breeding improvement over the past century has come from empirical breeding, which selects for yield. Advances in agricultural genomics and marker-assisted selection have revolutionized plant breeding. Modern or precision breeding procedures may produce more nutritional, resource-efficient, and climate-resilient crop cultivars. Hence, plant breeding is one of the most powerful and sustainable tools that can be used to achieve sustainable development goals.

Keywords: Agriculture, plant breeding, food security, sustainability, climate change.

Computer Modeling of Horticultural Crops

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The agricultural production system, including the horticultural production system, is extremely complex. The agricultural and horticultural production systems are affected by many abiotic and biotic stresses that are caused by weather extremes, pests, and diseases, and other factors. Compared to traditional agricultural crops that are mainly valued for yield quantity, most horticultural crops are valued for both their quantity and quality including internal and external quality. Computer models that simulate growth, development and yield of traditional agronomic crops have been common for the last 30 years in the research domain. However, computer models that simulate growth and development of horticultural crops have been limited, except for the more common crops such as tomatoes and potatoes. In addition, the number and types of crops that are covered by horticulture is much broader compared to traditional cereal and legume crops and, in many cases, with limited knowledge and detailed published research for horticultural crops. Dynamic computer simulation models are comprised of many different mathematical equations that are based on state-of-the-art science. In general, crop simulation models predict growth and development of a crop, the soil and plant water balance, and the soil and plant nutrient balance, with emphasis on nitrogen and phosphorus, and various other processes. These crop simulation models operate at what is called a daily time step; this means that these computer models simulate growth and development on daily basis, starting at planting or transplanting until harvest maturity is predicted or reached. Some processes are simulated at hourly or smaller time steps, such as vegetative and reproductive development and photosynthesis. Most crop simulation models require daily weather data, including maximum and minimum air temperature, total precipitation, and total solar radiation; soil surface and profile information that describe the physical and chemical characteristics of the soil; crop management, including planting or transplanting date, row and plant spacing, the dates and amount of irrigation applications, and the dates, amount, and type of fertilizer management applications; and genetic characteristics, especially as it relates the specific variety, cultivar, or hybrid that is being grown, as input. The models then predict flowering, maturity, and other critical development dates; leaf, stem, root, and fruit growth, and final yield and yield components. The Decision Support System for Agrotechnology Transfer (DSSAT; www.DSSAT.net) is a crop modeling platform that is widely used across the globe, with over 1,100 users in Pakistan alone. DSSAT includes crop simulation models for over 40 different crops, including tomato, green bean, sweet corn, bell pepper, pineapple, and strawberry as horticultural crops. Recent developments also include the prediction of the internal quality of strawberry in addition to fresh weight. However, further research is

needed to develop models for other horticultural crops. The crop simulation models including the models for horticultural crops have shown to be excellent tools for understanding the dynamic Genotype×Environment×Management interactions. When integrated with decision support systems, they also can provide actionable information for growers and other stakeholders. With the rapid changes in agriculture towards a digital system, crop simulation models for horticultural crops will play a key role in helping to develop current and future practices that are economically and environmentally sustainable under a changing climate.

Below, please find some screen shots of the DSSAT software (Figure 1) with examples for tomato simulations (Figure 2). For additional information, please check the references.

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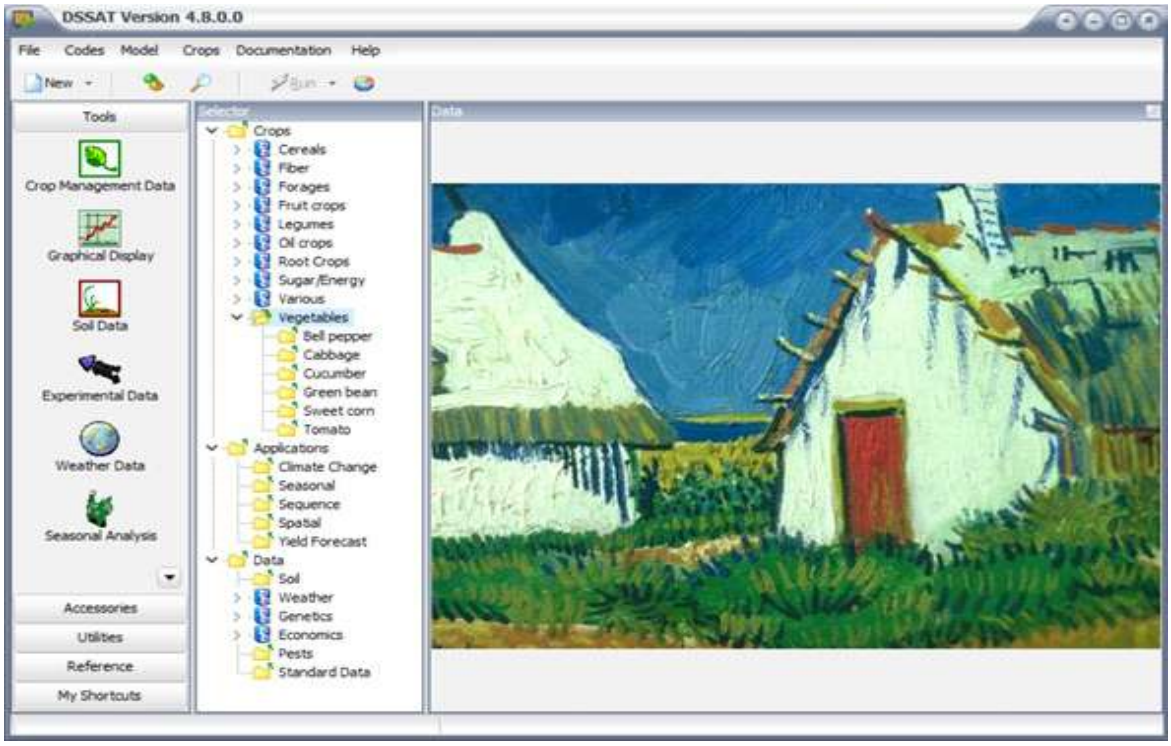

Figure 1. Screen shot of the DSSAT shell with the current crop simulation models for vegetables shown.

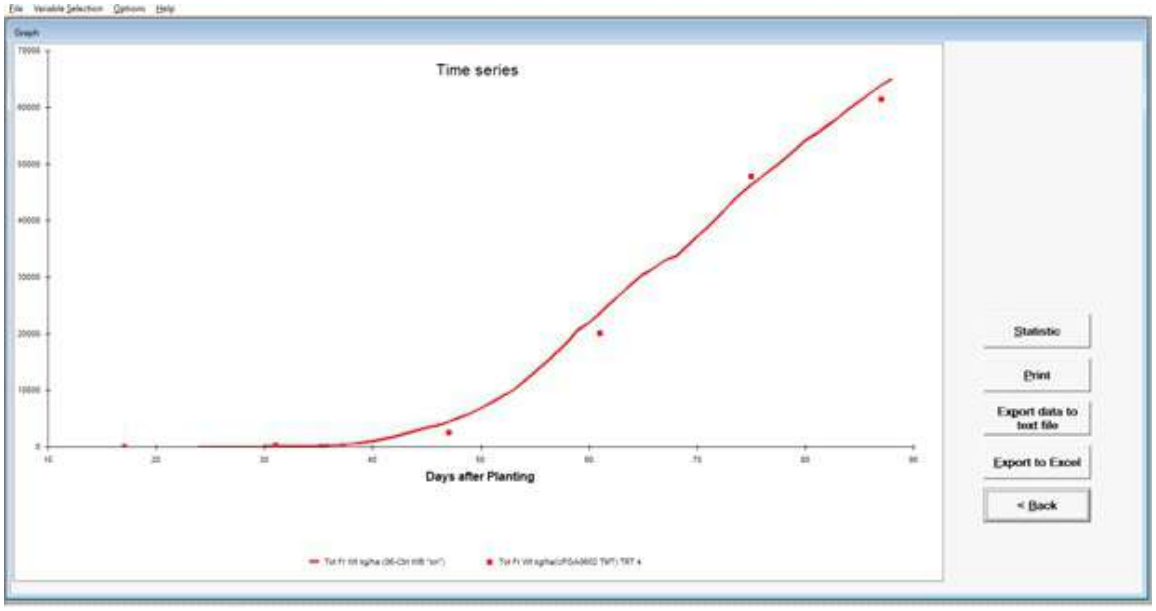

Figure 2. Comparison between simulated and observed tomato fruit weight.

Key Insights From "Labour Productivity: The Forgotten Yield Gap"

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Context

This abstract summarises a recent paper published by the same authors in Agricultural Systems https://authors.elsevier.com/c/1fPLw,70zHnRtv and contextualises the work for Pakistan (Cock et al., 2022). In brief, we argue that in agriculturally advanced countries, increases in labour productivity – that is, increases in the economic output per unit of labour input – have been several-fold greater than corresponding increases in yield. The gap in labour productivity between the Global North and the Global South is now much greater than the yield gap. This large labour productivity gap, unless remedied, will: (i) condemn many farmers in the Global South to live in poverty; and (ii) make them less competitive and force them to follow the well-established trend of exiting farming altogether, which (iii) will contribute to greater dependence on imported food in many countries.

Summary

Most public agencies still see increased crop yields as the principal means to meet demand for food while little attention is paid to the welfare of the millions who eke out a living from farming. Labour productivity (i.e. *the economic output per unit of labour input*) is rarely mentioned as a major driver of increased agricultural production even though it has made modern agricultural remarkably efficient. Labour productivity has increased faster than yield in the Global North: from 1911 to 2000, yield in the USA increased 5-fold while labour productivity increased 15-fold. In the Global South labour productivity has lagged and is often an order of magnitude less than in the Global North. The large increases in both labour productivity and yield in the richer countries make it difficult for poorer countries to compete in a globalized world. These large increases in labour productivity in the richer countries compromise food security in the poorer areas of the world. Low labour productivity is a driver of poverty, reduced food production and greater dependence on imported foods.

Two explanations of why labour productivity remains low include:

1) Low yields tend to be associated with low labour productivity, but this is not universally true. Wherever rice, wheat, and maize are grown, their value is similar in a globalised world: labour productivity of the top decile countries in income distribution for these crops is 60-fold greater than the lowest decile, whilst yields are only 2-3-fold greater. Hence, labour productivities are inherently low in low-income countries and are not *necessarily* related to low yields or low value products. .
2) The GDP of a country explains most of the differences in labour productivity.

Under modern mechanized agriculture 2–5 hours of farm labour produce the food consumed by a person in a year, whereas non-mechanized systems require approximately 200 times more labour. Hence, there are large opportunities for increased labour productivity through mechanization, automation, and use of digital technologies:

Weed Control. Notwithstanding the environmental concerns, chemical weed control remains a crucial pillar of labour productivity, but it is not widespread in the Global South. Increasingly there are now exciting new options for automatised control with robots, but questions remain on farmers' access to these technologies.

Agronomic practices. Agronomic practices can increase labour productivity even though they do not necessarily increase yield. Despite these opportunities, the agronomic emphasis in poorer countries focuses on closing the yield gap with scant attention to labour productivity.

Crop traits. Inherent plant traits are rarely discussed in terms of labour productivity. However, they may be important. Plant breeders could beneficially include labour productivity in their selection criteria.

Increased yield. Higher yield *per se* often increases labour productivity.

High value products. For the small farmers with limited land area, an attractive means to increase output, in monetary terms, is participation in value chains associated with higher value crops.

Most public policies still envisage the road to the modern world paved with cheap food without proper regard to rural livelihoods. Unless livelihoods are incorporated into approaches to transform food systems there is a major risk of achieving environmental and nutritional objectives on the backs of the rural poor. It is encouraging that national leaders are increasingly aware of this: labour productivity is now part of the policy dialogue, especially in Africa. Yet, agricultural research and development policies in the South still focus on increased yields of the staple food crops with minimal consideration of labour productivity.

In the richer countries, labour-saving technologies have largely been developed by the private sector through induced innovation. Only 5% of global private R&D takes place within the developing countries. This limits the capacity to develop appropriate labour productivity enhancing opportunities. Further, soft infrastructure such as universities, research centres, secondary and tertiary education facilities, and an industrial base are often lacking. Yet, such soft infrastructure is essential to induce innovation, especially in smaller and poorer countries. So even if there is a demand for innovation that increases labour productivity, the capacity to answer the demand is fragile in many low-income countries.

Recognition of labour productivity's importance as a driver of inclusive agricultural transformation is essential. A fundamental policy change is needed to emphasise inclusive rural prosperity per se, rather than seeing the rural population as a residual source of cheap labour that produces cheap food. This must include the empowerment of women, who are often excluded from decision-making, although they often constitute the majority of the

rural labour force.

Policy changes must be reflected in programmes that support labour productivity improving technologies and interventions. Changes will require more and refocussed research and development with an emphasis on the distinct contexts of the Global South. Further, improved hard and soft infrastructure, an industrial base to facilitate greater endogenous development, and the establishment of value chains for a diverse range of higher value products are essential.

The need to increase labour productivity is most urgent in the poorest countries where land holdings are small. A shift to higher value products can be an effective means to increase labour productivity and improve rural welfare.

Research and development efforts to link the small farm to both local and international markets is essential. These linkages should include organisational arrangements, such as cooperatives, availability of capital and other inputs. Establishing fit-for-purpose infrastructure along the supply chain will be essential.

The greater emphasis on high value crops should go hand in hand with increased land and labour productivity of the basic food crops. Policies supporting improvements in both, rather than one at the expense of the other, are needed.

Any intervention used to increase labour productivity and improve rural livelihoods must be considered within the context of the local food system and should not be implemented in isolation. Innovation systems must embrace the multiple interactions among actors involved in innovation to foster development. An innovation systems approach that combines improvements in both hard and soft infrastructures can lead to increased labour productivity and foster inclusive agricultural development which redresses the rural-urban imbalance.

Improving labour productivity in low-income countries will require support for small farmers in their shift to higher value crops. This should go together with strong policy support for education and knowledge generation, particularly in the more remote, rural regions. The entire rural workforce and particularly women must be included in the development of new policies and technologies. High value crops and horticulture will play an important role in this transition.

For further details see: Cock, J., Prager, S., Meinke, H. and Echeverria, R., 2022. Labour productivity: The forgotten yield gap. Ag.Syst., 201, https://doi.org/10.1016/j.agsy.2022.103452

Pest Management in Landscape Areas in Qatar

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This study highlights various pests causing huge economic and losses to the landscapes of Qatar. Several landscape pests have been recorded in Qatar, however, key destructive pests that caused huge financial, and reputation losses are discussed here. Subterranean termites are considered one of the most devastating pests in terms of huge financial losses causing damage to commercial and domestic facilities. High humidity and palm trees' transportation from one place to another is the major factors spreading this pest throughout the country. Saw bug is another pest massively spread over the huge stretch of Qatar landscape, mainly on domestic facilities. It is due to the high volume of moisture in the soil, condensation, and decomposed fertilizers. Millipede has also been found over the large landscape area of Qatar, especially in public areas, homes, and gardens. This pest is concentrated in an area with a high volume of moisture in the soil and sometimes emerges in the shape of large colonies having hundreds causing inconvenience to the people. Snail and slug are also common mainly due to the moisture in the soil causing huge damage to the plants and vegetation. Environmental friendly pest management techniques along with eco-friendly chemical pest control are highly recommended in the highly infested areas to reduce further pest infestation.

Keywords: Pest control, landscaping, eco-friendly, Qatar.

Towards Quality Seed Potato Production: Impact of Genotype and Physiological Status of Seed tubers

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Potatoes, unlike other significant crops, are commercially multiplied via seed tubers. The availability and supply of healthy seed tubers are a need for optimal potato crop production. The physiological state of seed tubers is critical for developing healthy plants and overall tuber yield. From sprout initiation to new plant emergence, the physiological status of the seed tuber is heavily regulated by genotype, chronological age, and environmental factors. The available volume of certified potato seed tubers in Pakistan is deficient and insufficient to meet farmer demand. Hence, this study focused on assessing the interaction between genotype and physiological status of seed tubers on tuber yield and quality. A two-factorial, the completely randomized design was used in the experiment. Factor 1 was made up of six different genotypes, whereas factor 2 was made up of three different physiological states of the seed tuber (i.e. *Stage 1*: single sprout state, *Stage 2*: multiple sprout state, and *Stage 3*: branched sprout state). The effects of genotype, physiological status of seed tubers, and their interactions were highly significant ($P \leq 0.001$). Genotype Arizona outperformed by exhibiting the shortest days to emergence and the highest canopy cover (%), number of leaves plant^{-1}, total plant leaf area, harvest index (HI), mean tuber weight, total tuber yield plant^{-1}, and seed tuber yield (%). The physiologically younger seed tubers yielded higher values for most potato growth and yield influencing characteristics. Furthermore, genotype Arizona plants grown from *Stage 1* (single sprout state) seed tubers required the fewest days to emerge and produced the highest canopy cover (%), number of leaves plant^{-1}, total plant leaf area, HI, mean tuber weight, total tuber yield, and seed tuber yield (%). The information gained in this study will be highly beneficial in developing a low-cost, long-term indigenous seed tuber production system in Pakistan.

Keywords: *Solanum tuberosum* L., genotype, physiological stage, seed tuber, yield.

Comparative Morphological Responses of Different Varieties of African Marigold (*Tagetes erecta* L.) to Water Stress

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African marigold (*Tagetes erecta* L.) belongs to the family Asteraceae and is an important ornamental medicinal plant grown for its attractive flowers and phytochemical richness. *Water stress* is significant abiotic stress that restricts the development and effectiveness of plants in semi-arid and arid areas. This study focused on the characterization of water stress tolerant varieties based on morphological characteristics. The research was executed in the Horticultural Research Area of the Arid University, Rawalpindi, with completely randomized design (CRD) consisting of three varieties (F1 Inca yellow, F1 Inca orange, and Alkaram F1 Golden), and four-irrigation regimes, i.e., 100% (T1), 75% (T2), 50% (T3) and 25% (T4) and four replications for each treatment. Response characters included physiological characteristics*viz.,* height of plant (cm), number of leaves per plant, root length (cm), and number of flowers per plant, fresh and dry weight (g) of shoot, fresh and dry weight (g) of root. The V2 (Inca F1 Yellow) revealed more resistance to water stress conditions as compared to the V1 (Inca F1 Orange) and V3 (Alkaram F1 Golden). Due to its stress resistance character, V2 (Inca F1 Yellow) is commercially recommended in the arid region to save water in stress conditions with minimum loss in crop production and nutritional budget.

Keywords: Ornamental, water deficiency, stress tolerance, morphological parameters, conservation of water.

Mitigation of Cadmium Toxicity through Basal Application of Melatonin in Pepper Seedlings

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The contamination of food crops with heavy metal toxicity seriously affects human health. In this study, the basal application of melatonin was carried out in Pepper (*Capsicum annum*) plant to halt the effect of cadmium toxicity. It is one of the most important vegetable species for consumption after tomatoes and onions worldwide. A pot experiment was laid out in a completely randomized design with three replications. In order to explore the effect of exogenous application of melatonin through soil drench, forty days old seedlings of two pepper cultivars, viz. Super Shimla and Ganga were used. The control seedlings (To) were simply irrigated with distilled water. Basal application of 200 ml of 5 µM melatonin solution was carried out once every three days up to 12 days to melatonin-treated seedlings (T1). After this, T1 (melatonin-treated seedlings) and T2 (melatonin-untreated seedlings) were flooded with 0.1 mM cadmium sulphate for ten days. On the last day of cadmium stress, photosynthetic parameters were measured using an infrared gas analyzer, and antioxidant enzyme activities were determined through spectrophotometric methods. The results indicated that 5µM melatonin application reduced visual damage but increased shoot and root biomass in pepper seedlings. Moreover, melatonin also improved water relations, photosynthetic parameters, and the activities of antioxidant enzymes, including superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), while lowering malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) contents. On the other hand, cadmium sulphate solution showed negative impacts on physiological characteristics in pepper seedlings. Thus, the results of this research indicated that treatment of pepper seedlings with 5µM melatonin through soil drench could be used to improve early seedling growth and antioxidant enzyme activities under cadmium stress.

Keywords: *Capsicum annuum*, oxidative damage, cadmium stress, photosynthetic pigments, hydrogen peroxide.

Spermidine Counters Salt Stress by Limiting Reactive-Oxygen Species (ROS and Alleviating Antioxidant Defence System in Strawberry

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Salinity is a universal stressor that hampers the normal metabolism of plants and thus limits the quality and quantity of produce. Spermidine (Spd) is a polyamine known to play a vital role in plant growth, development, and stress endurance. Herein, we compared the impact of salt stress (NaCl at 120 mmol) on strawberry (*Fragaria vesca* L.) growth and physiology. Results showed that salt stress restricted plant growth, minerals uptake, chlorophyll fluorescence, and photosynthetic process in strawberry plants after three days of salt stress. However, exogenous spermidine (0.1 mM) application reduced the accumulation of malondialdehyde (MDA), hydrogen peroxide (H_2O_2), proline, and electrolyte leakage, thus leading to an increased tissue water content and photosynthetic process. External application of Spd also reduced reactive oxygen species (ROS) accumulation, resulting in membrane stability and rigidity. In addition, the endogenous level of abscisic acid (ABA) was alleviated in salt-treated strawberry plants. Spd effectively coordinated with the ABA signalling pathway by down-regulating the expression of ABA-related genes, whereas induced the expression level of *RBOH1* and other salt-related genes, including *SlMYB102, SlHKT1, SlWRKY1, and SlDREB2*. The accumulation of H_2O_2 was decreased in both leaves and roots after Spd treatment, which helps to detoxify the excessive ROS production by increasing antioxidant enzyme activity and up-regulating antioxidant-related gene expression. Overall, our results will help understand the impact of Spd in altering salt stress severity and thus can be helpful to hasten the defence system of plants under salinity conditions.

Keywords: Spermidine, reactive oxygen species, hydrogen peroxide, abscisic acid signaling, salt stress.

Impact of the Soilless Growing System and Greenhouse Environment on Tomato Growth and Productivity

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Food security and safety has been challenging for sprawling population and changing climatic scenario. Pakistan needs 150% increase in crop productivity during 2050 to feed the growing populace. Hence, alternate crop production systems (e.g., soilless cultivation) must be evaluated and standardized per local scenario. Therefore, the present study was planned and performed for testing different plum tomato cultivars under various soilless cultivation systems and temperature regimes in a partially environment-controlled greenhouse equipped with a fan and pad evaporative cooling system. The study was laid out under completely randomized design (CRD) with a three-factor factorial arrangement (cultivation system, tomato cultivars, and temperature zones). Cultivation systems (grow bags and trough/channel system), temperature regimes (T0 = 23-24 °C, T1 = 26-27 °C, and T2 = 29-30 °C), and tomato cultivars (Sahil, Red Rock, Sandal, Sallar and Surkhail) were the treatment combinations. The results elaborated that Red Rock cultivar grown in trough/channel cultivation system under 26-27°C significantly ($P \leq 0.05$) increased inter-nodal distance, leaf area, plant height, shoot fresh weight, photosynthetic rate, transpiration rate, stomatal conductance, mesophyll conductance, sub-stomatal CO_2, water use efficiency and intrinsic water use efficiency, and yield attributes. However, total soluble solid, titratable acidity, ascorbic acid, anthocyanin, total phenolic contents, total antioxidants, superoxide dismutase (SOD), peroxidase (POX), and catalase (CAT) were found maximum in grow bag under 29-30 °C. Conclusively, Red Rock may be suggested to cultivate in a trough/ channel soilless cultivation system under a partially environment-controlled greenhouse by maintaining temperature around 26-27 °C to obtain maximum plum tomato yield.

Keywords: *Lycopersicon esculentum*, Grow-bag, temperature regimes, gas exchange, phytochemical

Field Evaluation of Turf Grass Species Korean (*Zoysia japonica*) and Tifway (*Cynodon transvaalensis* × *Cynodon dactylon*) in Response to Herbicide Treatments

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Turfgrasses are prime verdure covers on parks, golf courses, athletic fields, airports, schools, cemeteries, home lawns, commercial buildings, and roadsides. Weeds in turf instantly reduce growth because they compete for water, nutrients, light, and aeration. A field study was conducted to assess the effect of weed control practices on two famous turf grass species viz., Korean (*Zoysia japonica*) and Tifway (*Cynodon transvaalensis*×*Cynodon dactylon*). Treatments were manual hoeing (2 hoeings), pendimethalin @ 3 ml/100 ft^2 and bromacil @ 3 ml/100 ft^2. Pendimethalin was sprayed just before plugging, while bromacil was sprayed after the three weeks of plugging, using a T-jet nozzle fitted knapsack sprayer after calibrating the volume of water. Results showed that Korean (*Zoysia japonica*) turf grass under Bromacil (3 ml/100 ft^2) exhibited the maximum numbers of tillers (16.9), length of tiller (8.5 cm), number of leaves per tiller (13.2), inter nodal distance (12.2 mm), fresh weight of tiller (3.2 g), dry weight of tiller (1.5 g), moisture percentage of grass (58.2%), uniformity (7.5) and smoothness (6.7). In the case of Tifway (*Cynodon transvaalensis*×*Cynodon dactylon*), maximum numbers of tillers (16.3), length of tiller (12.8 cm), number of leaves per tiller (13.5), inter nodal distance (7.4 mm), fresh weight of tiller (3.2 g), dry weight of tiller (1.1 g), moisture percentage of grass (55.7%), uniformity (7.7) and smoothness (7.8) were recorded best under bromacil (3 ml/100 ft^2). Uniformity and smoothness were determined visually through a scale having a 1 to 9 rating. In uniformity, 1 means minimum uniformity and 9 means maximum uniformity, and in smoothness 1 means uneven growth, and 9 means highly even growth. In short, the best weed control practice was bromacil 3 ml/100 ft^2.

Keywords: Bromacil, Pendimethalin, pre-emergence post-emergence herbicide, turf grass.

Pumpkin Rootstocks Improve the Growth of Watermelon under Less Available Boron Conditions

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Boron (B) is a micro-element essentially required for the physiological functioning of plants. The deficiency of B negatively affects watermelon growth and results in thick, curled, brittle chlorotic leaves with reduced leaf expansion*Grafting* is an environment-friendly technique that can be utilized to mitigate B deficiency in watermelon. This study used the commercial watermelon cultivar Zaojia-8424 [*Citrullus lanatus* (Thunb.) Matsum. and Nakai.] grafted onto pumpkin (*Cucurbita maxima* ✕ *Cucurbita moschata*) rootstock cv. Qingyan Zhenmu No. 1 to investigate rootstock's response against three B (0.25 µM, 25 µM, and 75 µM) levels. Self-grafted watermelon plants were used as control. Our results showed that dry mass accumulation, leaf chlorophyll content, photosynthetic assimilation, and stomatal conductance in pumpkin rootstock grafted plants were higher at 25 µM B level compared with control plants at 75 µM B level. Moreover, pumpkin rootstock improved B accumulation by enhancing the expression of aquaporin (*NIP5;1, NIP6;1)* and B transporter (*BOR2, BOR4*) genes in the roots and leaves at 25 µM B compared with control plants at 75 µM B level. Up-regulation of SOD (*SOD1, SOD2*) and CAT (*CAT2-1, CAT2-2*) genes and down-regulation of PCD (*PCD2-1, PCD2-2*) genes in pumpkin grafted plants at 25 µM B level significantly reduced H_2O_2 and malondialdehyde (MDA) biosynthesis compared with control plants. We conclude that pumpkin rootstock can improve plant growth by enhancing B uptake from the soil solution and transport to above-ground plant parts under less available B conditions. Therefore, the use of pumpkin rootstock can reduce fertilizer use and the cost involved in it.

Keywords: Grafting, rootstocks, boron deficiency, ion uptake and transport, abiotic stress tolerance.

Role of Plant Growth Regulators on the *In vitro* Regeneration of Chrysanthemum (*Dendranthema morifolium* L.)

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Experiments were carried out to check the effect of different concentrations of IAA (0.0, 0.1, 0.2, 0.3, and 0.5 mg L^{-1}) and BAP (0.0, 0.5, 1.0, and 2.0 mg L^{-1}) either alone or in combination on the regeneration of chrysanthemum plantlets using leaf disc explants. Data were recorded on days to shoot initiation, shoot initiation percentage, the average number of shoots per explant, length of shoots (cm), number of leaves, and number of nodes per shoot. Highly significant shoot multiplication was obtained with MS media supplemented with different concentrations of IAA and BAP. The lowest concentration of IAA (0.1 mg L^{-1}) exhibited the minimum days to shoot initiation (5.5), maximum shoot initiation (70.0%), shoots per explant (2.2), shoot length (3.0 cm), leaves (8.1), and nodes per shoot (3.5). In the case of BAP, the intermediate concentration (1.0 mg/L) exhibited least days to shoot initiation (5.0), maximum shoot initiation (76.7%), shoots per explant (3.4), shoot length (3.8 cm), leaves per shoot (9.5) and nodes per shoot (4.3). As far as the combination of both (IAA and BAP) is concerned, significantly better results were obtained when MS media was fortified with lower concentrations of IAA (0.1 and 0.2 mg L^{-1}) combined with intermediate concentrations of BAP (1.0 and 2.0 mg L^{-1}) regarding the regeneration of chrysanthemum plantlets. Excellent response was achieved regarding the rooting of chrysanthemum micro-shoots when they were sub-cultured into ½ strength MS media supplemented with 0.2 mg L^{-1} IBA.

Keywords: BAP, Chrysanthemum, *Dendranthema morifolium*, *in vitro* culture, IAA, IBA, Regeneration and rooting.

Micropropagation in Cyclamen: Multiple Shoot Induction through Corms

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The Pakistani floriculture industry is experiencing various problems at the national level, mainly due to the lack of investment in research and development by the corporate and government sectors. Every year, many plant species and variants are imported from various areas of the world due to a scarcity of indigenous hybrid materials of enticing and seasonal flowers and foliage plants. The floriculture industry has a total stake of US$ 1.8 billion in flowering bulbs, which includes lilium, gladiolus, hyacinth, amaryllis, and cyclamen, among other bulbs. Cyclamen is a spectacularly beautiful flowering corm, and annually, a modest number of cyclamen is imported from the Netherlands for potted plants. The price of one plant in Islamabad-Pakistan flower marketplaces in winters can reach Rs. 600. The *in vitro* multiplication and propagation approach can aid in the availability of plants at reduced prices in the local area. Hence, in this study, corm slices with rooting sections of cyclamen cv. Pewter White was used for multiplication. The explants were cultured on MS-medium supplemented with naphthalene acetic acid (NAA), and gibberellic acid (GA_3) (0.2, 0.4, 0.6, 0.8, and 1.0 mg L^{-1}) used alone and in combination. Indole-3-butyric acid (IAA) (0.2, 0.4, 0.6, 0.8, and 1.0 mg L^{-1}) was fortified in MS-medium for rooting. MS-medium supplemented with 0.4 mg L^{-1} NAA+GA_3 resulted in the maximum shoot proliferation, whereas the ideal shoot length (3 cm) was observed on MS-medium fortified with 1.0 mg L^{-1} of GA_3. The earliest shoot formation was observed with MS-medium supplemented with 0.6 mg L^{-1} GA_3. On the contrary, the MS-medium fortified with 1.0 mg L^{-1}, IAA resulted in the best root formation after inoculation in terms of root length (4 cm) and early rooting (19.5 days). Such findings could help the rapid and sustainable multiplication of important flowering bulb plants like cyclamen in Pakistan.

Keywords: Cyclamen, PGR, *in vitro*, multiple shoot induction.

Micropropagation of Turmeric as an Alternative to a Seed-derived Method for Clean Planting Material

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Turmeric is a commercially important spice cultivated for the production of secondary metabolites, including curcuminoids which are used in different pharmaceuticals, neutraceutical, cosmeceutical, and textile industries. Propagation of turmeric through seed-derived rhizomes possesses slow vegetative growth with reduced secondary metabolites and frequently transmits fungal and bacterial diseases over generations. Micropropagation of turmeric paves the way to circumvent these limitations and provides a promising source for the production of disease-free healthy plant material with an increased metabolic profile. *In vitro* cultures of turmeric were established by using explants, i.e., 1.0-3.0 cm of sprouted buds, 0.6−2.0 cm of shoot tip, and 3.0−4.0 mm of dormant rhizome buds, which were primarily sterilized with 0.4% mancozeb for 2.0 minutes in combination with 30% sodium hypochlorite for 20 minutes and eradication of endogenous bacterial contamination cefotaxmine 50 mg L^{-1} was also used in media to produced contamination free cultures. Shoots were proliferated by transferring developed shoots of 3.0−4.0 cm on media supplemented with cytokinin, i.e., BAP at two different concentrations such as 2.0 mg L^{-1} and 4.0 mg L^{-1}. The BAP at 4 mg L^{-1} proved to be most effective for shoot proliferation and recorded an average of 8 shoots per explant with a shoot length of 2.5−3.6 cm and 4.0−5.0 expanded leaves per shoot within 8 weeks. Results concluded that the proliferated shoots of turmeric via microporpagation may provide a source of healthy, clean planting material for microrhizome induction.

Keywords: Turmeric, micropropagation, seed rhizome, PGRs.

In vitro Regeneration and Characterization of Colchiploid Germplasm in Acid Lime Cultivars

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Induced polyploidization has been widely used as a promising tool to widen the germplasm base and enhance heterozygosity in fruit crops. In this study, induced polyploids were developed by treating seeds of acid lime cultivars, viz. Mexican lime 'ML' and Eustis limequats 'EL' with different levels of antimitotic agent colchicine viz. 0, 0.01, 0.05, 0.1% and their phenotypic traits were investigated. The higher dose of colchicine (0.1 %) substantially decreased the percentage of seed germination by (48%, 50%, shoot length (6.17 cm, 5.14 cm), and inter-nodal distance (3.8 cm, 3.2 cm) in both cultivars (ML and EL, respectively). However, the number of leaves (6.33) markedly increased with the increasing level of colchicine in the ML cultivar. *In vitro* regeneration was established in the colchiploid plant material for further multiplication. Nodal segments of putative colchiploid plants were cultured on Murashige and Tucker basal medium fortified with various levels of BAP and NAA for clonal multiplication, and their *in vitro* regeneration responses were assessed. In explants developed at a higher colchicine level (0.1 %), the percentage of shoot induction was highly reduced (45.83 %) in ML compared with control. Cultivars EL took fewer days to induce the shoots (11.4) than ML. More number of shoots per explant (7), higher plant survival (50 %), and more number of leaves (23.2) were exhibited by ML compared with EL at a higher (0.1 %) level of colchicine. Cytological and genetic studies of putative polyploids are in progress for screening the developed germplasm for ploidy and genetic polymorphism.

Keywords: Colchicine, ploidy, shoot regeneration, micropropagation.

Influence of Various PGRS on the *In Vitro* Propagation of Two Potato Cultivars

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Micro-propagation is considered a very effective approach to speed up the high-quality pathogen-free plantlets production regarding phenotypic and genotypic uniformities in potatoes. The main factors influencing the parameters of growth and development of potato micro-plants are the variety of features and composition of the nutrient medium. Thus experiments were conducted to check the response of different PGRs to the *in vitro* propagation of two potato cultivars at the National Institute of Genomics and Advanced Biotechnology (NIGAB), National Agricultural Research Centre, Islamabad. This research was conducted in a completely randomized design with a factorial arrangement. Different concentrations and combinations of PGRs were assigned as factor I, whereas two potato cultivars were assigned as factor II. Each treatment was replicated six times. For shoot proliferation, nodal explants were inoculated in a culture medium fortified with different arrangements of BAP and NAA. A combination of BAP + NAA @ 1.5+0.5 ppm responded optimally amongst all the other combinations, as earliest shoot initiation (5.4 days), maximum shoots (4.0), shoot length (4.4 cm), leaves (7.0) and nodes (8.6) were recorded in this treatment. For *in vitro* root development, half strength MS medium fortified with IBA exhibited good results than IAA. Higher IBA levels @ 0.2 and 0.5 ppm performed significantly well for *in vitro* rooting as compared to IAA and control treatments, as earliest root initiation (5.7 and 5.4 days), the highest number of roots (16.2 and 19.5), and root length (6.3 and 7.1 cm) were observed in both these IBA concentrations, respectively. The potato cultivars (Kuroda and Asterix) showed a non-significant behavior for *in vitro* shoot proliferation, whereas cv. Kuroda performed better for *in vitro* rooting than Asterix.

Keywords: *Solanum tuberosum* L., *in vitro* multiplication, BAP, NAA, *in vitro* rooting.

Impact of Humic Acid Amended Growing Media and IBA on Propagation of Lemon (cv. Singhar) Via Stem Cuttings

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Dera Ismail Khan (D.I.Khan), a southern region of the province Khyber Pakhtunkhwa (KPK), is considered the birthplace of the lemon cultivar Singhar which is very famous for its large size fruit, seedlessness, juiciness, and high yield. There is a high demand for developing a simple, optimal, commercially feasible, and sustainable nursery production method for lemon (cv. Singhar). The capability of cuttings to rooting success depends upon several factors such as cutting type and length, growing season, growing media (GM), root-promoting substances, etc. Therefore, this study mainly focused on elucidating the effects of GM and root-promoting substances on the rooting, growth, and survivability of lemon stem cuttings. The experimental design was two factorial CRD replicated eight times.*Factor 1* consisted of two GM (viz. sandy loam and clay soil) amended with 0.0, 1.3, 2.6, 3.9, and 5.1 ml HA m^{-2}. *Factor 2* consisted of six concentrations of IBA (viz. 0 (control), 100, 200, 300, 400, and 500 mg L^{-1} water). Semi-hardwood healthy stem cuttings (23 cm in length with 10 buds) were dipped halfway in the corresponding IBA concentration for 24 hours and later stuck into the corresponding GM under a moist condition. Environments created by different GM, and IBA applications and their interaction (GM×IBA) significantly (P<0.001) affected all the examined parameters. The combination of IBA (400 mg L^{-1}) and sandy loam GM ameliorated with 3.9 ml HA m^{-2} produced maximum plant survivability (PS). On the contrary, PS was the lowest in clay GM alone at 0 mg IBA L^{-1}. The results concluded that the reactivity of the IBA application in lemon stem cuttings largely depends on GM's physical and chemical properties. Overall, this study would help formulate the clonal multiplication technology package of lemon (cv. Singhar) via stem cuttings.

Keywords: Humic Acid, Indole-3-Butyric Acid, rooting, lemon, growing media.

Standardization of Growing Media and Propagation Time Using Air Layerage Technique for Lemon

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Lemon plants are traded in large quantities in Dera Ismail Khan; therefore, it was needed to explore a longer window of time for the propagation through air layering and find out the best material used in air layering to get maximum success for the production of lemon plants. Growing media planned were cinnamon, aloe vera, leaf mould, farm yard manure (FYM), and silt. Time of propagation studies included the last week of February to August with weekly intervals. The parameters studied were root diameter (mm), number of roots, number of root bud, the maximum length of root, branches per plant, fresh root weight per plant, and dry root weight per plant. Leaf mould and the mixture of FYM+silt were found to be the best material for air layering in lemon. It was further concluded that March was the best period for the multiplication of lemon through air layering. Correlation studies revealed that growing media with high moisture retaining capacity resulted in the best root development in the air layers.

Keywords: Propagation, lemon, layerage.

Effect of Different Substrate Disinfection Methods on the Performance of King Oyster Mushroom (*Pleurotus eryngii*)

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One of the most expensive steps in mushroom production is the disinfection of the substrate. This study was designed to disinfect the substrate for cultivating king oyster mushrooms from various pathogens with chemicals (formalin, carbendazim) and steam sterilization in the drum. For this purpose, three different concentrations of formaldehyde (0.5%, 1%, and 1.5%) and carbendazim (5, 10 and 15 g /100 L) were used to treat (immersed substrate for 30 min) the wheat straw and cotton waste substrates for the production of king oyster mushroom. The control substrates were immersed in just water at the same time. The experiment was laid out in a completely randomized design (CRD) with ten replications. The data was collected in three flushes. The efficacy of treatments was evaluated for yield and biological efficiency (BE) and average mushroom weight. Yield and BE ranged between 125−450 g/kg and 34.5−80% in cotton waste and 87.6−370 g/kg and 15.76−72% in wheat straw, respectively. The highest yield and biological efficiency were obtained at 1% formaldehyde with 5 g/100 L carbendazim in cotton waste and wheat straw substrate. The results revealed that the formaldehyde and carbendazim combination would be a viable and promising technique for the disinfection of substrates for king oyster mushroom cultivation. Therefore, it can be concluded that chemically disinfecting the substrates instead of steam sterilization in drums for cultivating king oyster mushrooms can be used to save time for mushroom growers.

Keywords: Papaya, seed priming, growing media, potassium nitrate, biomass.

Comparative Effect of Seed Priming and Growing Media on Seed Germination and Seedling Growth of Papaya (*Carica Papaya* L.)

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An experiment was conducted to assess the comparative effect of seed priming and growing media on seed germination and seedling growth of papaya. Papaya seeds were primed in distilled water and 1% potassium nitrate (w/v) for 12 hours. The un-primed seeds were taken as control. The growing medium was prepared by mixing different ratios of the canal silt, bagasse, and coco peat. The data was recorded for seed germination percentage, mean germination time (MGT), germination index (GI), seedling vigour index (SVI), fresh biomass of shoot (g), fresh biomass of root (g), dry biomass of shoot (g), dry biomass of root, quality index of the seedlings, sturdiness quotient and leakage of the electrolytes. The interactive effect of seed priming and growing media exhibited the best results for seed germination (99.33%), MGT (3.33 days), SVI (5886.5), fresh biomass of shoot (13.61 g), fresh biomass of roots (2.90 g), quality index of the seedlings (0.17) and sturdiness quotient (38.47) in reaction to the treatments where seeds were primed in distilled water and grown in canal silt + bagasse + cocopeat (1:1:1) growing medium. The minimum leakage of the electrolytes (38.74%) was observed in reaction to the treatments where seeds were primed in distilled water and grown in canal silt + bagasse + cocopeat (1:0:1) growing medium. This study concluded that seed priming with distilled water and grown in media comprising canal silt, bagasse, and cocopeat (1:1:1) was optimal for all papaya seed germination and seedling attributes.

Keywords: Papaya, seed priming, growing media, potassium nitrate, biomass.

Sugarcane Pressmud: A Potential Agricultural Waste for Containerized Nursery Production of Marigold

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In Pakistan, garden soil is mostly used as a substrate for containerized plant production, which does not support sustainable nursery production due to weed infestation and soil-borne diseases. For producing superior quality saplings, using economical and sustainable substrate mix is the key element. Therefore, a study was conducted to evaluate a few of the agricultural wastes as soilless substrate components such as coco-coir, sawdust, rice hulls ash, composted peanut hulls, and sugarcane pressmud used in different volumetric ratios along with negative control (sand:silt; 50:50), positive control 1 (coco-coir: sugarcane pressmud; 50:50) and positive control 2 (coco-coir: rice hulls ash: sugarcane pressmud; 33:33:33). These treatment ratios were evaluated for their phyisco-chemical properties and their effect on nursery raising attributes of marigold. The highest seed germination (100%) was observed in sawdust: rice hulls ash: sugarcane pressmud ratio of 30:30:40, and positive control treatment 2 excelled the rest of the treatments. Positive control 2 resulted in the highest germination index (400-435), seedling vigor index (2000-2100), seedling shoot length (10-12 cm), seedling root length (10-13 cm), seedling length (20-25 cm), total leaf chlorophyll contents (55-58 SPAD), seedling fresh and dry weight (1.0 and 0.5 g, respectively). Results depicted that the greatest electrical conductivity (2881 dS m^{-1}), nitrogen contents (1.166%), phosphorus and potassium contents (87.31 and 253.22 mg L^{-1}, respectively), water holding capacity (69.40%), porosity (77.18%) and organic matter contents (88.51%) were recorded in positive control 2 (coco-coir: rice hulls ash: sugarcane pressmud; 33:33:33). This treatment had optimal pH (6.21) and most stable aggregates, which would be adhered to each other and would not break easily during transportation from one place to another. In summary, coco-coir in combination with rice hulls ash and sugarcane pressmud resulted in the best nursery growth attributes, and nursery workers may use this combination for high-value uniform quality nursery production of ornamentals.

Keywords: Pressmud, agricultural waste, nursery production, growing media, marigold.

Adaptability Performance of Various Exotic Potato Varieties at Multilocations of Gilgit Baltistan

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A trial of nine exotic potato varieties (Bartina, Sante, Pameela, Melanto, Lady Rosetta, Roko, Asterix, Koruda, and Zena Red) was conducted at different locations in Gilgit Baltistan (GB) at an altitude of 7000 feet above sea level. The seed potato was planted on raised ridges that were 5 m long, spaced 0.75 m apart with 0.15 m between plants. The initial dose of nitrophos (25 kg kanal^{-1}) was applied at the time of planting, and urea (10 kg kanal^{-1}) was applied at three different stages. The whole experiment was replicated three times, and the data was collected and analyzed using a randomized complete block design (RCBD). In this study, the variety Roko, Lady Rosetta, and Bartina showed 100% plant emergence, followed by Melanto, Asterix, and Sante (99%). In contrast, the least plant emergence was recorded in the Zena Red variety throughout the study locations. Maximum plant height (100.3 cm) was recorded in Pameela across the locations. The maximum number of stems (05) was recorded in Bartina followed by varieties Lady Rosetta (4.4) and Roko (4) stems plant^{-1}. The minimum (1.4 and 1.8) number of stems plant^{-1} was noted in Zena Red. Similarly, the maximum (12.8) number of tubers plant^{-1} was recorded in Melanto, followed by Lady Rosetta. The variety Roko exhibited the highest yield (30.9 mt ha^{-1}). The Sante and Zena Red varieties appeared to be the least adaptive ones, exhibiting 12.0 and 8.9 mt ha^{-1} tuber yields, respectively. This study provided the basis for screening out adaptive and high-yielding potato varieties under the agro-climatic conditions of GB, Pakistan.

Keywords: *Solanum, tuberosum* L., seed potato, adaptability, yield.

Genotype-by-Environment (G×E) Interaction on the Dynamics of Yield Formation in Okra

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This study aimed to assess the dynamics of yield formation in two diverse genotypes of okra (Sabz Pari, Arka Anamika) across seven contrasting N environments (0, 50, 100, 150, 200, 250,and 300 kg ha^{-1}) and to quantify a range of component traits which may determine the genetic (G), environmental (E) and their interaction (G×E) effects on the important plant processes controlling yield formation. Results indicated the presence of significant components of variations (G, E, and G×E) for the majority of traits. The ranking of genotypes changed across the environments for the majority of traits. Genotype Arka Anamika proved more responsive to N availability by producing maximum dry matter and yield with an increase in N level. Sabz Pari on the other hand, exhibited better results for harvest index (HI) and nitrogen use efficiency (NUE) under N limited conditions. Overall, Arka Anamika appeared superior by producing a 50.96% yield increase over Sabz Pari. Analysis of correlation coefficients indicated significant inter-relationships between most traits studied. It was concluded that yield formation in okra is a complex phenomenon affected by the interaction of multiple yield-determining component traits. Finally, the economic analysis indicated that the application of N increased the benefit-cost ratio (BCR) over control; however, genotypic differences were evident. N availability in the range of 100-150 kg ha^{-1} gave the highest BCR of 15.6 to 16.2, respectively, for genotype Sabz Pari. Arka Anamika, on the contrary, gave the highest BCR of 19.6 at the maximum N level (300 kg ha^{-1}) but with the highest cost of production. It was concluded that N levels of 150 and 300 kg ha^{-1} are optimum rates for Sabz Pari and Arka Anamika, respectively, for obtaining better yields and economic returns in okra under resource (N) limited and optimum growing environments, respectively.

Keywords: Okra, Genotype-by-Environment (G×E) interaction, key traits, phenology, yield.

Genetic Evaluation for Yield and Quality Attributes in Spinach (*Spinacia oleracea*) Under Heavy Metals Stress

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Spinach (*Spinacia oleracea*) is the main leafy vegetable in the world. Spinach has more nutritional components like protein, vitamins, fats, and a high rate of palatability in comparison to other leafy vegetables. Heavy metal pollution is a major concern that is produced through different sources. Heavy metals affect agricultural soil, plant growth, and environmental components in Pakistan. Studies have shown the capability of spinach to bio-accumulate heavy metals from the soil. Hence, this research was conducted to check the effect of lead and chromium stress on the growth of spinach plants, yield, nutritional parameters, and tolerance to heavy metals. 13 genotypes were sown in soil by using a completely randomized design. Two different levels of lead (Pb) and chromium (Cr) (7.5 mM and 15 mM) were applied, respectively, with one control group. Data were recorded for leaf quality attributes, i.e., crude protein (3.13%), crude fat (1.41%), acid detergent fiber (54.07%), ash contents (8.48%) and growth parameters, i.e., germination percentage (86.67%), number of leaves per plant (12.8), shoot length (5.1 cm), root length (18.48 cm), shoot fresh weight (0.2485 g), root fresh weight (0.1247g), root dry weight (0.0254 g), shoot dry weight (0.0193g), biomass (85.416), and chlorophyll (56.1). Analysis of variance results was highly significant for growth and quality parameters. Results indicated that genotypes Z-V, FA-13-18, FA-69, and National-5 attained the maximum germination percentage, growth, and leaf quality (ash contents, crude fat, and crude protein) of spinach under lead and chromium-affected areas. The results of this research showed that Z-V, FA-13-18, FA-69, and National-5 genotypes have high genetic variability, and this variability could be used in breeding for the enhancement of yield and quality of spinach such as for high chlorophyll contents in those areas where heavy metals stress is high.

Keywords: Spinach, heavy metals, lead, chromium, quality.

Assessing Causes and Effects of Declining Chilgoza (*Pinus gerardiana*) Forests Nuts Yield in South Waziristan Agency, Pakistan

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Pinus gerardiana Wallich ex. D. Don. (Chilgoza) forests enlisted as endangered in the Red Data book by IUCN are decreasing continuously in South Waziristan Agency (SWA), Pakistan. The area is home to pure natural forests of *P. gerardiana*, fulfilling the community's household needs and source of revenue generation from the sale of nuts. Only a few studies are available globally on the decline of *P. gerardiana*; however, no research work is done in the current study area. Hence, a research survey was conducted in tehsil Birmal of South Waziristan Agency (SWA) to determine various causes and effects in the decline of *P. gerardiana* forest nuts and explore different possible remedial measures. The data collection included direct interviews and filling out questionnaires from the respondents. The respondents selected were growers, nuts collectors, and merchants of *P. gerardiana* nuts. Besides poor management and deforestation, climate change also has affected *P. gerardiana* nuts production. Various threats, i.e., overgrazing, overharvesting, insects and pest attacks, overcutting for fuelwood, diseases (dieback), and injuries during harvesting using local tools have decreased nuts yield and regeneration. The research findings confirmed that nuts yield has substantially decreased due to the collection of 100% nuts, resulting in the non-availability of seeds for natural regeneration. The collected pine nuts are used as a major food for medicinal use, exported worldwide, and used locally, especially in winter. These nuts are managed commonly by the community for profit sharing. The significant implication of the study is to take the local and provincial governments and NGOs on the same page to monitor climate change, introduce improved harvesting techniques, and focus on restoring degraded nuts yield. Various training and seminars for conservation of *P. gerardiana* forests will enhance the livelihood of local people and will help the national revenue on a sustained basis.

Keywords: Chilgoza, nuts, yield, South Waziristan Agency.

An Overview of Germ Plasm Unit (Tropical), Agriculture Research Institute, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

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Germ plasm (GP) is a valuable natural resource that provides knowledge about the genetic composition of a plant species, therefore crucial for conserving plant diversity. The successful use of genetic resources necessitates their diligent collection, storage, analysis, documentation, and exchange. The Agriculture Research Institute (ARI), Dera Ismail Khan (D.I.Khan), Khyber Pakhtunkhwa (KPK) has a precious Germ Plasm Unit (GPU) of tropical fruit plant species that was established under PHP Swiss during 1999 −2003 and later under the government of KPK during 2003−2008 at Rakhzandani, D.I.Khan. At GPU, different fruit plant species and varieties are protected and preserved. Among these are 22 varieties of mango, 21 varieties of date palm and citrus species, 14 varieties of ber, 11 varieties of guava, 06 varieties of olive, and 02 varieties of falsa and peach. Hence, the GPU provides a strong base for certified nursery fruit plant production. With the collaboration of the Federal Seed Certification and Registration Department (FSC&RD), the GPU has so far registered 04 varieties of date palm (viz. Dhakki, Gulistan, Muzawati, Shakri), 01 variety of mango (viz. Langra Panyala), 01 variety of seedless lemon (viz. Singhar), while 02 varieties of ber are in the registration process. In addition, the GPU has also registered 10 fruit plant nurseries to ensure the availability of true-to-type and disease-free fruit plants to the area growers. In conclusion, the GPU has achieved great success in preserving the precious indigenous and exotic fruit germ plasm and increasing the area under fruit crops to uplift the socio-economic conditions of the poor farming community.

Keywords: Germplasm, plant genetic resources, conservation, propagation, genotype-by-environment (G×E) Interaction.

True Potato Seed Breeding: History, Progress and Prospects

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The breeding and cultivation of diploid True Potato Seeds (TPS) remained well known and dominated the markets in history, becoming a future breakthrough for the potato crop. TPS breeding was initiated in early 1959 by a Chinese researcher in the northern potato cultivation areas of China. It was established for tetraploid genotypes. TPS-based breeding and cultivation were greatly popularized and commercialized until 1979, then gradually lost their popularity. This research evaluated and summarized various factors causing the reduced interest in TPS breeding. After 1990, the research on this subject was paused due to the limitations of self-incompatibility and inbreeding depression as major constraints. The recent discovery of neofunctionalization of the *S-RNase* gene caused the self-compatibility in potato, which led to hybrid and precision breeding. Now the world is going to enter the era of potato hybrid breeding based on diploid TPS. This research is aimed to summarize the history, progress, and future prospects of TPS breeding to gain insight into the various factors affecting the success and failure of TPS.

Keywords: True potato seed, TPS, diploid, hybrid.

Physiological Responses of Grapevine Cultivars at Key Phenological Stages under Varying Environmental Conditions

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Seasonal climatic variability is a key challenge in many grape-growing regions across the globe, which affects phenology, growth, physiological responses, and yield at harvest. Unfavorable climatic conditions impair the plant's physiological processes, such as chlorophyll accumulation, gas exchange, and photosynthesis in grapevine leaves. It is critical to unlocking the complex physiological behaviour of different grapevine cultivars for key phenological stages under varying environmental conditions. The present study was designed to evaluate the main physiological process such as photosynthesis, gas exchange, chlorophyll contents, and water use efficiency of four table grape cultivars at key phenological stages under varying environmental conditions at two sites in the Pothwar region in a factorial experimental setup, i.e., location×year×cultivar×phenological stage. Physiological responses of table grape cultivar were recorded at 5 leaves, full bloom, berry set, veraison (colour change), and harvest for the two consecutive vintages, i.e., 2019 and 2020, at Islamabad and Chakwal. The results indicated that mean photosynthetic activity was 30.7% higher at a relatively colder location, i.e., Islamabad, while the transpiration rate was 10.4% more than Chakwal. Among the cultivars, photosynthetic activity was more for cvs. NARC Black and Sugraone, which varied with phenological stages and more photosynthesis and transpiration, were recorded at the berry set stage; however, water use efficiency peaked near blooming. Higher growing season temperature near ripening stages negatively affected photosynthesis, transpiration, and leaf water use efficiency (WUE). Similarly, stomatal and sub-stomatal conductance varied for grapevine cultivars at key phenological stages with environmental variability at the location for both vintages.

Keywords: Grapevine physiology, environmental variability, photosynthetic responses, Pothwar region.

Impact of Irradiated Pollens on Compatibility and Fruit Traits in Intervarietal Crosses of Guava

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Irradiated pollen grains are a useful resource for inducing parthenogenesis in fruit crops. In guava, little is known about the metaxenial effect of gamma irradiated pollen grains on fruit size and quality in the intervarietal crosses. Hence, closed floral buds of guava cultivars (round 'R' and pyriform 'P') were treated with varying levels, viz. 0, 100, 200, 350, 500, and 700 Gy of gamma irradiation source and reciprocal crosses were made during 2018-2021 in the experimental fruit garden of the Institute. Both cultivars and irradiation treatments exhibited significant differences. Pollen viability was maximum in both cultivars (>90%) in non-irradiated pollen grains, and viability was reduced to 34% at a higher irradiation level (700 Gy). Other quantitative traits like fruit weight and size were maximum when pollinated with non-irradiated pollen grains. Both fruit weight and size were reduced with an increase in the gamma irradiation level. Among the selfed cultivars with non-irradiated pollens, maximum fruit weight (129.6 g) was observed in the P×P cross. However, seed setting was minimum (103-113 seeds) in R×R and P×P crosses, indicating enhanced self-incompatibility. Maximum TSS (9.91 °Brix) was observed in the R×R cross, followed by the P×R cross (9.78 °Brix). Total sugars were higher (6.61%) in the R×R cross compared to P×P and reciprocal crosses. The LD50 of the guava cultivars was achieved at higher irradiation doses (700 Gy and 500 Gy) based on percent seed germination. It was concluded that both irradiated and non-irradiated pollens showed a marked impact on sexual compatibility and metaxenial effects on fruit size and quality traits. The fruit growth and quality were reduced when pollinated with pollens irradiated at higher doses indicating a reduced metaxenial effect due to lower pollen viability. In conclusion, extensive breeding interventions for multiple seasons are suggested to rule out environmental variability's impact and better understand the metaxenial phenomenon.

Keywords: Metaxenia, reciprocal crossing, breeding, fruit quality, compatibility.

Phenotypic Evaluation and Genetic Analysis of Reproductive Phase in F1 Transgenics of Chrysanthemum Plants: A Case Study

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Gene expression at the transcriptional or translational levels is prevented by the epigenetic regulation of any gene, which is referred to as gene silencing. Among various gene silencing techniques, RNA silencing (RNAi) is a unique gene regulation technique that involves sequence-specific targeting and RNA degradation. However, the effectiveness of transgene-induced RNAi in F1 generation of chrysanthemum has not been studied yet. In the current study, we used RNAi-constructed *CmTFL1* (white-flowered) and *CmSVP* overexpressed (yellow-flowered) transgenic plants from previously conducted two studies for our experiment. Cross hybridization was performed between these intergeneric transgenic and non-transgenic plants of the winter-growing chrysanthemum selection "37" (light pink-flowered). The transgene *CmSVP* was confirmed in F1 hybrids by RT-PCR analysis, whereas hybrids of *CmTFL1* parental plants were non-transgenic. Besides this, quantitative real-time PCR (qPCR) was used to explain the molecular mechanism of flower development using reference genes. Intergeneric and interspecific hybrids produced different colored flowers, unlike their respective parents. These results suggest that generic traits of *CmSVP* overexpressed plants can be transferred into F1 generations when crossed with mutant plants. This study will aid in understanding the breeding phenomenon among intergeneric hybrids of chrysanthemum plants at an *in vivo* level. Furthermore, transgenic plants will be more suitable for sustainable flower yield under a low-light production system.

Keywords: Cross hybridization, RNA silencing, hybrid identification, quantitative real-time PCR.

Zeolite Amendment to Mitigate Pb Stress in Chili Pepper Plants Irrigated by Sewerage Water

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Irrigation with heavy metal contaminated water causes heavy metal toxicity in fresh fruits and vegetables, which is unsafe for humans. The effect of Pb contamination induced by sewerage water (SW) irrigation was studied through pot experiments on growing chilli plants. For mitigation purposes, zeolite was used as a soil amendment. Different concentrations of zeolite (i.e., 0.75 g kg^{-1}, 1.50 g kg^{-1}, and 2.25 g kg^{-1} soil) were applied along with SW, whereas fresh water-grown plants were used as control. SW-grown chilli plants exhibited high Pb content that significantly reduced reactive oxygen species (ROS), activities of antioxidant enzymes such as superoxide dismutase (SOD), peroxidase (POD), and catalase (CAT), along with the net photosynthetic rate, gaseous exchange, and transpiration rate. The most favourable results were achieved at a concentration of 0.75 g zeolite kg^{-1} soil, that had not only reduced the accumulation of Pb but also significantly enhanced the net photosynthetic rate, gaseous exchange, and transpiration rate (18.90 µmol $m^{-2}s^{-1}$, 0.23 mmol $m^{-2}s^{-1}$, 5.69 mmol $m^{-2}s^{-1}$ respectively) than SW-grown plants (10.79 µmol $m^{-2}s^{-1}$, 0.20 mmol $m^{-2}s^{-1}$, 3.43 mmol $m^{-2}s^{-1}$, respectively). Furthermore, the physiological aspects of the chilli plants are significantly increased, such as plant height, leaf area, plant fresh biomass, and fruit number and fresh fruit weight were significantly increased by 21%, 31%, 34%, 62%, 14%, respectively as compared to control plants (SW). However, the higher zeolite concentrations, i.e., 1.50 g kg^{-1} soil and 2.25 g kg^{-1} soil, had negatively impacted the growth attributes of plants. Therefore, the mitigation of heavy metal contaminated soil with zeolite (0.75 g kg^{-1} soil) can be further investigated under field conditions for its future implications.

Keywords: Heavy metal, lead, sewerage water application, stress enzymes, chilli pepper.

Effect of Foliar Applications of Chitosan and Salicylic Acid on Tomato Genotypes under Heat Stress Conditions

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Tomato is one of the most valuable vegetables in acreage, produce yield, business, and consumption. It is used daily as food and forms an essential part of the diet in Pakistan. In several parts of the world, heat stress is a major agricultural issue due to the temperature rise. High temperatures severely impact seed germination, plant growth, floral dropping, pollen viability, fruit size, and weight. Hence, this study was conducted to find the response of chitosan (CTS) and salicylic acid (SA) to mitigate heat stress. A completely randomized design (CRD) with a factorial arrangement was used (two factors, i.e., tomato genotypes and chemicals). Eight genotypes of tomato (*viz.* V1 = Subar Tic, V2 = LOO525, V3 = LO4845, V4 = CLN-2366A, V5 = LOO493, V6 = LOO602, V7 = Roma, and V8 = Nagina) were evaluated against different chemical treatments (*viz.* T0 = Control, T1 = 1.53 mM SA, T2 = 200 ppm CTS, and T3 = Combination of T2 and T3). Tomato plants (60 days old) were introduced to heat stress (i.e., air temperature of 40 °C). Then recovery was made through the use of chemicals (CTS and SA) in the aforementioned tomato genotypes. Data were gathered for several parameters determining tomato growth and yield. Among tomato genotypes, CLN-2366A performed best for all parameters under heat stress conditions. It recorded maximum shoot length (6.43 cm) and root length (3.10 cm). Among chemical treatments, T3 yielded maximum fresh weight (6.90 g) and dry weight (1.77 g), T1 showed maximum photosynthetic rate (7.00 μ mol m^{-2} s^{-1}), and T3 showed a higher transpiration rate (1.09 μ mol m^{-2} s^{-1}). The above discussion showed that the effect of CTS and SA has a beneficial effect on migrating heat stress in tomato plants.

Keywords: Food security, tomato, heat stress, chitosan, salicylic acid.

Influence of Transplant Time, Foliar Applications and Maturity Stage on Strawberry Plant Health, Yield and Fruit Quality

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Strawberry is a non-climacteric small fruit with visual appeal and desirable flavour. However, strawberry production in Pakistan is still at its infancy stage and facing certain production and postharvest challenges. Here in this study, a series of field trials were conducted to determine the optimum transplant time of strawberry runners in Punjab province, to optimize foliar applications of 24-epibrassinolide, methyl jasmonate, calcium chloride, and oxalic acid for plant health and yield improvement, and to understand the impact of harvest maturity on fruit quality of strawberry fruit cv. Chandler. Results suggested that transplantation during the first half of October (day temperature 25-30 °C) favoured plant growth, flowering, yield, and fruit quality. Foliar trials revealed that pre-harvest application of 3 µM 24-epibrassinolide favoured vegetative growth and enhanced yield, whereas foliar application of 0.5 mM methyl jasmonate appreciably affected both vegetative and reproductive quality attributes, thus suggesting the potential use of these phytohormones in commercial formulations. In another study, foliar application of 1 mM oxalic acid significantly promoted nutrient uptake, plant growth, fruit yield, and instrumental and sensory attributes of strawberry fruit. In comparison, the foliar application of calcium chloride remained useful at low doses (0.5% and 1.0%) to reduce the incidence of disorders and get marketable yield. On the other hand, the foliar application of 2% calcium chloride resulted in leaf discoloration and reduced fruit size. Harvest trials showed that fruit having attained >70% red surface colour had better fruit quality and reduced fungal decay. Overall, research interventions introduced here may lead to yield increment and fruit quality improvement, thereby increasing the market life of strawberries and ensuring farmers' profitability.

Keywords: 24-epibrassinolide, methyl jasmonate, calcium chloride, oxalic acid, microbial decay.

Phenological Response of Red Palm Weevil (*Rhynchophorus ferrugineus*, Olivier) (Coleoptera: Curculionidae) on Six Different Varieties of Date Palm

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The red palm weevil, *Rhynchophorus ferrugineus* (Olivier), is a notorious insect pest of the palm family around the palm-growing areas of the world. Hence, the biological effects of six date palm varieties, *viz*. Dhakki, Mazafati, Aseel, Gulistan, Begum Jungi, and Fasley on the red palm weevil. The experiment was laid out in a completely randomized design (CRD) with 5 replicates in the laboratory of the Entomology Department, Gomal University, Dera Ismail Khan, Pakistan. The newly emerged grubs were provided a soft portion of the respective varieties' stem in plastic boxes with mesh on top for ventilation purposes at controlled laboratory conditions of 27 ± 2 °C, 65 ± 2% R.H. The observations were documented on the fecundity, larval and pupal developmental periods, adult life span, and sex ratio of red palm weevil. The Dhakki variety was the most susceptible, having a maximum number of eggs hatching (89.80%) and weight losses (8.90 g). In contrast, the Fasley variety was found to be the least susceptible, exhibiting the lowest egg hatching (71.60%) and weight loss (2.94 g). The maximum larval developmental duration of 87.2 days was recorded on the Fasley variety, which decreased to 64.8 days when red palm weevils were cultured on the Dhakki variety. The maximum survival (93.42%) was recorded on the Dhakki variety, while the lowest survival (66.41%) was recorded on Fasley. The maximum pupal developmental period (34.20 days) was noted on the variety Fasley. In contrast, a minimum developmental duration of 20.20 days was recorded on the variety Dhakki. The maximum adult longevity (110 days) of female weevils was recorded on variety Dhakki, while the minimum adult longevity of 50.27 days was recorded on variety Fasley. Results concluded that genotypic variations influence red palm weevil development and can be utilized to manage the pest.

Keywords: Red palm weevil, varieties, infestation, biology, IPM.

Mitigation of Cadmium Toxicity through Melatonin Application in Strawberry Plants at the Fruiting Stage

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Cadmium (Cd) is one of the most harmful metals to plant species. It is soluble in water and can easily be taken up by plants, disrupting the internal cell structure and activating various metabolic pathways. Melatonin is an important signalling molecule stimulating various physiological and biochemical mechanisms against numerous abiotic stresses. In the current study, a pot experiment was conducted to evaluate the effect of foliar application of melatonin on cadmium-stressed strawberry plants. The experiment was laid in completely randomized design (CRD) with three replications. Control plants (To) were simply irrigated with distilled water. The foliar application of 100 µM of melatonin solution was carried out once every 3 days up to 12 days to melatonin-treated plants (T1). Afterward, T1 (melatonin-treated plants) and T2 (melatonin-untreated plants) were irrigated with 1mM cadmium sulphate solution for one month. Various physiological, growth, and yield parameters were estimated. The exogenous melatonin application significantly improved the activities of antioxidant enzymes such as superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), whereas hydrogen peroxide (H_2O_2) and malondialdehyde (MDA) contents were reduced. The melatonin treatment had an inhibitory effect in T1 plants and significantly increased the shoot dry weight, root dry weight, shoot length, root length, and fruit growth by 42.1%, 53.5%, 11.25%, 16.57%, and 18.07%, respectively as compared to T2 plants. Unlike T1 plants, the cadmium sulphate solution had significantly deformed the fruit shape in T2 plants. Our findings suggested that the foliar application of 100 µM L^{-1} melatonin solution can significantly alleviate the Cd stress in strawberry plants at the fruiting stage.

Keywords: Strawberry, stress, melatonin, cadmium, fruit quality, plant quality.

Identifying and Characterizing the Value Chain Coordination Structures in the Potato Industry of Pakistan

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The value chain actors need to coordinate formally or informally to deliver the value desired by their customers. The coordination structures may range from very loosely controlled to vertically integrated arrangements. The study has identified various value chain coordination structures operating in the potato industry of Pakistan. For this purpose, a focus group discussion was held with the Growers' Association of Pakistan (Pakistan Kissan Ittehad) officials, which revealed different coordination structures in the potato industry. In-depth interviews with 30 growers from districts Sahiwal and Okara in Punjab province further helped identify and characterize the value chain coordination structures. According to the findings of thematic content analysis, the coordination structures may be identified as spot-market (selling through auction in the nearest wholesale markets), modular (supply to exporters' turn-key suppliers with the defined product or process standards), relational (supply to modern retailers with produce specific promises and obligations) and captive (supply to processors under a written agreement). This study concluded that growers operating under written agreements are more satisfied than those who sell to local traders and through an auction on the spot in nearby markets.

Keywords: Coordination structures, potato, value chains, Industry, Pakistan.

Does Value Chain Approach Enhance the Profitability of Small Potato Farmers in Punjab?

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Potato growers with small land holdings contribute a major share in potato farming. Various production, post-harvest, and market constraints such as lack of information regarding consumer preference result in low-quality potatoes incompatible with market demand, depriving them of better profit margins. Under the strengthening vegetable value chain in Pakistan (SVVCP) project, smallholder potato farmers were selected and facilitated to conduct market research through the 'walking the chain' tool to understand consumer preference for potato quality in the market to receive a premium price. Based on learning from the market research, the low-quality seed, inadequate use of fertilizers, and lack of sorting and grading were major factors contributing to the poor quality contrary to the market requirements. The SVVCP experts developed interventions including using 1-3 generation seed, sorting of disease tubers, fungicidal seed treatment, soil analysis-based fertilization scheme, sorting and grading at the time of harvesting, and direct marketing to the identified traders. Extensive participatory farmer field trials and training were arranged to build the capacity of small farmers to adopt the 'best practice' interventions. In potato cropping season 2020-21, one smallholder potato farmer adopted the 'best practice' interventions and stored potato cv. Sante in cold storage. The high-quality potato consignment was directly delivered to the wholesaler and thus increased gross profit margin (GPM) to 225% compared to the traditional farmer. Later, in season 2021-22, seven farmers fully and partially adopted the 'best practice' interventions through the value chain approach and increased their GPMs from 77% to 240%. The current study indicated that adopting a value chain approach significantly increased the profit of small farmers by improving the quality of potatoes according to the consumers' and/or customers' preferences.

Keywords: Small holder farmers, potato, profitability, quality improvement, value chain.

Empowering Smallholder Onion Farmers through Value Chain Approach

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Onion is one of Pakistan's most important vegetable crops due to its versatile use as a condiment in salad and as a spice in cooking dishes. Many smallholder farmers cultivate onions in Pakistan and are struggling to improve their profit due to the difficulties in changing conventional production and marketing systems that are not helping them. In an Australian Centre for International Agricultural Research-funded project, "Strengthening Vegetable Value Chains in Pakistan (SVVCP)," a value chain approach combined with participatory action research methodology was followed. Small farmers were trained by physically "walking the onion chain" with a multidisciplinary research team to understand the quality issues perceived by chain members, particularly the end consumers. During the "walking the chain," quality issues and the causes were identified. Farmers proposed interventions to mitigate the quality problems. After the adoption of the intervention, onion farmers conducted a commercial pilot consignment to test the benefit of the interventions. The commercial pilot consignment (63% gross margin) earned significantly higher than the traditional consignment (52% gross margin), and SVVCP farmer's return on investment (167%) was 1.54 times higher than the traditional one (108%). The onion consignment demonstrated that farmers' participation in value chain analysis and marketing is a practical approach to motivate farmers to implement a value chain approach. The smallholder farmers are empowered through the value chain approach as they can negotiate a better price with the buyers rather than being dictated by the buyers in the traditional system.

Keywords: Smallholder, value chain approach, quality improvement, vegetable production.

Yield and Quality Response of Potato to Split Application of Nitrogen and Phosphorous Fertilizers

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Potato is the major non-cereal food crop widely cultivated throughout the world. Potato requires high doses of nutrients for proper growth, yield, and quality production. Among the major nutrients, the potato plant requires, nitrogen (N) and phosphorus (P) play an important role in determining the yield and quality of potatoes. This research was therefore conducted to examine the effect of major essential nutrients (N and P) on the yield production of four diverse potato cultivars (V1 = Santa, V2 = Berna, V3 = Lady Rosetta, and V4 = Musica). The experiment was laid out following a randomized complete block design (RCBD) with three replications. The N and P treatments consisted of complete factorial combinations of N (100 kg acre-1) and P (75 and 50 kg acre^{-1}), and N:P = 100:75 kg acre^{-1} and N: P =100:50 kg acre^{-1} split N and P applications, plus one unfertilized control. The source of N and P was DAP and urea, respectively. The yield and quality parameters data were collected and statistically analyzed to assess the effects of N and P. The response of fertilizer application showed the maximum marketable yield of Lady Rosetta under (100 Kg N + 50 Kg P and 100 kg N + 75 Kg P acre^{-1}). Results concluded that potato variety Lady Rosetta outperformed the other varieties by exhibiting maximum marketable tubers per plant and overall tuber yield with 100 kg N + 75 Kg P acre^{-1}.

Keywords: *Solanum tuberosum* L., chemical fertilizer, split application, yield.

A Case Study on Value Addition Business Led By Rural Women in District Khairpur, Pakistan

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The income of poor smallholder families can be increased by developing, producing, and marketing value-added vegetable-based products based on local market needs in a rural context. In developing countries, however, significant community engagement, product development, and marketing challenges exist. This paper reports a pilot-scale example of the value-addition of vegetable products developed, produced, and marketed by women in a poor village in Khairpur district, Sindh, through an Australian Centre for International Agricultural Research-funded project titled, "Strengthening vegetable value chains in Pakistan (SVVCP)." The research approach adopts a value-chain perspective first to identify market opportunities for a value-addition product suitable for the local market in terms of customer requirement, quality, and price compatibility. The value-added product was evaluated to determine how poor rural families can organize resources to produce and market the products in local markets. The rural families were trained to produce value-added products such as green chilli chutney and vegetable mixed pickles suitable for the local market in terms of customer requirements. Women played an active role in preparing the green chilli chutney and vegetable mixed pickles; men marketed the products. The value addition enterprise added PKR 4,612 to the monthly income of smallholder families. This study also suggests lessons and recommendations take similar value-addition product-based commercial initiatives for rural women in other villages.

Keywords: Value-added business, value chain, marketing, rural women.

A Whole Family Approach Improves Gender Inclusion in Onion Value Chain in Rural Sindh

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Women play a significant role in the agriculture sector in Pakistan. However, they have limited access to technical skills and market information, including product specifications requirements, participation in decision-making associated with farming in the family, and equitable share in income or wages. Women lack technical skills due to discrimination in access to information on crop production, harvest, and postharvest handling. Rural women are also disadvantaged as they do not have access to markets due to cultural barriers, leading to limited income generation opportunities and leadership roles in the household context based in rural Sindh. Under the Australian Centre for International Agricultural Research funded project, "Strengthening Vegetable Value Chains (SVVCP) in Pakistan," the whole family approach was employed through a female social mobilizer for gender engagement in the project activities. Following the whole family approach, consultative planning of activities was facilitated with the males and females of the households in onion production to improve women's participation. The capacity of 10 women farmers and 3 labourers were built through farmers' training, field demonstrations, and field days to perform harvest and postharvest activities to differentiate the product according to buyers' needs. Information gathered through "walk the chain" in the onion value chain was also presented to women during women farmers' training. A short video was also shown to women to understand what characteristics their buyers want in the onions and helped them participate in marketing decisions. Women's wages were increased by PKR 20 per bag for their improved skills in postharvest handling activities such as onion bulb cutting, sorting, and grading. These women were given leadership roles based on these enhanced skills to train other women. Women farmers were satisfied with the increased income and the improved quality of onions that lasted for over six months for personal consumption.

Keywords: Whole family approach, smallholder, gender inclusion, livelihood.

Role of Minor Fruits in the Economy of Pakistan

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The climate of Pakistan is suitable for cultivating a wide range (about 35) of fruit; however, most of them possess small production areas and are classified as minor fruit. Conversely, these fruits are not minor in nutritive and economic value. Limited R&D support and less consumer awareness are the critical factors for their limited cultivation. Hence, a project was designed and funded by HEC under the NRPU grant (5933) to highlight the role of minor fruits in the economy of Pakistan. Seven minor fruits were initially selected, i.e., grapes, mulberry, jamun, pomegranate, litchi, phalsa, and ber. The project's objectives included commercial and lab-scale research on critical monitoring of existing supply chains, documenting and intervening in key supply chain issues, quantifying and characterization of postharvest losses, nutritive profiling, developing value-added products, and capacity building/training of minor fruit crops. The project resulted in the development of ten value-added products from the selected fresh minor fruits (jamun leather, jamun drink, phalsa popsicles and drink, mulberry jam, leather, grapes raisins). In addition, the market study of these value-added products was also completed covering the aspects of sensory reception, consumer product-price responses, labelling, and packing of the developed product. The project also developed various interventions to reduce the postharvest losses of minor fruits. These include applying various ripening delaying chemicals (oxalic acid, quinic acid, salicylic acid, and methyl jasmonates) and introducing modified packing compared to the conventional packing in various fruit. The project also quantified postharvest fruit quality losses in various fresh fruit supply chain steps. The effect of direct fruit transportation and indirect fruit transportation was also evaluated. The fruit handled through these interventions showed relatively less weight loss, less perishability, and improved biochemical fruit quality than those handled without these interventions.

Keywords: Minor fruits, value addition, supply chain, capacity building.

Postharvest Quality Management of Jamun (*Syzigium cumini* Skeels.) Fruit by Combined Pre- and Postharvest Oxalic Acid Treatment

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Jamun is a highly nutritious minor fruit crop. However, after harvest, its fruit deteriorates rapidly on the shelf. This research was planned to assess the effect of oxalic acid (OA) treatments on jamun fruit quality and shelf-life. The study consisted of an experiment executed for assessing the effect of an already optimized dose of OA (2 m*M*) as a pre- and postharvest treatment alone and in-combination [control (untreated), pre-harvest application only, postharvest application only, pre + postharvest application) on jamun fruit quality and shelf life. After treatment, fruit was air dried and kept under ambient conditions (25±2 °C, 60-65% RH) for the evaluation of different fruit physiological (weight loss, color, skin shriveling), biochemical (total soluble solid, titratable acidity, vitamin C, pH) and antioxidative parameters [antioxidants, total phenolic contents (TPC), anthocyanin, and activity of antioxidative enzymes superoxide dismutase, peroxidase, catalase, and polyphenol oxidase] under ambient conditions. The result revealed that pre + post-harvest application of OA significantly lessened the jamun fruit physiological losses [weight loss (11%), peel colour *L* (19.90), *a** (2.0), *b** (0.50), skin shriveling (1.70 Score), disease occurrence (30%), respiration rate (23.0 mmole kg^{-1} hr^{-1})] and retained biochemical fruit characters [total soluble solid (16.2 °Brix), titratable acidity (0.3%), vitamin C (40.5 mg 10 ml^{-1}), juice pH (3)] and anti-oxidative parameters [antioxidants (93% DPPH), TPC (155 mg GAE 100 g^{-1}), anthocyanin (1.5 ΔA g^{-1} FW)] as compared to control fruit. Moreover, combined pre- and postharvest OA-treated fruit exhibited significantly higher activity of various antioxidative enzymes [super oxide dismutase (57.21 U mg^{-1} protein), peroxidase (0.37 U mg^{-1} protein), catalase (31.3 U mg^{-1} protein), polyphenol oxidase (3.30 U mg^{-1} protein)]. Thus, combined OA application as pre + postharvest retained fruit quality and decreased postharvest losses in jamun fruit during storage under ambient conditions.

Keywords: Respiration rate, total soluble solids, total phenolic contents, fruit weight loss.

Impact of Oxalic Acid on Post-Harvest Shelf Life and Quality of Bell Pepper at Cold Storage

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Sweet pepper (*Capsicum annum* L.) is a highly perishable vegetable crop under ambient temperature that undergoes rapid weight loss. Hence, the present study aims to evaluate the impact of oxalic acid (OA) to maintain the quality of bell pepper kept under low-temperature storage conditions. For this, physiologically mature fruits were subjected to three OA treatments, viz. 5 mM OA, 7 mM OA, and untreated fruit were considered as control. After treatment application, fruits were stored at 7 ºC for 28 days, and data were noted every 7 days with conditioning at 20ºC for 2 days. Results showed that fruits treated with 7 mM OA showed minimum values of fruit weight loss, wrinkles, chilling injury, and decay compared to control. Oxalic acid (7 mM) treated fruits showed a decrease in fruit firmness, enhanced vitamin-C content, and retained the fruit colour compared to the control group. Moreover, electrolyte leakage and total phenolic content were non-significantly affected by 7 mM OA. In addition, the application of 5 mM OA maintained titratable acidity in bell pepper. It showed the minimum change in total soluble solids and TSS:TA till 28 days in storage. Hence it is concluded that postharvest application of 7 mM OA can be used effectively to keep bell pepper fruit at low temperature for 21 days with the best eating quality.

Keywords: Oxalic acid, shelf life, quality, bell pepper.

Postharvest L-Cysteine Application on Storage Life and Quality of Commercial Table Grapes Cultivars of Balochistan

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Table grapes exhibit a wide consumer demand due to their high nutritional properties. However, the high perishable nature limits their extended market window. Hence, the current study was conducted to assess the effect of postharvest application of 0.25% L-cysteine coating on storage life and quality of three commercial table grapes cvs. Sundarkhani, Khismishi and Shaghali of Balochistan during cold storage. The results showed that 0.25% L-cysteine treatment had a significant impact on the quality and storage life of table grapes berries. In addition, the 0.25% L-cysteine treatment retained softness, lessened the rachis browning, reduced berries shattering, minimized the disease incidence, reduced weight loss, and lower respiration rate compared to the control treatment. The quality traits such as the ratio of total soluble solids and titratable acidity (TSS:TA) ratio of fruits, increased with the progression of the storage period. Maximum electrical conductivity (EC) was achieved in untreated fruits of cvs., Sundarkhani, Khismishi, and Shaghali. L-cysteine-treated berries maintained the TA at a higher level than untreated berries in cv. 'Sundarkhani' during the storage period. Furthermore, TA decreased to an average during day 20 in cv. 'Khismishi' and 'Shaghali'. Additionally, a decrease in ascorbic acid content was determined in all three L-cysteine treated cvs. However, the highest concentration of ascorbic acid was found in L-cysteine treated cv. 'Khismishi' in contrast to untreated control berries at the 20 days of cold storage. Based on findings, it is suggested that edible coating of amino acids like L-cysteine plays a beneficial role in reducing fruit spoilage, minimizing postharvest loss, and enhancing table grape's quality and storage life.

Keywords: L-cysteine, storage, quality, table grapes.

Standardization of Optimum Temperature for Dehydration of Whole Banana

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Pakistan is among the large fruit-producing countries. However, quality fruit exports are less compared to many countries because of poor pre- and post-harvest management practices. Most of the fruit is wasted in the field as there are limited fruit processing units. However, the shelf-life of fruits can be enhanced by post-harvest treatments or drying. *Drying* is a centuries-old long-term preservation method adapted to various fruits and vegetables. *Banana* is a climacteric fruit that releases plenty of ethylene, making it challenging to enhance the shelf-life. In this study, we planned to standardize the dehydration temperatures for bananas (whole fruit). An indigenously made dehydration chamber was used where banana fingers were kept under different temperatures (45, 50, 55, and 60 °C) to standardize the most optimum temperature for dehydration. Time taken to complete dehydration, moisture contents, and protein contents were the parameters which were compared for banana fingers kept under different temperatures. Results showed significant differences among all treatments. Data showed that banana slices kept under 50 °C showed higher protein contents, color, texture, flavor, and overall acceptability. Banana slices kept under 60 °C took a minimum time to complete the dehydration (18 hrs), followed by whole bananas kept under 50 °C, which took 24 hrs. However, the quality of dried bananas was not suitable under 60 °C. Based on the results, it is recommended that banana fingers should be kept at 50 °C for better-dried fruit quality and protein contents.

Keywords: Banana, dehydration, protein contents, sensory scores, climacteric fruits.

Effect of Different Packaging Materials on Postharvest Quality and Shelf Life Dynamics of Wild Black Raspberry (*Rubus occidentalis* L.) fruits

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Black raspberry is an important fruit in a temperate region. Due to the ideal climatic conditions, raspberry plants have been found wild in Rawalakot. The proposed study was conducted to test the impact of packaging materials on postharvest quality and shelf life of wild black raspberry fruits. Fruits were harvested fully ripe and stored for 7 days at 4 ºC using different packaging materials (styrofoam, acrylic boxes, corrugated boxes (3 plies), corrugated boxes (5 plies), plastic trays, and plastic containers as control. Results obtained showed that maximum fruit weight loss (44.39%) and fruit spoilage (47.25%) were observed in fruits stored in plastic containers, while the minimum fruit weight loss (16.58%) and fruit spoilage (23.94%) were observed in fruits stored in acrylic boxes. Similarly, TSS (61.41%) and pH (4.53) were recorded maximum in fruits stored in acrylic boxes, while the minimum TSS (10.33%) and pH (3.61) were observed in fruits stored in plastic containers. In case of TA (0.61%), vitamin C (0.16 mg 100 g^{-1}), antioxidants (1.91%), total phenols (0.39 µg100 g^{-1} FW), total anthocyanins (15.55 mg of cyanidin-3-glucoside per liter) and total flavonoids (2.11 mg 100 g^{-1}) maximum values were recorded in acrylic boxes. Sensory attributes like taste (6.19 score), texture (4.85 score), aroma (4.08 score), and overall acceptability (5.76 score) were also maximum in fruits stored in acrylic boxes. It could be concluded that black raspberry fruits stored in acrylic boxes showed good results as the quality of fruits was retained for 5 days.

Keywords: Indigenous fruits, packaging materials, shelf-life, antioxidants.

Improvement of Quality and Shelf-Life of Strawberries Cv. Chandler with Edible Coatings

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Strawberry fruit contains high moisture content that generally limits its shelf life to three to four days under ambient conditions. However, various natural and synthetic coatings may help maintain fruit quality and improve shelf life. Therefore, this study aimed to explore the effect of *Aloe vera* extract (AVE), moringa leaf extract (MLE), oxalic acid (OA), and ascorbic acid (AA) on shelf life and quality of strawberry cv. Chandler. Physically mature fruits were harvested from a commercial orchard located in Multan. The fruit was dipped in aqueous solutions (Control, MLE (6%), AV (20%), OA (1mM), and AA (5 mM) and kept under ambient conditions (25±2 ºC and 55-60% RH) for quality evaluation on a daily basis till marketability. Results indicated that postharvest dipping of MLE (6%) significantly reduced strawberry fruit's respiration rate, ethylene production, and firmness during shelf studies for five days. The lowest weight loss was observed in OA-treated fruit compared to others. During the shelf period, a significant increasing trend was observed for total soluble solids, ripening index, carotenoids, and anthocyanin, while a reverse trend was observed for titratable acidity, vitamin C, total phenolic, and total antioxidants in strawberries. Moreover, the application of edible coatings significantly affected this increase or decreasing trend in fruit bio- and phytochemical attributes. Additionally, AA-treated fruit exhibited higher activities of different enzymes, including catalase, polyphenol oxidase, and superoxide dismutase at the shelf. Moreover, peroxidase activities and malondialdehyde contents were found to be higher in OA- and MLE-treated fruit during shelf studies. Conclusively, the application of edible coatings, especially 6% MLE, significantly improved the fruit quality and shelf life in strawberry cv. Chandler.

Keywords: *Aloe vera*, moringa leaf extract, oxalic acid, ascorbic acid, strawberry.

Short-term Ultrasound Treatment Preserved Fruit Quality and Extended Storage Life of Fresh Strawberries

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Ultrasonication is an emerging eco-friendly and non-thermal technology with the potential to control decay and decontaminate fresh fruits and vegetables, thereby extending their shelf life. This study was conducted to evaluate ultrasound treatment's efficacy in extending the storage life of fresh strawberry fruit cv. Chandler. Strawberries were treated with ultrasound waves (40 kHz at 100 W) for 3, 6, and 9 minutes under aqueous conditions and stored at 2±0.5 °C and 95% relative humidity for 12 days. Regardless of treatment duration, sonicated fruits exhibited a 95-99% reduction in pesticide residues compared to untreated strawberries. Ultrasound treatment for 3 minutes inhibited fungal decay, reduced moisture loss, and maintained membrane permeability, total soluble solids, and anthocyanins in strawberry fruit during cold storage as compared to control but statistically comparable to other sonication treatments. Enzyme assays revealed that ultrasonication for 3 minutes elevated activities of peroxidase (20%), catalase (13%), and superoxide dismutase (10%) enzymes when compared with control. The overall positive influence of ultrasound treatment for 3 minutes led to 6 days extension in the storage life of strawberries compared to control. Thus, it can be concluded that short-term ultrasonication can be used to decontaminate and disinfect strawberries before fresh consumption and extend their storage life without compromising fruit quality.

Keywords: Strawberry, ultrasound, physiochemical, microbial disinfection, shelf-life.

Improvement in Chilling Tolerance of Harvested Banana Fruits by Hydrogen Sulfide Regulated γ-Aminobutyric Acid Shunt Pathway and Ascorbate Glutathione Cycle

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The effect of hydrogen sulfide (H_2S) fumigation was investigated on chilling injury (CI) of' 'Basrai' banana fruit at the Department of Horticulture, Bahauddin Zakariya University, Multan, Pakistan. The work was conducted under the factorial layout of a completely randomized design in September 2021. Each treatment contained three replicates, with 15 banana fingers in each replication and 45 banana fingers in each treatment at each sampling period. The fruit was stored at 7 ºC with 90 ± 2% relative humidity for a period of 10 days. Various attributes were investigated in the peel tissues of banana fruits. It was observed that H_2S (2 mmol L^{-1}) conserved markedly higher chlorophyll contents along with suppressed chlorophyll degrading peroxidase and chlorophyllase enzyme activity. The treated banana fruit exhibited substantially lower browning degree and soluble quinones content. The treated bananas had substantially higher endogenous H_2S content and higher activity of its biosynthesis-associated enzymes such as D-cysteine desulfhydrase and L-cysteine desulfhydrase, along with significantly lower ion leakage, lipid peroxidation, hydrogen peroxide, and superoxide anion concentrations. H_2S-treated banana fruit showed increased proline content and proline metabolism-associated enzymes, including ornithine aminotransferase, Δ1-pyrroline-5-carboxylate synthetase, and proline dehydrogenase. In the same way, H_2S fumigated banana fruit accumulated higher endogenous γ-aminobutyric acid (GABA) due to enhanced activity of glutamate decarboxylase and GABA transaminase enzymes. The H_2S treated fruit exhibited higher total phenolics owing to stimulated phenylalanine ammonia-lyase and lower polyphenol oxidase and peroxidase activity. The treated bananas exhibited higher ascorbate peroxidase, catalase, glutathione reductase, dehydroascorbate reductase, monodehydroascorbate reductase, and superoxide dismutase activity, along with higher glutathione and ascorbic acid concentrations and significantly lower dehydroascorbic acid content. In conclusion, H_2S treatment could be utilized for CI alleviation of banana fruit during cold storage.

Keywords: Antioxidant activities, chilling injury, cold storage, lipid peroxidation, proline accumulation.

Application of Hydrocolloids as Biocomposite Coating Delays Ripening and Senescence by Activating Antioxidant Enzymes and Deactivating Cell Wall Degrading Enzymes in Coated Tomato Fruits

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Tomato is an important food commodity from a nutritional and commercial perspective; however, freshly harvested tomatoes have a shorter shelf life. Edible coatings could be an effective tool for delaying the ripening and senescence of fruits and vegetables. A study was conducted by preparing a novel combination of hydrocolloid gum arabic (GA) and carboxymethyl cellulose (CMC) to delay the postharvest life of harvested fruits of tomato cv. Sahil F1 Hybrid. Tomato fruits were coated with either 10% GA, 0.5% CMC or their combination (i.e. GA 10% + CMC 0.5%) and stored for 20 days at 20 °C (90 ± 2% RH). The use of biocomposite coating inhibited weight loss, respiration and ethylene production rates, decay incidence, and accumulation of stress markers, such as malondialdehyde (MDA) and hydrogen peroxide (H_2O_2). Applying biocomposite coating greatly preserved the total phenolic compounds, ascorbic acid, lycopene, color, organic acids, and total soluble solids compared to individually coated or non-coated tomato fruits. Additionally, higher activity of antioxidant enzymes and reduced activity of cell wall degrading enzymes, thus higher cell wall fractions, were noticed in biocomposite coated fruits. Overall acceptability was also higher in biocomposite-coated fruits. In conclusion, coating based on GA plus CMC was superior to their individual coating in prolonging the ripening phase, maintaining higher biochemical attributes, delaying senescence, and increasing the acceptability of tomato fruits for a longer period.

Keywords: *Solanum lycopersicum* L., hydrocolloids blend, gum arabic, carboxymethyl cellulose, fruitstorage quality.

Carboxymethyl Cellulose Coating Maintains Postharvest Qualities of Chiku Fruit during Storage

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Chiku fruit is a good source of vitamins and minerals. Chiku is a highly perishable fruit and susceptible to various pathogen attacks, due to which it cannot store for a very long time at ambient temperature. Carboxymethyl cellulose (CMC) is a polysaccharide-based hydrocolloid edible coating. It possesses a significant potential of forming transparent and flexible layer binding to the surface of treated produce. This study investigated the effect of CMC at three concentrations of 0.5, 1, and 1.5% on the postharvest quality of chiku during storage at 20 °C for 15 days. Chiku fruit treated with 1% CMC potentially inhibited the fruit rot disease, weight loss, and soluble solids concentration. Furthermore, 1% CMC significantly maintained fruit texture, titratable acidity, ascorbic acid, total phenolics, and DPPH activity compared to the control. These results indicated that the 1% CMC might be a simple and innovative technique to inhibit pathogen attack and retain the postharvest quality of chiku fruit during storage.

Keywords: Chiku, carboxymethyl cellulose, coating, postharvest quality.

Postharvest Dipping of Grapes in Oxalic Acid Solution Improves Physiological and Biochemical Attributes of Berries

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Oxalic acids play significant roles in the different metabolic processes of plants, and their exogenous application has received much attention for enhancing the shelf and storage life of fruits. However, there is a lack of information about the roles of oxalic acids in improving the postharvest quality of grapes. Hence, this study aimed to check the impact of exogenous postharvest application of different oxalic acid concentrations on postharvest quality and shelf life of grapes cv. Sundarkhani. Healthy fruits were harvested from a commercial orchard in the Balochistan province (30°41'22.9"N 68°21'05.4"E). After harvesting, fruits were dipped in aqueous solutions of oxalic acid (OA) having different concentrations (T0 (control), T1: 0.5 mM OA, T2: 1 mM OA, and T3: 2 mM OA) along with Tween-20 (1 mL L^{-1}) as a surfactant for 5 minutes. The highest ethylene production (5.32 µmol C_2H_4 kg^{-1} h^{-1}) and weight loss (18.33%) was observed in T0 on day 3 and 4, respectively, along with the lowest pH value (3.93), and vitamin C content (43.53 %), and soluble solid concentrations (SSC, 24.0 °Brix) at harvest. T3 showed the lowest ethylene production (0.52 µmol C_2H_4 kg^{-1} h^{-1}), respiration rate (0.96 mmol CO_2 kg^{-1} h^{-1}), weight loss (0.33%) on days 4, 3, and 1, respectively, and the highest vitamin C content (62.58 %) on day 4. T2 represented the maximum SSC (31.33°Brix), titrable acidity (TA, 0.55%), and pH (4.13) on day 4 and the highest respiration rate (1.58 mmol CO_2 kg^{-1} h^{-1}) on day 2. A higher value of coordinate *L* (71.30) and *a* (-3.70) was found on day 2, and a higher value of *b* (14.61) was recorded on the first day in T1. We surmise that foliar application of oxalic acid @ 2 mM (T3) positively affected the postharvest quality of grapes.

Keywords: Berry quality, oxalic acid, postharvest, grapes.

Mulching Materials Influence Weed Emergence, Plant Growth and Postharvest Quality of Strawberry at Rawalakot, Azad Kashmir

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Strawberry is one of the most attractive fruit among berries. The current study was designed to test the efficacy of different mulching materials on weed control, morphological and physico-chemical characteristics of strawberry cv. Chandler under rain-fed conditions of Rawalakot. The experiment was laid out in randomized complete block design (RCBD) with six mulching treatments, including control (no mulch), poplar leaves, wood chips, coconut coir, newspaper, and black polythene. Data were recorded for various parameters and were subjected to analysis. Results showed that maximum weed control (89.67%) was found in strawberry plants grown in black polythene mulch. However, maximum survival percentage (95.75%), leaves per plant (8.0), flowers per plant (7.33), fruits per plant (5.33), runners per plant (8.33), chlorophyll a (8.55 g ml^{-1}), chlorophyll b (9.26 g ml^{-1}), total chlorophyll (18.14 g ml^{-1}), fruit weight (2.93 g), fruit diameter (2.73 cm) were found in strawberry plants grown in mulching material amended with coconut coir. Biochemical parameters like total soluble solids (TSS) (8.50%), titratable acidity (TA) (1.89%), vitamin C (0.25 mg/100 g), total anthocyanins (40.06 mg/100 g), total phenolics (0.60 mg gallic acid/100 g), total flavonoids (2.86 mg/100 g FW), and antioxidant activity (0.89 µg/100 mg FW) were also found maximum in plants grown in coconut coir. Based on current findings, it can be concluded that black polythene mulching material was better for weed control and coconut coir was better for morphological and physico-chemical characteristics of strawberry.

Keywords: Mulching, strawberry, physical quality, morphological properties, antioxidants.

Interactive Response of Genotype and Rooting Volume on Seed Tuber Production

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Potato is globally the fourth most prominent food crop after maize, wheat, and rice. Unlike other important crops, potatoes are mostly multiplied using seed-tubers. For effective production of the potato crop, the availability and supply of healthy seed-tubers is an essential requirement. Studies have shown that the size of the container is also an important factor affecting tuber number, size, and overall tuber quality. In Pakistan, the available volume of certified potato seed tubers is deficient and insufficient to meet farmers' demands. Therefore, the present study focused on assessing the interactive response of genotype and rooting volume on the yield and quality of seed tubers. The experiment was performed in two factorial, completely randomized design. Factor 1 consisted of six diverse genotypes, whereas factor 2 consisted of four rooting volumes (viz. 1.0 L (very small), 3.7 L (small), 7.5 L (medium), and 12.3 L (large)). Results revealed highly significant (P<0.001) effects of genotype, rooting volume, and their interactions. Genotype Arizona surpassed the rest of the genotypes by recording maximum canopy cover, the number of leaves plant^{-1}, total plant leaf area, harvest index (HI), mean tuber weight, total tuber yield plant^{-1}, and seed tuber (%). An increase in rooting volume positively affected the majority of traits studied. Maximum canopy cover, number of mother stem plant^{-1}, number of leaves plant^{-1}, total plant leaf area, HI, number of tubers plant^{-1}, mean tuber weight, total tuber yield plant^{-1}, and seed-tuber (%) was recorded under large-sized rooting volume. Furthermore, genotype Arizona×large-sized rooting volume registered maximum canopy cover, HI, mean tuber weight, total tuber yield plant^{-1}, and seed tuber (%). The data gathered in this study would be instrumental in developing indigenous production technology of quality seed tubers, which is cheap and sustainable.

Keywords: *Solanum tuberosum* L., genotype, rooting environment, seed tuber, yield.

Efficacy of Humic Acid in Combination with Multiple N Levels on the Growth and Yield of Tomato

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An experiment was conducted to assess the efficacy of humic acid (HA) application in combination with multiple nitrogen (N) levels on growth and yield production in tomatoes in Dera Ismail Khan. This research was carried out in a randomized complete block design with a split-plot arrangement and three replications. Five HA levels (0, 25, 50, 75, and 100 kg ha^{-1}) were assigned to the main plot, whereas three N levels (0, 75, and 150 kg ha^{-1}) were assigned to the sub-plots. Amongst the HA treatments, the maximum results for all the vegetative and fruiting parameters were obtained with the level of 50 kg ha^{-1} followed by 75 kg ha^{-1}. As far as N is concerned, plants grown under high N (150 kg ha^{-1}) produced maximum results for all the vegetative, and fruiting parameters. The combined application of HA (50 kg ha^{-1}) and N (150 kg ha^{-1}) exhibited maximum plant height, leaf area, number of leaves and fruits, fruit size and fresh weight, and fruit yield (63.17 t ha^{-1}). The least response was noted in control treatments in almost all the parameters under study.

Keywords: *Solanum lycopersicon* L., humic acid, nitrogen, growth, yield.

Influence of Different Nitrogen Doses and Seed Rates on the Growth and Production of Purslane

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A research study was carried out to check the impact of variable N levels and seed rates on the growth and yield of purslane under the growing conditions of Dera Ismail Khan, Khyber Pakhtunkwa, Pakistan. The experiment was laid out in randomized complete block design with factorial arrangement and three replications. The factor 1 consisted of nitrogen (N) application at four levels (0, 75, 150, and 225 kg ha^{-1}), and the factor 2 consisted of four seed rates (2, 3, 4, 5 kg ha^{-1}). Results indicated a significant effect of N and seed rate on the growth and herbage production of purslane. The highest N level (225 kg ha^{-1}) exhibited the maximum plant height, branches, leaves, leaf area, chlorophyll content, herbage fresh and dry weight, moisture content (%), dry matter content (%), and total herbage yield (40.72 t ha^{-1}). Different seed rates also had a significant impact on all the growth and yield parameters. The maximum leaf area, fresh and dry herbage weight, moisture content (%), dry matter content (%), and total herbage yield (37.12 t ha^{-1}) was recorded with the maximum seed rate of 5 kg ha^{-1}. Interaction of both factors (i.e. N and see rate) showed remarkable variation for growth and production parameters in purslane. Significantly maximum leaf area, fresh and dry herbage weight, moisture content (%), dry matter content (%), and total herbage yield (41.76 t ha^{-1}) was recorded with the highest seed rate (5 kg ha^{-1}) under 225 kg N ha^{-1}). The minimum herbage yield was recorded with the lowest seed rate of 2 kg ha^{-1} in the absence of N (i.e., control).

Keywords: *Portulaca olearacea* L., nitrogen, seed rate, herbage, yield.

Impact of Humic Acid on the Performance of Exotic Red Radish Genotypes

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An experiment was conducted to investigate the effect of humic acid (HA) on the development and production of three red radish genotypes at the horticultural research area, of Faculty of Agriculture, Gomal University, Dera Ismail Khan. The experiment was laid out in completely randomized design with factorial arrangement and three replications. The first factor consisted of HA with five concentrations (0, 25, 50, 75, and 100 kg ha^{-1}), while the second factor comprised of three red radish genotypes (Red Dragon, Red Prince and Red Meat). Different HA concentrations had a considerable impact on all the growth and production attributes of red radish. Among the HA concentrations, 75 kg ha^{-1} exhibited the maximum plant height (26.58 cm), leaf area (28.70 cm^2), leaf chlorophyll content (55.00%), root fresh weight (21.78 g), root dry weight (6.67 g) and total yield (14.15 t ha^{-1}). Different red radish genotypes significantly affected all the growth and yield parameters. Amongst the genotypes, significantly highest response was recorded in Red Prince as it produced maximum plant height (24.00 cm), leaf area (23.11 cm^2), leaf chlorophyll content (54.60 %), root fresh weight (27.60 g), root dry weight (6.75 g) and total yield (17.93 t ha^{-1}). These results showed the superiority of Red Prince genotype over Red Dragon and Red Meat for all the growth and production parameters under study.

Keywords: Red radish, humic acid, genotypes, leaf, root.

Effect of Plant Spacing on the Production of Turmeric (*Curcuma longa* L.) Under the Agro-Climatic Conditions of Dera Ismail Khan

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A field study was carried out to investigate the effect of plant spacing (30×10, 30×20, 30×30, 30×40, 30×50 cm^2) on the production of turmeric under the agro-climatic condition of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Results indicated that plant spacing has a significant effect on the different parameters studied. Results indicated that the plants spacing (30×50 cm^2) produced significantly better results for most parameters including plant height (67.73 cm), number of leaves $plant^{-1}$ (8.00), leaf length (35.22 cm), leaf width (9.92 cm), number of stem $plant^{-1}$ (5.67), number of fingers $plant^{-1}$ (15.67), finger length (5.37 cm), finger weight (76.10 g), finger diameter (4.22 mm) and turmeric yield (2184 kg ha^{-1}) than rest of the treatments.

Keywords: Medicinal plant, leaf length, plant spacing, turmeric, yield.

Effect of Water Deficit Conditions on *Tagetes* Varieties in Relation to Bio-chemical Parameters

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Water stress is a significant abiotic stress that negatively affects the plant growth determining processes. The arid regions of Pakistan are facing severe water stress due to less than 60 cm annual rainfall, which is insufficient to meet the plants' requirement. There is an enzymatic or non-enzymatic antioxidant defence mechanism to prevent the plant from oxidative stress under water stress. It is known to be the most effective defence mechanism of plant under drought condition. Hence, an experiment was executed at the horticultural research area of the Arid University, Rawalpindi following the completely randomized design (CRD). Treatments consisted of three marigold varieties (F1 Inca yellow (V1), F1 Inca orange (V2) and Alkaram F1 golden (V3), and four-irrigation regimes i.e., 100% (T1), 75% (T2), 50% (T3) and 25% (T4). Each treatment combination was replicated four times. Results indicated that the bio-chemical parameters such as chlorophyll content, oil yield (g), protein content, antioxidant activities (superoxide dismutase-SOD, catalase, and ascorbate peroxidase-APX), and proline content showed an increasing trend with an increase in water stress. Among the varieties, F1 Inca orange (V2) appeared more water stress tolerant.

Keywords: Floriculture, water stress, alteration of physiology, defence mechanism, biochemical parameters.

Testing the Feasibility of Aquaponics in Farming Poor Community of Potohar

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The need for more food and pressure on resources such as land, water, and nutrients has increased with the increasing world's population. There is an urgent need to find alternative, sustainable and reliable methods of food security. Over the last few decades, scientists have found novel and innovatory ways to grow food that cumulatively can be the key to feed efficiently and sustainably for the world growing population. Aquaculture is one the most advanced plant growth technology which can effectively reduce poverty, malnutrition, and enhance the socio-economic status of the farmers. Aquaponics is a sophisticated agricultural system that uses fish waste (including particulate matters and dissolved nutrients) in the aquaculture recycling subsystem as a nutrient medium to produce edible plants with connected hydroponic subsystems. The aim of this research review was to provide basis for the development of sustainable agriculture production in the form of aquaponics to generate better fruits, vegetables and fish quality without the use of chemical fertilizer(s) with minimal environmental impact in the Potohar region of Pakistan.

Keywords: Aquaponics, fish farming, food production, hydroponics.

Vegetable Grafting: Recent Developments in Pakistan

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Vegetable grafting is comparatively a new technique that was introduced in Pakistan during 2017 by the researchers of University of Sargodha, Pakistan. Currently several public and private organization are working for its development and adoption in Pakistan. Research work related with vegetable grafting is in progress at University of Sargodha, University of Agriculture, Faisalabad, Muhammad Nawaz Shareef University of Agriculture, Multan, Sindh Agriculture University, Tandojam, Pir Mehar Ali Shah Arid Agriculture University, Rawalpindi, and Ayyub Agricultural Research Institute, Faisalabad. From these trials, researchers have got some promising results. According to our research trials conducted at the Department of Horticulture, University of Sargodha, we observed that hole insertion grafting proved better for the preparation of grafted transplants of muskmelon and cucumber compared with tongue approach grafting and cleft grafting. We also observed that use of indigenous cucurbitaceae rootstocks have helped improve the salt tolerance of cucumber, and growth and yield of watermelon and bitter gourd. Use of pumpkin as a rootstock improved the per fruit weight of watermelon by up to 68.15% compared with self-grafted watermelon plants. Grafting bitter gourd genotype BG4 onto bitter gourd genotype BG3 improved the number of fruits per plant by up to 22%. Average per fruit weight of BG3 grafted onto BG4 rootstock was 269 g, while self-grafted BG3 and wild type-grafted bitter gourd plants had per fruit weight of 126.80 g and 118 g, respectively. Considering the potential of grafting/rootstocks, herein we suggest that this technique can be effectively utilized to improve the growth and productivity cucurbitaceae vegetables in Pakistan.

Keywords: Rootstocks, abiotic stresses, salinity, grafted transplants, seedlings.

Studies on Phenotypic and Yield Response of Roselle (*Hibiscus sabdariffa* L.) to Different Sowing Times in Agro-Climatic Conditions of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

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Roselle (*Hibiscus sabdariffa* L.) is recognized as a valuable food crop due to its nutraceutical potential, rich pigment content, and medicinal properties. A field trial was conducted at the experimental area of Agriculture Research Institute, Ratta Kulachi, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan during the cropping season of 2018 to examine the phenotypic and yield responses of roselle to different sowing times. The study was carried out following randomized complete block design with six different sowing times i.e. 110 (20th April), 125 (5th May), 140 (20th May), 155 (4th June), 170 (19th June), and 185 (4th July) day number of the year 2018. Statistical analysis of the data collected during the experimental study showed that there was a significant polynomial relationship between day number of the year and various vegetative parameters including plant height, stem diameter, and the number of leaves per plant as well as reproductive parameters like the number of calyces per plant, individual calyx fresh weight, calyces fresh weight per plant, calyces dry weight per plant, and dry calyces yield per hectare. Further analysis of the data showed a positive linear relationship between dry calyces yield and the number of calyces per plant, individual calyx fresh weight, calyces fresh weight per plant as well as calyces dry weight per plant. This study concluded that there was a polynomial relationship between day number of the year and studied vegetative as well as reproductive growth parameters of roselle, while there was a linear relationship between dry calyces yield and the number of calyces per plant, individual calyx fresh weight, calyces fresh as well as dry weight per plant.

Keywords: Roselle, *Hibiscus sabdariffa*, growth, yield.

Interactive Response of Humic Acid and Variable Nitrogen Application on Yield Production in Tomato

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A field study was conducted to investigate the response of different humic acid (HA) concentrations along with nitrogen (N) levels on tomato yield production under the growing conditions of Dera Ismail Khan (D.I.Khan). Two factors (viz. HA and N) were tested using a randomized complete block design with split-plot arrangements and three replications. Main-plot consisted of five HA concentrations (0, 25, 50, 75, and 100 kg ha^{-1}) applied during tomato nursery raising, while subplot comprised of three N levels (0, 75, and 150 kg ha^{-1}) applied after seedling transplantation. HA concentrations considerably influenced all seedling development and production parameters of tomato. Plants receiving HA (50 kg ha^{-1}) produced maximum plant height, fruits $plant^{-1}$, fruit length and diameter, fruit fresh and dried weight, yield $plant^{-1}$ and total fruit yield and showed its superiority over all the other HA concentrations used. Amongst different N levels, the maximum N level (150 kg ha^{-1}) produced maximum plant height, number of leaves, fruits $plant^{-1}$, fruit length and diameter, fruit fresh and dried weight, yield $plant^{-1}$, and total fruit yield. The combined application of HA (50 kg ha^{-1}) and N (150 kg ha^{-1}) superseded the rest of combinations for the majority of vegetative and yield parameters.

Keywords: *Lycopersicon esculentum* L., humic acid, nitrogen, seedling, yield.

Response of Bottle Gourd to Foliar Application of Iron Sulfate

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Vegetables play a key role in the balance diet by providing not only the energy but also supplying vital protective nutritive elements either minerals or vitamins. Application of microelements fertilizers can enhance the plants resistance to environmental stresses. Foliar fertilization is an effective practice for the application of some micronutrients. Iron is necessary for the biosynthesis of chlorophyll and cytochrome responsible for enhancing the plant growth and yield. Hence, the research was carried out to evaluate the effect of iron on the growth and yield of bottle gourd. The trial was conducted in randomized complete block design comprising of four treatments of iron sulfate (T_1: 0.0, T_2: 0.5, T_3: 1.0, and T_4: 1.50 mg L^{-1}) replicated three times. The aforementioned treatments of iron sulfate were applied at 3, 6 and 9 weeks after the transplanting through foliar spray. Different reproductive and vegetative growth parameters including fruit weight, fruit yield per vine, and fruit length etc., were recorded. Different levels of iron sulfate showed significant variations among, germination percentage, shoot and root length, number of leaves per plant, fruit fresh weight, fruit diameter and chemical parameters like vitamin C, total soluble solids (TSS), and chlorophyll content. The foliar application of iron sulfate (1.0 mg L^{-1}) was found best for recording 50 days taken to first flowering, fruit width (12.2 cm) and fruit length (44.6 cm) compared to control treatment (without foliar spray). Fruit yield per plant (1.6 kg), average fruit weight (965.09 g), and number of fruits per plant (8.66) were improved under all iron sulfate treatments compared to non-treated plants. This study concluded that bottle gourd responded significantly to the foliar application of iron sulfate.

Keywords: Bottle gourd, iron sulfate, growth, yield, quality.

Influence of Exogenous Silicon on Physiological and Antioxidant Enzyme Activities of Tomato (*Lycopersicon esculentum* L.) Under Salinity

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Abiotic stress drastically affects the crops by reducing the crop yield. In this study, the combined effect of silicon and salinity was investigated on the physiological and antioxidant activities of enzymes in tomato plants. The experiment was laid in completely randomized design (CRD) with four treatments of silicon (T 0 (control), T1 (2 *mM*), T2 (4 *mM*), and T 3 (6 *mM*)) each with three replications. The saline conditions were prevailed at NaCl concentration of 50 and 75 dS m^{-1} for 10, 15 and 20 days' time period. Among different levels of exogenous silicon application, T2 (4 *mM*) recorded significantly higher values parameters including plant height (47 cm), fruit weight (58.26 g), total chlorophyll (46.32), and antioxidant activities such as superoxide dismutase (SOD 75%), peroxidase (POD 63%), and catalase (CAT 71%). Our results concluded that silicon application under salinity was useful in alleviating NaCl induced deleterious effects in tomato at all the growth stages.

Keywords: Tomato, silicon, superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), salinity.

Distinctive Evaluation of Lisianthus (*Eustoma grandiflorum*) on the Basis of Morphological Characteristics

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Lisianthus (*Eustoma grandiflorum*) is a new floral crop, introduced in the market due to its rose-like flower, extended postharvest life and vibrant colours. It is ranked in top ten cut-flowers worldwide. An experiment was conducted to assess four cultivars of echo series of lisianthus plants on the basis of morphological characters. The echo-series were first double flowers introduced for cut-flower production in the market. The experiment was conducted at floriculture program of Horticultural Research Institute, National Agricultural Research Center, Islamabad. The evaluation was done on the basis of yield and quality parameters required for market value. The cultivars revealed genetic variation for the required traits. The cv. Echo White revealed preeminent results for number of flowers (28.33), flower diameter (6.46 cm), plant spread (24.33 cm) and stem girth (10.33 mm), Echo Pink showed excellent results for plant height (62.32 cm), flower stalk length (17.33 cm), fresh flower weight (1.88 g), and number of petals per plant (14). On the other hand, the cv. Echo Blue showed exceptional results for flower stalk girth (3.23 mm). In conclusion, the cv. Echo Pink was excellent in flower stalk length, plant height and more number of petals, which are required characteristics in market, and could be utilized further, in breeding programmes.

Keywords: Lisianthus, echo series, variation, flower, stalk girth.

Precision Horticulture: A Step towards Sustainable Production

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Precision horticulture aims to maximize the productivity of orchards. This is especially true in areas where high-quality production standards justify the use of site-specific management practices to improve both quality and yield. New orchard management technologies increase production efficiency and quality, while reducing environmental impact. The rapid advancement of computer and internet technology, as well as geographic location technology, opens a wide variety of possibilities for the development of efficient distributed database strategies for precision horticulture. Crop sensors, yield monitors, local and remote sensors, global positioning system (GPS), variable-rate application equipment and machinery, geographic information systems, and data analysis and interpretation systems are all required for its practical implementation. Monitoring and controlling horticulture aim to take advantage of the wide range of available observations to characterize the orchard's variability and make management decisions by efficient use of fertilizers, seeds, and chemicals.

Keywords: Geographic information systems, orchard, precision horticulture, variability.

Comparative Evaluation of Herbicides and Manual Weeding Effects on the Growth and Yield of Summer Crop of Onion cv. Nasarpuri

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Onion is the second most important vegetable crop after tomato in the world. Onion is grown during winter in the Punjab plains of Pakistan but demand is high in summer and early winter. Major issue in summer grown onion is weeds population which reduce productivity and also increase the disease incidence. To control the weeds for the improvement of onion productivity during summer, an experiment was carried out during July 2018 at the Vegetable Research area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Two different herbicides i.e., Quizalofop-p-ethyl (Patwari, Orange Protection) and Oxyfluorfen (Hadaf, Evyol Group), hand weeding along with a control treatment (no weeding) were compared in onion cv. Nasarpuri after 30 days of transplanting. The size of the plot was 30 ft^2. Randomized complete block design was used to conduct the experiment. Results showed that maximum bulb diameter, i.e. 62.1 mm and 60.9 mm was noted in hand weeding and Oxyfluorfen, respectively. Dry matter content was highest in Quizalofop-p-ethyl (17.1%) and control treatment (17.0%). Maximum plant biomass (108.7 g), fresh bulb weight (136.4 g), yield (6.4 kg/plot), nitrogen, phosphorus and potassium contents (7.3%, 0.27%, 0.42%, respectively) were recorded in Oxyfluorfen treatment. While, chlorophyll content were reduced in Quizalofop-p-ethyl treatment compared to control and other treatments. It was concluded that Oxyfluorfen (Hadaf, Evyol Group) was found to be the best herbicide to control the weeds and increase the bulb productivity in summer crop of onion cv. Nasarpuri.

Keywords: Herbicide, weed control, growth, yield, onion.

Phosphorus Dose Effects On Growth, Yield and Quality of Different Varieties of Potato

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Potato is the world's 4th most grown and demanded vegetable crop due to a rich source of nutrients, starch, vitamins and minerals. Phosphorus is the second major nutrient, required by the potato for leaf initiation and shoot meristem activity but its availability is declining because of depletion of mineral reserves. Therefore, an experiment was carried out at vegetable research area, University of Agriculture, Faisalabad to compare the effect of two phosphorus levels (50 and 75 kg acre^{-1}) on four potatoes varieties (SH-704, FD-73, Sante and Ruby Red). Experiment was laid out under randomized complete block design with split plot arrangement having four replications. Results revealed that maximum plant height (53.5 cm) and number of stems per plant (7.0) were noted in SH-704 variety with 50 kg acre^{-1} phosphorus. However, maximum tuber fresh weight (115.0 g), tuber dry weight (71.7 g), tuber diameter (5.9 cm), total tuber yield per plot (11.4 kg), weight of goli tuber (104.3 g), tuber specific gravity (1.08 g cm^{-3}) and seed tuber per plot (3.6 kg) were recorded in Sante variety in response to 50 kg acre^{-1} phosphorus application. Maximum chlorophyll content (21.6 CCi) and weight of marketable tuber yield per plot (3.5 kg) were observed in Sante and FD-73 varieties, respectively under 75 kg acre^{-1} phosphorus treatment. However, all other varieties produced highest marketable yield in response to 50 kg P acre^{-1}. Highest value of potash in tuber (0.28 %) was recorded in Ruby Red, while the maximum nitrogen (11.3%) was noted in SH-704 with the phosphorus level of 75 kg acre^{-1}. However, phosphorus content in tuber was not significantly affected by varieties and phosphorous treatments. In conclusion, the phosphorus rate of 50 kg acre^{-1} appeared the best for ensuring the maximum vegetative growth and highest yield of potato tuber.

Keywords: Fertilizer, marketable tuber, photosynthetic pigment, *Solanum tuberosum* L.

Guava Wilt Disease (GWD: A Silent Pandemic

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Pakistan has a lower output of 7.74 tones ha^{-1} in guava when compared to the main African and Asian guava producing countries, such as South Africa, Taiwan, Brazil, and Indonesia with annual yields of 25, 23.59, 23.3, and 22.14 t ha^{-1}, respectively. One of the limiting factors in lowering the guava yield is guava wilt disease (GWD) after fruit fly among biotic factors. GWD is the foremost pathogenic menace, not only destroying highly productive guava orchards but also diminishing overall guava production in Pakistan. In Pakistan, significant losses have been reported in key guava producing areas such as Lahore, Faisalabad, Sahiwal, and other districts. A considerable lot of orchards in various areas, particularly Faizpur (Sammundri, Faisalabad), experienced high plant mortality because of this syndrome. The oppressed plant's green leaves turn yellow with mild leaf curling from the margins at the terminal branches, which eventually turns crimson and falls. Twigs bear flowers that do not grow, and newly produced leaves and blossoms dry out and fall. All damaged branches' fruit remains unripe/underdeveloped or mummified (hard, black and stony). The entire plant may defoliate and eventually die. A medium day length and mild temperature may aid in the disease's rapid spread. The wilt disease is caused by a variety of variables, including improper management, agronomic methods, nursery procurement, and post-planting factors for plant care and maintenance. This disease can be controlled by developing resistant strains against *Fusarium* species. Another noteworthy disease-controlling measure is sanitary and phytosanitary measures at both the farm and export levels, which could assist in orchard management and post-planting care, such as intelligent play with plant production aspects.

Keywords: Guava, wilt, biotic stress, pandemic.

Effect of Plant Based Extract on Phytochemicals and Morphological Properties of Calendula (*Calendula officinalis* L.)

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Foliar application of plant-based extracts is effectively used fertilization technique which is environment friendly. It is necessary to produce organic flower production by using the plant-based extracts as a bio-stimulant. The objective of this research was to improve the morphological and phytochemical properties of calendula plant by using the natural plant-based extracts to promote the sustainable agriculture. Experiment was conducted at the Gardening Wing, Estate Management Department of University of Agriculture, Faisalabad. Experiment was arranged according to randomized complete block design (RCBD) with three replications. Three different plant-based extracts (i.e., moringa leaf extract, garlic extract, and turmeric extract) were applied to calendula plants in various concentrations, thereby, comprising a total of seven treatments. Data were analyzed using Fisher's analysis of variance (ANOVA) technique and treatment means were compared using Tukey's test at 5% probability level. Maximum plant height (73.46 cm), number of leaves (168.33), number of shoots (8.00), root length (11.20 cm), number of flowers (55.00), petal length (2.60 cm), petal area (1.21 cm^2), total phenolic contents (4.30), and early 1st flower bloom (30 days) was found with 30% garlic extract. On the other hand, the maximum leaf area (20.91 cm^2), leaf length (8.60 cm), DPPH (2,2-diphenyl-1-picrylhydrazyl) radial scavenging activity (53.46%), and total flavonoid contents (15.99 mg CE g^{-1}) were recorded with 20% moringa leaf extract. The parameters including petal width and leaf width showed non-significant results among the treatments. It was concluded that garlic extract (30%) significantly enhanced most of the vegetative and floral parameters in calendula.

Keywords: Calendula, moringa leaf extract, garlic extract, turmeric extract.

Breaking Bud Dormancy in Grapevines with Garlic and Onion Paste

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Viticulture is the most flourishing branch of horticulture. For profitable viticulture, breaking bud dormancy is essential to produce timely and uniform fruiting buds to capture proper markets. Different organic and synthetic compounds are being used in different parts of the world for breaking bud dormancy in grapevines. In this study, the response of grapevine to garlic and onion pastes with respect to contributing traits was investigated in two varieties viz. Perlette and King Ruby. The trial was laid out in randomized complete block design with factorial arrangement. The treatment included P1= control, P2 = garlic cloves paste, P3 = green garlic paste, P4 = green onion paste, and P5 = onion bulb paste. The results revealed that all parameters were significantly affected by the interactive effect of varieties and garlic/onion paste. The grapevine treated with green garlic paste (P3) produced better results indicated by 13.41% sprouted bud, 27.94 sprouted buds cane^{-1}, 19.45 days to bud induction, 138.88 leaves sprout^{-1}, 25.12 bunches cane^{-1}, 36.83 cm size of bunches, and 74.50 days to maturity after treatment application. In case of varieties, the “Perlette” surpassed the rest with 11.89% sprouted buds, 24.95 sprouted buds cane-1, 17.96 days to bud induction, 136.85 leaves sprout^{-1}, 21.10 bunches cane^{-1}, 31.45 cm size of bunches, and 85.60 days to maturity after treatment application. It was concluded that the green garlic paste proved to be more effective on grapevine for timely, uniformly, and early production.

Keywords: Dormancy, bud breaking, garlic paste, onion paste, grapevine.

Shellac Wax Coating to Improve the Storage Quality and Shelf Life of Strawberry Fruit (*Fragaria ananassa* L.)

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Strawberry is an extremely perishable fruit that has a very short shelf life. Therefore, its postharvest handling is a serious problem throughout the world. Its deterioration can stretch out to 40% during the transportation and storage. The main reason for deterioration of fruit quality is microbial growth, fungal attack, and mechanical damage during transportation. Reduction of the metabolic rate, fruit rot control, and cold storage, are the main techniques that have proven to be effective in extending the shelf life of strawberries. This study was carried out in the postgraduate laboratory of Horticulture Department, Sindh Agriculture University, Tandojam in a three replicated completely randomized design. The strawberry fruit cultivar "Chandler" was coated with 5%, 15%, and 20% shellac wax and then placed in an open shade for 15-20 minutes and later stored in cold storage. The temperature was maintained at 5˚C throughout the experiment, and analysis was recorded after 0, 2th, 4th, 6th, 8th, 10th, and 12th days of storage. The strawberry fruit coated with 5% shellac wax exhibited fresh fruit weight of 10.67 g, dry fruit weight of 10.33 g, fruit shape index of 1.56 mm, disease score of 1.14, decay incidence of 4.66%, damage incidence of 1.28%, fruit weight loss of 74.00 g, pH of 3.32, total soluble solids of 7.33 °Brix, and electrical conductivity of 66.60% on the 12th day of storage. The overall results of this experiment indicated that shellac wax coating of 5% shellac wax performed best throughout the storage period followed by 10% shellac wax, 15% shellac wax, and control, respectively.

Keywords: Wax coating, storage, shelf life, strawberry.

Pre-Storage Coating of Aloe Vera with Methyl Salicylate Maintained the Quality of Cold Stored Sweet Pepper (*Capsicum annuum* L.)

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Sweet pepper belongs to the family Solanaceae and is admired due to its unique taste and rich source of vitamins and minerals. It is highly sensitive to moisture loss due to its perishable nature. Storage at low temperature for a prolonged duration induces chilling injury (CI) in sweet pepper. The objective of this study was to evaluate the combined impact of aloe vera (AV) coating and methyl salicylate (MS) on the amelioration of chilling injury and maintenance of the quality of sweet pepper. For this purpose, freshly harvested fruits were transported to the lab and randomly divided into two groups. One group was washed with potable water (control) and the other group was dipped in AV (25%) + MS (0.05 mM) solution followed by drying at ambient temperature. Finally, fruits were stored in cold storage at 7 ºC for 24 days. Results showed that AV+MS treated fruits have significantly reduced weight loss and incidence of CI and maintained a high score for overall visual quality. Moreover, ascorbic acid, total phenolic content, and antioxidant capacity were also maintained high compared to control. In addition to this, the production of hydrogen peroxide and malondialdehyde was found minimum in AV+MS treated fruits during post-storage evaluation. In conclusion, pre-storage coating of AV+MS can be considered an effective treatment for the maintenance of fruit quality in cold storage.

Keywords: Chilling injury, cold storage, sweet pepper, visual quality.

Growth and Yield Response of Broccoli to Exogenous Application of Chitosan

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Broccoli is a vegetable that is progressively perceived as a healthful wellspring of phytochemicals, including glucosinolates and phenolics. Broccoli is a cash crop, but unfortunately, in Pakistan, its area under cultivation is limited due to a lack of production technology. Farmers' income can be improved by switching to high cash production of non-traditional crops such as broccoli. Hence, this study was conducted to see the impact of exogenous application of chitosan (CTS) on broccoli and to investigate the differential growth, morphological and physiological changes of broccoli cvs. 'Palmira' and 'Saki' under the foliar-applied CTS (viz., control, 25, 50, 75, 100 ppm). The CTS solution was sprayed on the abaxial and adaxial surfaces of leaves and flower head in such a way as to obtain complete coverage of the plant. Foliar sprays were repeated at two-week intervals starting from 30 days after transplanting. Different vegetative (plant height (cm), number of leaves, stem length (cm), stem diameter (cm), head shape, leaf area (cm^2), fresh weight leaves (g), dry weight of leaves (g), the weight of primary curd (g), the diameter of primary curd (cm), number of secondary curds and biochemical attributes (TSS, titratable acidity, vitamin C, reducing and non-reducing sugars) were studied. The maximum plant height (59.6%), number of leaves (20.3%), and head shape were observed in cv. 'Palmira' (2.3%) with 50 ppm CTS. Furthermore, CTS (75 ppm) application in cv. 'Palmira' increased the yield up to 562.64%. Moreover, compared with control, broccoli's quality and biochemical traits also enhanced significantly with CTS application. The maximum TSS were noted in cv. 'Saki' (5.8%) and vitamin C contents were maximum in cv. 'Palmira' (2.1%) with 50 ppm CTS. So, the results of this study showed that the application of 50 and 75 ppm CTS positively influenced broccoli's physical and biochemical traits.

Keywords: *Broccoli,* cashcrop, yield,chitosan, traits.

Morphological Variability in Gamma Irradiated Germplasm of Grapefruit

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Induced mutations have played a pivotal role in grapefruit (*Citrus paradisi* Macf.) varietal development, and most of the commercial cultivars are bud sports or induced mutants. Hence, gamma irradiated budwood at 0, 40, 80, 100, 120, and 140 Gy of three grapefruit cultivars (Rio Red, Red Blush, and Pink Ruby) were grafted on Rough lemon rootstock. The developed plant population was transplanted under a randomized complete block design in the experimental fruit garden of the institute and screened for morphological variability during the year 2021. After three years of transplanting irradiated germplasm, it was observed that gamma irradiations had a significant impact on most of the morphological variables, viz., plant height (116.0 to 79.20 cm), bottom trunk diameter (12.56 to 8.62 cm), plant canopy (70.4 to 41.06 cm), number of leaves per branch (159.82 to 85.99), number of sub-branches (21.99 to 18.14) and inter-nodal distance (1.13 to 0.58 cm). Most parameters showed a significant decrease with an increase in the gamma dose. Grapefruit cultivars also showed significant variability as cv. Rio Red had maximum plant height (116.20 cm), bottom trunk diameter (11.80 cm), number of lateral branches (17.56), branch length (43.24 cm), and number of sub-branches (23.9), compared to Red Blush and Pink Ruby cultivars. In contrast, the number of acrotonic branches (2.78), plant canopy (59.87 cm), number of leaves (168.86), and inter-nodal distance (0.9 cm) were found more in cv. Pink Ruby. Conclusively, gamma irradiation considerably affected plant morphology. Cultivar Rio Red irradiated population performed better and showed more vigorous tree growth with maximum branching. The promising mutant plant material will be multiplied and screened for fruit production and quality parameters. The current study will act as a baseline for future breeding programs and the development of improved varieties.

Keywords: Induced mutation, phenotypic variability, vegetative growth, gamma rays, grapefruit.

Diminution of Cadmium Stress in Cucumber Seedlings by Controlling the Photosynthesis and Antioxidant Mechanism by Exogenous Application of Glutamic Acid

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Vegetable production in heavy metal contaminated soils is a serious concern affecting food quality. Glutamic acid (GA) has been extensively studied as a stress-responsive antioxidant molecule, and its function is involved in triggering plant growth during abiotic stress. Therefore, in the present study, the alleviating role of exogenously applied GA was examined in soil-grown cucumbers under four levels of cadmium (Cd) (0, 5, 10, and 20 mg Cd kg^{-1}) and two levels of GA (0, 10 mM). Two cucumber cultivars, 'V1 Ashly' and 'V2 SSC-228' were studied for the purpose. Significant decreases were more pronounced in the photosynthetic parameters under the Cd stress alone in both cultivars. However, pronounced deleterious effects were observed in the V1 compared to V2 in plant growth and photosynthetic attributes. However, the exogenous treatment of GA significantly improved the plant growth and chlorophyll contents of plants under the Cd stress. The GA also decreased the Cd contents in the cucumber roots and leaves and further decreased the reactive oxygen species (ROS), which were elevated by the high Cd concentrations. Interestingly, the antioxidant enzyme activities superoxide dismutase and peroxidase (SOD and POD) increased under the different elevated Cd levels in the leaves of the plants. However, the catalase and ascorbate peroxidase (CAT and APX) activities were reduced with an increasing Cd concentration in the soil in both cultivars. Meanwhile, the exogenously applied GA exhibited synergic effects and activated the antioxidant enzyme activities in the cucumber leaves under the Cd stress. In this study, the V2 cultivar was more tolerant to Cd stress than the V1. Furthermore, the findings of this study highlight that a GA application can play a significant role in enhancing plant growth and stimulating the biochemical activities in cucumbers under Cd stress.

Keywords: Heavy metal, vegetables, signalling molecule, plant growth, reactive oxygen species.

Exogenous Application of Glutamic Acid Promoting Cucumber (*Cucumis sativus* L.) Growth under Salt Stress Conditions

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Salinity is expected to be the major destructive abiotic stress that causes ionic and oxidative damage leading to growth reduction and ultimately plant death. Glutamic acid (GA) is α -amino acid used by almost all living beings in the biosynthesis of proteins. Therefore, in the present study, we tried to investigate the effect of foliar application of GA on greenhouse-grown cucumber plants under various salinity levels. This study used two cucumber (*Cucumis sativus* L.) cultivars indigenous as V1 and SSC-228 as V2. The experiment was laid down using a completely randomized design (CRD) under a two-way factorial. Treatment consisted of four levels of salinity (0, 3, 6, and 12 dS m^{-1}) and two levels of GA (0, 10 mM). Salinity was induced by mixing the salt and soil before seed sowing, whereas GA was applied exogenously via foliar spray when the vine length reached its maximum. High values of plant fresh and dry weight (0.77 ± 0.026 and 0.30 ± 0.01, respectively) root and shoot fresh and dry weights (0.5 ± 0.009, 0.27 ± 0.004, 0.19 ± 0.01, and 0.11 ± 0.02, respectively) were observed in V2 at 10 mM GA. V1 enhanced activities of superoxide dismutase (0.29 u g^{-1} FW), guaiacol peroxidase (3.51 u g^{-1} FW), and ascorbate peroxidase (0.39 µ mol AsA mg^{-1} chlorophyll min^{-1}) were observed in salt-stressed cucumber leaves. Both varieties showed unusual behavior for malondialdehyde in decreasing manner with increasing salinity levels (2.0333 µ mol g^{-1} FW at 12 dS m^{-1} in V1, while 1.98 µmol g^{-1} FW at 12 dS m^{-1} in V2. However, exogenously applied GA was beneficial in promoting cucumber growth by determining parameters under salinity stress. Foliar application of GA improved plant growth and defense mechanisms with minimum destruction and under salt stress.

Keywords: *Cucumis sativus*, salinity, glutamic acid, antioxidant machinery, plant growth.

Postharvest Hypobaric Treatment Inhibited Fungal Decay, Maintained Cosmetic Quality and Retained Phytonutrient Profile of Jujube During Low Temperature Storage

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Jujube is known as the king of arid fruits, exhibits limited shelf life, and is highly susceptible to fungal decay. The present study aimed to evaluate the effect of hypobaric treatment on the inhibition of microbial spoilage and maintenance of fruit quality of jujube during low-temperature storage. Jujube cv., seedless, was subjected to hypobaric treatment for 20 kPa for 30, 60, and 120 min, followed by low-temperature storage (5±1 °C) for 24 days with a 6-day interval. Jujube fruit treated with postharvest hypobaric treatment at 20 kPa for 120 min significantly inhibited fungal decay (score), fungal count (CFU g^{-1}), and postharvest disease incidence during the entire period of storage. On d-24, the treated fruits exhibited lower weight loss (2.7%), respiration rate (1.3 mmol CO_2 kg^{-1} hr^{-1}), electrolyte leakage (38.2%), suppressed MDA (13.5 µmol kg^{-1} FW), and H_2O_2 (216.1 µmol kg^{-1} FW) contents, retained higher chlorophyll contents (18.2 µg kg^{-1} FW) and antioxidants in terms of DPPH radicle scavenging activity (63%), total phenolic concentrations (54.7 mg GAE kg^{-1} FW), ascorbic acid contents (129.2 mg kg^{-1} FW) with maintained visual quality (7.5 score) and marketability index (71.3%) during storage. Nevertheless, the total soluble solids, acidity, sugar acid ratio, and fruit pH were insignificantly affected by these treatments. After 24 days of storage, the fruits treated with hypobaric pressure treatments presented better-eating quality (taste, flavour, aroma, and overall acceptability) than untreated control fruits. To sum up, the hypobaric treatment at 20 kPa for 120 min could be considered as food safe non-chemical approach with subsequent storage at low temperature for lowering postharvest decay and maintaining the quality of jujube fruits.

Keywords: Eating quality, hypobaric treatment, fungal decay, total antioxidants.

Genome Wide Analysis of Plant Specific YABBY Transcription Factor Gene Family in Carrot (*Daucus carota*) and its Comparison with Arabidopsis

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YABBY gene family is a specific transcription factor in plants and a DNA binding domain that includes various functions, including regulation of style length in flowering plants and polarity development of lateral organs. The genome of the carrot (*Daucus carota* (ASM162521v1)) was utilized to discover members of the YABBY gene family members via an online web technique, i.e., BLAST (Basic Local Alignment Search Tool). Structure of gene, location of genes on chromosomes, proteins motifs, phylogenetic investigation, synteny, dual synteny analysis, transcriptome analysis, and miRNA targets was analyzed. Here, we recognized 11 specified YABBY genes erratically dispersed on all nine chromosomes. YABBY proteins in carrot assembled into five subgroups (AtINO, AtCRC, AtYAB5, AtAFO, and AtYAB2) created on the well-known classification of arabidopsis. The wide range of YABBY genes in carrots was due to segmental duplication, which was detected as prevalent when equated to tandem duplication. Transcriptomic analysis showed that one of the DcYABBY genes was highly expressed during anthocyanin pigmentation in carrot taproot. The cis-regulatory elements (CREs) analysis unveiled the occurrence of elements that mainly responds to light, cell cycle regulation, drought inducibility, ABA hormone, seed, and meristem expression. Furthermore, a comparative study among carrot and Arabidopsis genes of the YABBY family indicated five sub-families or groups, and each group contained one or more AtYAB genes. The wide-ranging genome assessment of YABBY genes showed orientation for cloning and functioning properties in carrot.

Keywords: Carrot, YABBY, plant specific transcription factor, genome wide, bioinformatics.

Plant Water Relations and Efficiency of Various Commonly Used Houseplants

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Water relationship is an essential aspect of various metabolic processes that take place in plants, particularly in houseplants which are usually exposed to various abiotic maladies. Water level affects various physiological and biochemical processes in plants. Hence over-watering or drought conditions may negatively affect plant growth and development. Mostly, houseplants are sensitive to the quality and quantity of irrigated water. Hence, in this study, houseplants commonly preferred by the users were assessed for their water requirements and water use efficiency. Five different species of *Dracaena* and *Cordyline* genus (i.e., *Dracaena marginata* 'bicolor,' *Dracaena marginata* 'tricolor', *Cordyline fruticosa* 'red'. *Cordyline terminalis* 'green' and *Cordyline fruticosa* 'Rubra') were evaluated for the purpose. The study was designed under a completely randomized design, and data recorded was analyzed by ANOVA using an LSD test at a 5% probability level. The data regarding various physiological and biochemical parameters were gathered, and the following findings were obtained. The minimum amount of average irrigation demand (AID) (1787 ml), and low rates of morphological and physiological attributes were recorded in *Cordyline fruticosa* 'Rubra' i.e., average growth rate (8.47 cm), average evapotranspiration (40.16 mm day^{-1}), and average transpiration (18.68 mg m^{-2} s^{-1}). Leaf area (22.8 cm^2) of *Cordyline fruticosa* 'Rubra' was more than leaf area of *Dracaena marginata* bicolor and *Dracaena marginata tricolor*, but less than *Cordyline terminalis* 'Green' and *Cordyline fruticosa* 'Red'. On the other hand, *Cordyline terminalis* 'Green' had maximum average AID (2417 ml), average growth rate (13.07 cm), average evapotranspiration (55.3 mm day^{-1}) and average transpiration (25.74 mg m^{-2} s^{-1}) than all plants species under study, followed by *Cordyline fruticosa* red, *Dracaena marginata* bicolor and *Dracaena marginata* tricolor. All these results proved that *Cordylin fruticosa* 'Rubra' requires minimum irrigation frequency among all other plants tested in the study.

Keywords: Irrigation frequency, houseplants, water requirements, water use efficiency.

Advances in the Environmentally Friendly Management of Red Palm Weevil, Rhynchophorus ferrugineus (Coleoptera: Curculionidae)

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The red palm weevil (RPW), the most invasive insect pest of the palm family, is considered the most dangerous pest around the globe. Three out of four life stages of weevils are concealed inside the host plants, leaving only the adult stage for controlling it. Using sex pheromone (Ferrugineol) for managing red palm weevil is considered the most rewarding technique of IPM. The current study was conducted to determine the relative potential of four treatments (sex pheromone, sex pheromone + date fruit + sugarcane pieces, sex pheromone + ethyl acetate, and sex pheromone + jaggery water) applied to assess the attraction behaviour of weevils. The treatments were applied randomly at two locations in Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, including the Germ Plasm Unit (GPU) and Fruit Nursery Farm having date palm plants of different ages of four varieties, Dhakki, Gulistan, Aseel, and Begum Jangi of date palm. The treatments were applied for three consecutive months (February till April) in 2022. The pheromone traps were installed at two feet under shade on the western side of date palm plants. The results revealed that sex pheromone + jaggery water was the most effective treatment among the treatments and attracted the maximum number of 127 weevils, followed by sex pheromone + ethyl acetate attracting 53 weevils. In contrast, sex pheromone + date fruit + sugarcane pieces were found to be the least effective treatment in attracting red palm weevils and attracted only 15 adult weevils. Among the two selected locations, the population of red palm weevil was found comparatively higher at GPU compared to the Nursery farm, Dera Ismail Khan.

Keywords: Red palm weevil, integrated management, sex pheromones.

Assessment of Stevia (*Stevia rebaudiana* Bertoni) Growth under the Climatic Conditions of Dera Ghazi Khan

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Stevia (*Stevia rebaudiana* Bertoni) is a perennial herb with natural sweetener leaves. Its fresh leaves and extracts are 16-32 and 245-340 times sweeter than ordinary sugar. This study was carried out to rationalize the morphological and economic parameters of stevia under subtropical growing conditions of Dera Ghazi Khan (D.G.Khan). The performance of stevia varied across the testing locations (DGKhan and Fortminro) for all the studied parameters. Soft top stem cuttings of stevia with five nodes were taken from 6-month-old disease-free mother plants from a private company and transplanted in a row during October. The stevia variety Criolla was tested for this research. Plots were created as three replicates, and the seedlings were transplanted in 65 cm × 35 cm row distances. The maximum plant height (35.60 cm), number of branches (35.30 cm), fresh leaf yield per plant (35.60 g), fresh leaf yield (1810 kg/ha), dry leaf yield per plant (13.20 g), dry leaf yield (433.10 kg ha^{-1}). Results concluded that stevia could be grown easily for its sweet leaves and stevioside in sub-tropical conditions of the D.G.Khan.

Keywords: Stevia, sugar, morphology, stevioside, natural sweetener.

Influence of Different Levels of Salinity to Check the Growth and Quality of Rose

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Soil salinity is a significant abiotic factor that adversely affects plant growth. In addition, the nursery and greenhouse industry is under pressure to recover and recycle fertilizer solutions and wastes. Most of these contain significantly higher salt concentrations that could cause harm to susceptible species of roses. In this study, the response of rose (*Rosa damascena* Mill.) was evaluated to several NaCl salinity levels developed by irrigating saline water with different salinities, viz. 0 (control), 50, 100, 150, 200, and 250 mM NaCl. Growth rates were significantly reduced as recorded for flower diameter, number of leaves per plant, number of shoots per plant, number of flowers per plant, number of petals per flower, fresh and dry weight of flower, and petals. Results depicted that plant growth and yield significantly reduced with an increase in salt concentration, mainly when >150 mM NaCl was applied. Therefore, it is suggested that *Rosa damascena* is best grown in soil with a salinity level of ≤150 mM.

Keywords: Roses, salinity, soil.

Micropropagation of Date Palm (*Phoenix dactelifera* L.)

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Date Palm (*Phoenix dactelifera* L.) is among the world's most beneficial and highly nutritive fruit crops. Pakistan is one of the leading producers of date palm and ranks sixth worldwide. The requirement of date palm plants cannot be fulfilled completely by just obtaining plants from offshoots, and it is also time taking. Micropropagation is an efficient technique to multiply plants. *In vitro* regeneration of date palm can help in rapid multiplication. In the present study, a protocol was established to acquire callus from different explants of date palm, including inflorescence, shoot tips, and embryo. The influence of various growth regulators (BAP, NAA, IBA, kinetin, and 2-4 D) was also evaluated for callus induction. Later on, regenerative callus was shifted to shooting and rooting media. NAA @ 2 mg L^{-1} with the combination of kinetin @ 1 mg L^{-1} gave the best results for callus induction (64%) in all explants. MS media supplemented with BAP (2 mg L^{-1}), and IBA (2 mg L^{-1}) was found most effective for shoot production for shoot induction. Regenerated shoots were then carefully transferred into media fortified with various doses of IBA for root induction. IBA @ 2 mg L^{-1} gave maximum (58%) rooting. Much work is still needed to be done in the future. Tissue culture has much potential in itself; researchers should turn towards micropropagation considering the importance and production of date palm in Pakistan. This will not only produce multiple copies of the elite cultivars but will also open the doors of advancement in the fruit industry of Pakistan.

Keywords: *In vitro*, growth hormones, regeneration, multiple shoot induction, explants.

Steps towards Mitigating the Drastic Hit of Climate Change on Fruit Ripening of Promising Date Palm cv. Dhakki

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Date palm (*Phoenix dactylifera* L.) is vital in providing millions of food and shelter. A prominent local cultivar, "Dhakki" of Dera Ismail Khan, Pakistan, is economically far more important for having a jumbo size, high pulp to stone ratio, fine texture, and quality taste. Therefore it is highly suitable for export targets. However, being a late cultivar, it is confronted with enormous environmental stresses. Stormy monsoon season coincidences with the period of date ripening and lack of preservation technology are among a few alarming factors causing quality deterioration and excessive post-harvest losses. Even though date palm is a thermopile species and can withstand large temperature fluctuations, recent climate changes, especially prolonged and uneven monsoon patterns, starting earlier and lasting till September, have caused multiple threats to Dhakki date production, such as spoilage of fruits at early ripening stage, hindering ripening and drying process. The study aimed to induce rapid artificial ripening in Dhakki fruits harvested at the firm and astringent khalal stage and complete the fruit curing/drying before the monsoon fall. In this context, different concentration of sodium chloride varying from 0.25 to 3.5% and acetic acid from 0.25 to 2.5% was investigated for fruit ripening. Date fruit was first immersed in the afore-mentioned treatment solution for 5 min and later ripened/cured in an aerated incubator at 38 to 40 °C for 72 hours. All of the treatments induced ripening of varying degrees. However, 2% sodium chloride appeared highly effective, introducing accelerated ripening and causing 75% excessive yield over the control sample. Results concluded that applying sodium chloride (2%) may accelerate the fruit ripening process and save the 2-3 weeks period. As a result, damages caused by monsoon and insect/ bird attacks are likely to be reduced considerably, thus increasing the yield of quality produce.

Keywords: Dhakki dates, *Phoenix dactylifera* L., accelerated ripening, curing, khalal.

Assessment of Various Organic Compounds to Hasten the Display Life of Cut Narcissus (*Narcissus tazetta*) Flower

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Narcissus (*Narcissus tazetta*), commonly known as daffodil, is a predominant spring flowering perennial plant from the Amaryllidaceae family known for its enchanting fragrance. It is usually grown for various purposes, including essential oil extraction, medicinal purposes, and as a cherished geophyte in the gardens. When cultivated as a cut flower on a commercial scale, it is always anticipated that it must possess hastened vase life. This is because cut flowers' longevity is of major importance for florists and consumers. After harvesting, living tissues in cut stems remain alive using the limited stored substrate. So, the exogenous energy source is required to maintain the quality and display life. For this reason, an experiment was designed to evaluate the performance of citric acid, sucrose, and salicylic acid as floral preservatives in vase solution at different concentrations; moreover, they are biodegradable and do not cause environmental pollution. The experiment was laid out under completely randomized design with three replications, and the ANOVA technique was used to analyze the data. Results revealed that citric acid @ 450 mg L^{-1} proved to be best in improving vase life (12.3 days), followed by salicylic acid when applied @ 300 mg L^{-1}. Similarly, dry weight (3.8 g), flower head diameter (37.3 mm), solution uptake (11.4 ml), and less ion leakage of petals were observed in the vase solution containing 450 mg L^{-1} citric acid. Similarly, salicylic acid @ 300 mg L^{-1} resulted in higher fresh mass (127.7 g), change in soluble solids of petals (3.46° Brix), and less change in electrical conductivity of the solution. (0.83 dS m^{-1}). So, using organic compounds including sucrose, citric acid, and salicylic acid proved to be useful in improving the display life of cut narcissus flowers.

Keywords: Vase life, cut flower, organic compounds.

Impact of Variable Nitrogen Levels and Seed Rates on the Growth and Yield of Fenugreek

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A research study was carried out to check the impact of variable N levels and seed rates on the growth and yield of fenugreek under the growing conditions of Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. The experiment was laid out in a randomized complete block design with a factorial arrangement and three replications. There were two factors, viz. variable nitrogen (N) levels (0, 25, 50, and 75 kg ha^{-1}) and fenugreek seed rates (4.94, 7.41, 9.88, and 12.35 kg ha^{-1}). Results indicated a significant effect of N and seed rate on fenugreek growth and herbage production. The maximum N level (75 kg ha^{-1}) exhibited the best results for almost all the parameters, including plant height, branches, leaf area, herbage fresh and dry weight, moisture content (%), dry matter content (%), and total herbage yield (23.73 t ha^{-1}). The seed rate of 12.35 kg ha^{-1} produced maximum plant height, leaf area, herbage fresh and dry weight, moisture content (%), dry matter content (%), and total herbage yield (26.93 t ha^{-1}). Mostly all seed rates showed better performance in combination with N levels. However, higher N levels (75 and 50 kg ha^{-1}) combined with the highest seed rates showed the best performance for the growth and yield of fenugreek. This study concluded that the growth and yield of fenugreek is significantly influenced by the interactive response of N and seed rates.

Keywords: Fenugreek, *Trigonella foenum-graecum,* nitrogen, seed rate, herbage.

Influence of Pollination Times on the Yield and Fruit Characteristics of 'Muzawati' and 'Kahraba' Date Palm (*Phoenix dactylifera* L.)

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This study was carried out to assess the influence of pollination times on fruit set, fruit physico-chemical characteristics, and yield of two date palm cultivars. The experimental layout was a randomized complete block design with split plot arrangements. The main block consisted of two female cultivars (viz. Muzawati and Kahraba), whereas the sub-block consisted of five pollination times (viz. 1, 2, 4, 6, and 8 days after spathe opening) and replicated thrice. Pollination was carried out as per the treatment plan by inserting 03 male strands into three female spathes of each aforementioned cultivar using a single male palm as a pollen source. Results revealed a significant effect of both date palm cultivar and pollination times on the fruit set, fruit physico-chemical characteristics, and yield. The maximum fruit length (3.87 cm), width (2.51 cm), weight (14.23 g), moisture (62.00%), and Total Soluble Solids (30.09 °Brix) were recorded in the Muzawati date palm cultivar when pollinated eight days after spathe opening. On the other hand, the maximum fruit set (90.10%) and fruit weight per bunch (17.11 kg) were recorded in Muzawati when pollinated one day after the spathe opening. The Kahraba date palm cultivar recorded the lowest values of all the parameters studied. Results concluded that early pollination ensures optimum fruit set and economic yield. On the contrary, late pollination improves fruit quality traits but at the expanse of lower fruit set and yield.

Keywords: Pollination timing, yield, fruit quality, date palm.

Impact of Liquid Pollination on Fruit Set, Quality, and Yield of Dhakki and Zahidi Date Palm (*Phoenix Dactylifera* L.)

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Improper pollination is among the major factors responsible for low fruit set and yield in most of Pakistan's commercial date palm varieties. An experiment was therefore conducted to evaluate the liquid pollen application on the fruit set, yield, and quality of Dhakki and Zahidi cultivars of date palm. The experiment was executed in a randomized complete block design with a split-plot arrangement. Two date palm cultivars (Dhakki and Zahidi) were considered as the main factor, and four pollen concentrations (viz. using 2, 4, 6, and 8 g pollen L^{-1} water) as sub-factors and repeated thrice. For pollination, a single pollen source was used. The three spathes of each Dhakki and Zahidi palm were pollinated by following the suspended pollen spray method using the aforementioned concentrations. In addition, 2 g of sugar was added to make the solution sticky. Results revealed that the maximum days to fruit set (23.40 and 22.10), fruit set (96.47 and 91.46%), fruit drop (43.7 and 26.81%), bunch weight (11.13 and 6.41 kg), and fruit yield (178.13 and 64.13 kg $plant^{-1}$) was recorded with the maximum pollen strength of 8 g L^{-1} in both the cultivars Dhakki and Zahidi, respectively. On the other hand, the minimum values of these parameters were exhibited by the pollen strength of 2 g L^{-1} in both the date palm cultivars. Overall, the cultivar Dhakki achieved maximum values of fruit quality attributes, including fruit size, fruit weight, and pulp weight. Hence, based on this study, the liquid pollen application of 8 g L^{-1} is recommended for achieving maximum fruit set and yields in date palm under the agro-ecological conditions of Dera Ismail Khan.

Keywords: Date palm, fruit setting, fruit quality, liquid pollination, yield.

Assessing the Whorl-Wise Spath and Fruit Physiochemical Characteristics of Different Date Palm (*Phoenix dactylifera* L.) Cultivars Grown in Dera Ismail Khan Region

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Different date palm varieties were evaluated for whorl-wise vegetative and fruit physicochemical characteristics. The experiment was laid out in a randomized complete block design with a factorial arrangement and three replications. Treatments consisted of six date palm varieties (Zaidi 1, Zaidi 2, Hilawi, Basra, Dhakki, and Gulistan) and three whorls-wise spathes (W1, W2, W3). Pollination was carried out from a single pollen source. The results indicated that maximum spathe length (141.28 cm), spathe width (4.28 cm), and the number of strands per spathe (66.0) were recorded in W1. The maximum number of fruit per strand (19.56), and the number of fruit per spathe (1196.0), was recorded in W2. Similarly, maximum fruit bunch weight (6.12 kg), fruit weight (10.59 g), pulp weight (9.68 g), fruit width (2.28 cm), and moisture content percentage (53.89%) were also recorded in W2. Among the varieties, the maximum length of the spathe (126.78 cm), the width of the spathe (4.81 cm), fruit per strand (24), fruit bunch weight (8.68 kg), fruit weight (20.28 g), pulp weight (20.0 g), fruit length (4.55 cm) and fruit width (2.44 cm) was recorded in variety Dhakki. In contrast, the maximum fruit set (88.11%) was recorded in the variety Zaidi 2. The highest TSS content (39.78 °Brix) was observed in Zaidi 1. The maximum number of fruit per spathe (1688) and moisture content (61.33%) were noted in variety Hilawi. The highest seed weight (1.54 g) was recorded in the variety Gulistan.

Keywords: Whorl, spathe, date palm, genotypes, fruit set.

Assessing the Impact of Nitrogen on the Growth and Yield Production in Red Beet

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To meet increasing food supply demands, farmers use chemical fertilizers to increase the productivity of crops. These approaches have resulted in environmental degradation and have negatively impacted soil health, microbial activity, and beneficial insects. Therefore, it is mandatory to rethink the existing agricultural activities involving fertilizers. Hence, a field experiment was executed in red beet crop following a completely randomized complete block design (RCBD) with three replications. Treatments consisted of seven contrasting nitrogen (N) environments created with the application of 0, 50, 100, 150, 200, 250, and 300 kg N ha^{-1}. Data on several yield- and beetroot quality-determining parameters were gathered. The results showed significant effects of N on various growth parameters and beetroot yield. The response of various growth parameters and yields to N rates was quadratic. Among the N environments, 250 kg N ha^{-1} significantly improved most of the growth parameters and produced the highest beetroot yield of 25.46 t ha^{-1} with an increase of 64.05% over control. This study helped elucidate the extent of N response to red beet growth and yield production.

Keywords: Interaction, genotype, nitrogen, yield, red beet.

Assessing the Response of Intra-Row Spacing on the Growth and Yield of Onion

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Yield production in onion is low in Pakistan compared to other onion-producing countries, mainly due to poor soil fertility and improper crop management practices. The proper plant spacing can improve the yield and quality of onion through enhanced nutrient availability, especially atmospheric nitrogen, and the provision of sufficient space for bulb growth. Narrow spacing produces a small bulb with a greater number of bulbs, while wide spacing gives a large bulb with a smaller number of bulbs per unit area. This study was therefore conducted to determine the effects of intra-row spacing on the growth and yield of onion genotype using a randomized complete block design with three replications. Treatments comprised three intra-row spacing (viz. 5, 10, and 15 cm). Data indicated a highly significant response of intra-row spacing on the growth- and yield-determining parameters of onion. The wider intra-row spacing (10−15 cm) exhibited better results in most parameters, including plant height, the number of leaves plant-1, total plant leaf area, neck thickness, bulb diameter, bulb fresh weight, roots plant^{-1}, TSS, and marketable bulb yield. On the contrary, the lowest values of the majority of parameters except root length were recorded with narrow (5 cm) intra-row spacing. In conclusion, wider (15 cm) intra-row spacing is recommended for ensuring better plant growth and bulb yield.

Keywords: Plant spacing, growth, yield, onion.

Strengthening Horticulture Sector Economy through Production and Cultivation of Certified Fruit Plants of Registered Varieties

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Pakistan is one of the world's largest agriculture-based countries. In the last decade, the agricultural sector contributed about 12% to the GDP, and horticulture constituted about 5% of agriculture. In 2020-21, 14.8 million tons of fruits, vegetables, and condiments were produced on 1.5 million hectares of land. According to the FAO report, global horticulture exports reached 124 billion dollars. Pakistan marginally contributed with a worth of 0.24 billion dollars, with far less than 1% share in world export. To increase the quality production and export of horticultural produce, there is a need to select well-adapted, high productive and genetically certified fruit plant species for orchards developments in the country. To meet this aim, the Horticulture Section of Agriculture Research Institute (ARI), Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, has selected and registered four date palm varieties (viz. Dhakki, Gulistan, Shakri, and Mozawati), one mango variety (Panyala Langra) and one variety of seedless lemon (Singhar). At ARI, certified plants of these fruit varieties are produced under the supervision of skilled personnel for further provision to nursery owners. This paper presents the procedure of producing certified fruit plants for further multiplication.

Keywords: Horticulture, date palm, mango, acid lime, certified plants.

Effect of Transplanting Time on the Yield and Quality of Sugar Beet (*Beta vulgaris* L.)

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Transplanting is a strategy that is commonly used to establish crops from a fully germinated seedling and replant it in a permanent location for growing. A field study was conducted at Gomal University, Dera Ismail Khan, Pakistan, to determine the effect of transplants on various dates on the yield and quality of sugar beet (*Beta vulgaris* L.) cv. California-KWS. The experiment was laid out in RCBD with three replications. Desired seedlings were achieved by sowing sugar beet seeds under nursery conditions one month before experimental sowing dates. Seedlings were four weeks old (4-6 leaf stage) when transplanted to the main field corresponded with sowing dates, i.e., October 1, October 11, October 21, November 1, and November 11, respectively. The study indicated that transplanting was significant for almost all studied characters. Postponing transplanting date decreased root and sugar yields. Transplanting on October 11 produced a maximum number of leaves (44.73 and 43.60), leaf area (502.90 and 494.54 cm^2), leaf weight (485.44 and 485.50 g), root weight (1473.5 and 1473.4 g), sucrose (16.55 and 16.63%), TSS (18.47 and 18.44%), root yield (63.90 and 64.16 t ha^{-1}), and sugar yield (10.57 and 10.67 t ha^{-1}) during the two growing seasons (i.e., 2013-14 and 2014-15, respectively). Hence, it is conferred from the results that transplanting on October 11 performed well. However, nursery raising and labor costs may affect the transplanting mechanism. However, the removed plants may be used as gap filler during thinning of the directly seeded field to maintain the proper plant population.

Keywords: Transplanting dates, sugar beet, yield.

Impact of Salt Stress on Secondary Metabolites and Expression of Selected Genes in Pea

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The growth, development, and productivity of pea are greatly affected by salt stress. This research studied the response of three important pea varieties to salt stress at biochemical and molecular levels. Three different levels of salt stress (NaCl): 50 mM, 75 mM, and 100 mM were applied to these varieties of pea, namely Climax, Green grass, and Meteor, in a hydroponic system. A reduction in morphological traits was observed with increasing levels of salt stress. Green grass depicted a maximum reduction in plant height (9.03 ± 0.55 cm), while the variety Climax showed more plant height (13.67 ± 0.58 cm) on the 100 mM salt stress, while root length (5.40 ± 0.26 cm) was minimum in Green grass variety and maximum (7.37± 0.12) in Climax in response to 100 mM NaCl. Variations in total phenolics, flavonoids, and proline contents were statistically significant for the interaction effects. Total phenolics content was highest in the Green grass variety (1.5 ± 0.07 mg GA/100g FW) while minimum (1.05 ± 0.08) in variety Climax at 100 mM treatment, while elevated levels of total flavonoids and proline contents were found in Climax variety, *i.e.,* 0.20 ± 0.004 and 0.037 ± 0.001 respectively) at 100 mM treatment of NaCl. Proline content (0.021 ± 0.0004) in low amount was found in Climax at 0 mM NaCl. The expression level of *Glutathione reductase (GR, Glutathione S-transferase (GST,* and *Mitogen-activated protein kinase3* (*MapK3*) genes increased significantly under higher salt stress (100 mM NaCl) compared to control. This study concludes that NaCl severely affects the pea plant morphological parameters. The salt stress-responsive *GR*, *GST*, *and MapK3* genes also showed an up-regulation with increasing salt stress, which probably helps pea plants survive under such unfavorable environmental conditions by producing the underlying metabolites.

Keywords: Flavonoids, gene expression, pea, proline, salt stress.

Postharvest Application of Botanical Extracts to Improve the Storage Life & Quality of Kinnow

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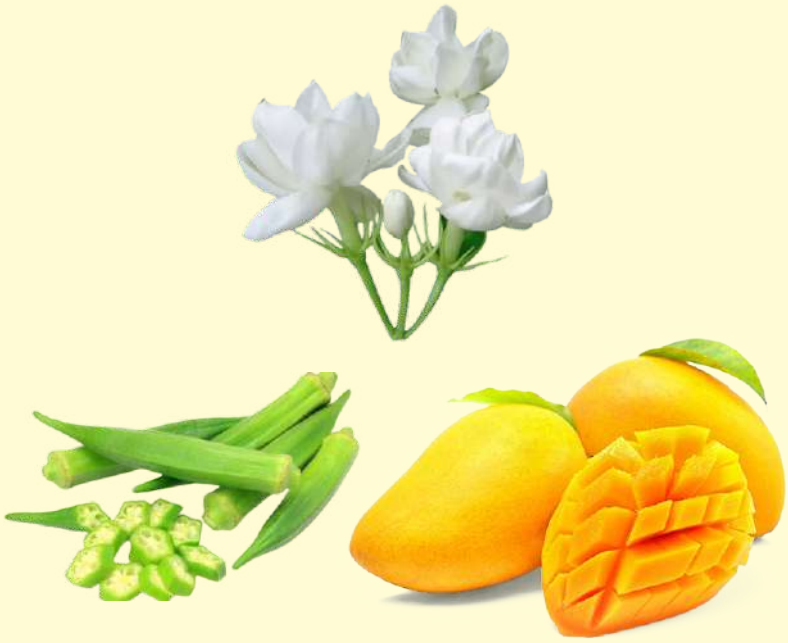
Citrus is one of Pakistan's most promising fruit crops, owing to its delicious taste and excellent aroma. Kinnow being a promising variety has significant importance in the global market. Pakistan is facing a drastic reduction in quality of kinnow mandarin due to improper postharvest management causing up to 40% losses. In this study, six oil coating doses were compared with commercial wax (fomesa wax). Results indicated that 30% coconut oil performed at par with commercial wax to extend storage life and maintain fruit quality parameters of kinnow fruit. Furthermore, 60% aloe vera showed similar results as a synthetic fungicide (TBZ) and controlled fruit decay up to (6.25%). The fruits of the same treatment also showed better biochemical characteristics relating to fruit quality after 90 days of storage. Lastly, we found that 30% coconut oil performed better than 60% aloe vera extract and synthetic fungicide. The fruits treated with 30% coconut oil showed minimum weight loss (11.70%), fruit rot (5.83%), maximum juice weight (42 g), biochemical parameters such as total soluble solids (10.90 °Brix), titratable acidity (1.09%), ascorbic acid contents (40 mg 100 g^{-1}**)**, total sugars (16%), maximum total antioxidants (70% inhibition) and maximum enzymatic activity [catalase (18.10 U mg^{-1} protein), peroxidase (0.79 U mg^{-1} protein) and superoxide dismutase (133.93 U mg-^{1} protein)] of kinnow mandarin fruits which were stored up to 90 days. It was concluded from the present study that pre-storage treatment of 30% coconut oil was found to be most effective in reducing decay losses and maintaining the fruit quality during 90 days of storage.

Keywords: Postharvest management, storage life, fruit quality, mandarin, kinnow.

Acknowledgments Due



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