Pir Mehr Ali Shah

# Arid Agriculture University Rawalpindi

# Pakistan

# ABSTRACTS

## International Horticulture Conference, Pakistan 2018

**25-27 APRIL 2018**

**Editors:** Nadeem Akhtar Abbasi, Touqeer Ahmad, Abdul Ahad Qureshi and Syed Zia ul Hasan

### Conference Venue

PMAS - Arid Agriculture University Rawalpindi
Shamsabad, Murree Road, Rawalpindi, Pakistan

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# International Horticulture Conference Pakistan

## 25-27 April, 2018

# Abstracts

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Touqeer Ahmad
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Syed Zia ul Hasan

**Department of Horticulture**
**PMAS-Arid AgricultureUniversity Rawalpindi -Pakistan**

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# Preface

It is my profound pleasure to welcome you to the ***International Horticulture Conference Pakistan 2018***. The depth and variability of the abstracts depict vitality of horticulture research and internationality of the conference. The organizing committee received 273 abstracts of which 200 abstracts were accepted based on relevancy and innovative excellence. A conference abstract book is a referable compilation of innovations and ideas. Therefore, the abstracts have been organized into nine sections covering various disciplines of horticultural science and technology, irrespective of the mode of presentation. Briefly, the Market Opportunity and Challenges section covers marketing prospects of national horticultural produce and marketing chain management. The Pre- and Postharvest Techniques covers innovative technologies to enhance the produce's shelf life and quality. The Processing Techniques and Value Addition highlights money addition techniques to horticultural produce harvested during peak production time and in fringe areas. The Insect and Disease section presents current research of integrated and environment friendly management of insects and diseases in orchards and gene engineering through molecular techniques for virus resistance in cropped fruits and vegetables. Variety Improvement and Propagation presents innovative research in somatic hybridization in citrus and a gene engineering for drought resistance. Production Technology section presents modern olive production package and soil plant nutrient level in apple orchards. The section on Dietetics and Pharmaceutical values highlights the value of fig, walnut and dates besides food allergies. The biotechnology section present molecular characterization and manipulation for horticultural crops improvement. Finally, the Nursery Certification section discusses issues with certified fruit plant especially the root stock selection criteria for table grapes.

I deeply appreciate the technical handling by Department of Horticulture with support from Department of Soil Science and SWC, Plant Breeding and Genetics, Food Technology, Entomology and Plant Pathology, PMAS-Arid Agriculture University Rawalpindi. I also extend my gratitude for a platform support by the Pakistan Society for Horticulture Sciences and financial cooperation by the Higher Education Commission of Pakistan, Punjab Agriculture Research Board, Pakistan Science Foundation and Punjab Higher Education Commission. I hope the abstract book would be a source of information for scientists, consultants, extension agents and growers with an interest in horticulture crop production and marketing.

**Prof. Dr. Nadeem Akhtar Abbasi**
Conference Convener

## Organizing Committee IHC PAK 2018

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- Mr. Usman Shoukat Qureshi, Lecturer Horticulture, PMAS-AAUR

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# Market Opportunities & Challenges for Horticultural Industry

**Trends in global floriculture: challenges and opportunities for Pakistan**

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The global cut flower industry is dominated by the Netherlands, although the flower export share of this country is declining. Developing countries like Colombia, Kenia, Ecuador and Ethiopia are rapidly strengthening their export position, supplying the USA and EU markets. The main point of entry for cut flowers in EU is the FloraHolland auction. The auction is a cooperative with 4500 members. This central market brings together supply and demand, has a transparent price setting and guarantees payment to producers. Trade is being executed through the auction clock, mediation or remote buying. Quality standards are set and checked for each product being offered to the auction. Quality and grading self-assessment, packaging and labelling are part of the product specifications at the auction. Roses are clearly leading the turnover list of imported products. One of the reasons is the relocation of Dutch rose producing entrepreneurs to developing countries. Other imported cut flowers are mainly niche products. The EU market structure shows a value chain from growers/exporters via the auction to traditional wholesalers, exporters, cash and carry, ending at specialized retail customers. Next to this channel the products find their way through supermarket suppliers to unspecialized retailers like DIY or gas stations. Shifting sales to these outlets has become a market trend. Retail margins make up about 45% of total price. The access to the EU market requires fulfilment of standard procedures. A phytosanitary certificate is needed to guarantee absence of quarantine pests or harmful pathogens. Plant Breeders Rights need to be respected, payment of license fees to originators of varieties is required. Cold chain management protocols should be respected. Corporate Social Responsibility, certified with fair trade labels, serves more and more as a prerequisite for retail sales. The external business environment for entrepreneurs in floriculture in the Netherlands is very favourable: economical, financial, geographic, social, legal, political, institutional, technological, market competitiveness elements classify positive. Utilities like water and energy, internet are highly reliable. The Pakistani floricultural production for the domestic

market has a narrow product basis, with limited resources and technology. The ambition is to develop a world class cut flower industry, which may be achieved if all required factors are critically considered and benefits of favourable climatic zones and cheaper manpower may be harvested

## Critical success factors and management practices for entrepreneurs in floriculture

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Small and medium size enterprises in floriculture many times are family owned businesses with low professionality and low organic growth. How to turn business into a successful and sustainable enterprise? Many businesses fail because of poor planning, lack of management skills, ineffective marketing, low operational sustainability without innovations and other reasons.

Have a plan**:** Business planning is a key for success. Set your long term goals, analyse your flower business environment internally and externally, develop a scenario and strategy, supported by financial perspectives. Create commitment and start realizing an action plan, aim at consistent management.

Become a manager**:** Management is situational according to size and type of enterprise. In all instances business functions like production, marketing, purchasing, public relations, human resources, administration and finance, are essential skills for successful managing flower businesses. Management is decision making aiming at controlling and anticipating to the ever changing business environment.

Improve operations**:** Implementation of innovation for production technology should be a continuous process. Improvement of facilities and equipment, aiming at efficiency increase, is necessary to remain profitable in a competitive environment. Product assortment and product quality are permanent subject to change. Sustainability of operations is essential for long term business success and acceptance in a changing market and social environment.

Be an entrepreneur**:** Being an entrepreneur is a balancing act between BRAINWORK (Vision, Planning, Evaluation, Learning capacity, Competence,

Leadership and Customer understanding) and FOOTWORK (Operations, Crop management, Resources and Staff). Too much footwork leads to inefficiencies, too much brainwork gives rise to lack of action.

## Current scenario of research of fruit crops in Bangladesh: challenges and opportunities

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Bangladesh economy is predominantly dependent on agriculture. So, the importance of horticulture in the national economy has been well justified. The Horticultural crops, particularly fruits, vegetables and spices are playing a vital role in crop diversification, human nutrition, economy, environment, with an ultimate goal of balanced diet, fight malnutrition, food self-sufficiency, biodiversity, environmental protection and poverty alleviation. In Bangladesh around 40 million peoples are suffering from micronutrient deficiency-the hidden hunger. Moreover, almost 70% peoples are below the poverty level. Our Government has paid much emphasis on rice but not on fruits, vegetable, spices and flowers production as our diet is rice based. Although there has been considerable success in variety development and technology generation in fruits and vegetables but their application are not adequate. Improved varieties of fruit like mango, guava, jackfruit, litchi, pineapple and banana are available in Bangladesh. The paper deals with mainly achievements, constraints and opportunities of horticultural crops (fruits) in Bangladesh for plantations and climate change. They are also contributing in nutrition and poverty alleviation of our land scarce, malnutrition affected and poor peoples. Bangladesh Agricultural University also established the largest fruit repository including a number of underutilized, tropical, subtropical, indigenous and temperate fruits here in Mymensingh. Contribution of the horticultural crops in the climate change, nutrition of poor people and to alleviate poverty in coastal (saline), hunger prone (monga) and flood affected areas also addressed. Plantation of underutilized fruit ber (Jujube) cv. BAU Kul 1 and in summer BAU dragon fruit tremendously

contributes in the poverty reduction and natural soil reclamation from saline to non-saline condition. Finally, the paper focuses on the future policy of the managements of horticultural crops in Bangladesh for economy, nutrition, food security, poverty alleviation and sustainable development. This paper also addresses the challenges and opportunities of fruit research and development in Bangladesh.

**Quality and safety issues for horticulture produce in Bangladesh**

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Fruits and vegetables are rich sources of vitamins, minerals, dietary fibers. Per capita consumption is still lower (212 g $day^{-1}$) than desirable amount (400 g $day^{-1}$).There exists food-phobia in the society. Consumption of fruits and vegetables has been dropped due to perceived health risks due to consumption of adulterated or unsafe foods. There are also reports of rejection of export consignments. Postharvest loss is substantial. Assurance of quality and safety is a challenge in the context of nutrition security, public health and export. Presence of chemical residues in food is a major food safety concern. Food Safety Act 2013 and establishment of BFSA are noticeable steps to deal with this deep-rooted problem. Consumption of safe fruits and vegetables and expansion of export can only be achieved if quality and safety controls are in place. Quality and safety issues in horticultural chains to be prioritized for domestic marketing and export. Postharvest losses substantial. The present paper deals with the safe horticultural production and policy.

**BAU germplasm center (GPC) fruit tree improvement program (FTIP)-a one stop service for fruit development, conservation, biodiversity, production, extension and research**

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Fruit tree improvement project (FTIP) - The largest depository/germplasm centre of fruits, medicinal plants and agro forestry in Bangladesh. Initially the project was established on 1 acre of land in 1991 funded by Swiss Agency for Development and Cooperation (SDC) whose mission was established of a seed bank and extension of technologies among the farmers. Over the past 26 years FTIP has developed a vast array of improved and conserve resources and science based appropriate technology for fruit tree propagation and managements. Currently it has been occupied 32 acres of land with the objectives i) to maintain the germplasm centre (GPC) as a facility for education, research and training ii) to conserve the germplasm resources ( fruit tree, medicinal plants and associated agroforestry sp. iii) To supply quality planting materials to various organization (DAE, BRAC, Proshika, World Vision Bangladesh, BADC, etc.). FTIP is possesses by 300 varieties of mango, 55 varieties of guava, 25 varieties of litchi, 48 varieties of citrus, 94 accession of Jackfruit, 67 species of minor fruits,18 species of exotic fruits collected from 52 countries including 97 species of medicinal plants. FTIP has been released total varieties of fruits. Recent achievement at FTIP developed 'BAU KUL (*Ziziphus mauritiana*)' which has been made a great demand all over the country. Another achievement polyembrayonic sapling of mango by which we can get easily authentic quality planting material (QPM) without vegetative propagation. Different systematic approach like sapling distribution, exchange visit, motivational tour, and demonstrations was performed for implementation of the project. In total 250 MS and 41 Ph.D. students has completed their courses and presently 20 PhD and 50 MS students are doing research here form different discipline. FTIP helps to education, research, propagation and disseminating improved germplasm and other technologies country wide through extension GOs, NGOs and private

sectors that will help the farmers to improve their economic condition as well as whole country. International organizations may exchange germplasm of fruits from this program.

## Conservation of underutilized fruits of medicinal value in Bangladesh Agricultural University Botanical Garden

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Underutilized fruits can contribute significantly to the nutritional requirement of the rural population. Most tribals depend on wild fruit bearing plants for food, medicine and medicinal supplement. But wild edible plants are facing threats in their natural habitats from various human activities like clearing of forested areas to set up farmlands. There is a urgent need for its conservation for future generation. Bangladesh Agricultural University botanical garden is rich in diversity of medicinal plants. In the present study some of the underutilized fruits tree species of medicinal value belonging to the different families are dealt with. A total of 58 plant species belonging to 24 families were reported from the BAU botanical garden. Rutaceae was the dominant botanical family with 7 taxa, whilst Moraceae was the 2nd dominant family with 6 taxa. Myrtaceae and Euphorbiaceae are represented by 5 and 4 members respectively. The four major reported life forms were shrubs, trees, herbs and climbers. Herbs make up the highest proportion of the edible species followed by tree, shrubs and climbers. All these species need to be conserved and propagated to save them from extinction in the near future. This study also contributes to the database of the plants of the country.

## Current status and issues of mango export and their possible solutions

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Mango is a highly cherished tropical fruit, full of health goodies for all ages. Pakistan is known for producing high quality yellow skinned cultivars, popular in both domestic and export markets. Current mangoes exports are around 45 million dollars, to over 40 countries, which can be increased to 65-70 million dollars. Developments in on-farm infrastructure, and capacity building of stakeholders through various international (Australia, USA, EU/UNIDO) and locally funded (Punjab Government) projects, have set the industry pace for export. However,

there are still challenges to industry including quality production, market reforms, export developments and value addition, which can be addressed through appropriate policy measures and technical and financial interventions.

## Prospects and challenges of Pakistan horticulture industry

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The population of Pakistan is increasing at increasing rate; however, various issues related to human health and nutrition exist. About 44% of Pakistan's population is facing acute malnutrition with special reference to essential micronutrients (40-80%) like iron, calcium, vitamin-A etc. The horticultural commodities can help in mitigating these issues. According to an estimate, per capita consumption of fruits and vegetables is about 6-10 times lesser as compared to the developed countries. So, there exists significant opportunity in the agriculture crop sector to shift its production focus from conventional crops to nutritive crops like fruits and vegetables. The presence of highly diversified agro-ecological zones in Pakistan, favors the production of variety of fruits and vegetables across the country. However, several challenges exist in the horticultural production and supply chains. The factors such as high cost of production, variability in market practices, lack of storage and value addition facilities, high import and export duties, and reduced international price due to poor quality make it difficult for local growers to compete with international market standards, which are primarily responsible for poverty in rural areas. The irrational use of agro-based chemicals (fertilizers, fungicides and pesticides), inappropriate dumping of city waste, irrigation with sewerage and industrial water to fruits and vegetable is continuously polluting the horticultural production system and environment. Stable supply of fruits and vegetables in the country can be ensured through quality production of these commodities and their trade. Sustainability in horticulture sector can be achieved through better breeding/genetics, bio-technology, crop modeling, climate smart and resilient crops, and capacity building of human resources. Collaborative efforts among

academia, research, extension as well as the federal and provincial research system will help to undertake strategic research. Horticulture is an important sector having significant contribution to the national GDP. Various developments have occurred in horticulture sector of the country since its birth. This manuscript provides a detailed account of the horticultural development in Pakistan over the last seven decades.

## Channelizing onions and tomatoes of Baluchistan to overcome shortage in Punjab and Sindh markets

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Nature has blessed this country with a diversified climate where almost all types of vegetables, fruits and crops can be grown. Due to various ecological zones of the country where the harvesting of onion and tomatoes ends in the plains the sowing of the same vegetables starts in the uplands of Baluchistan. The crops are ready for markets of Punjab and Sind when there is shortage especially during the months of July and August. According to one report, during the years 2014 to 2017 in the months of July and August, total import of tomato mostly from India through Waga border was 978 thousand tons worth 43,788 million rupees and the quantity of onion imported was 300 thousand tons valuing 5,748 million rupees. The growers of Baluchistan suffered heavy losses during these years. The total area under tomato in Baluchistan is 12,600 hectares with a production of 140,000 tons whereas the onions are grown on an area of 28, 200 hectares with a total production of 531,000 tons according to Agriculture Statistics 2016-17 of the Federal Government. The Government has realized the gravity of situation and during market survey of Lahore and Rawalpindi and discussion with the commission agents, growers and Market Committee members, the situation has been considerably improved and for the last two years. The import of onions and tomatoes from India has been banned and the demand in the main markets of the plains is fulfilled by the Province of Baluchistan. Consequently the growers of Baluchistan got good price of their produce during last year. As such area under

these two crops is increasing rapidly. It is anticipated that the Government will continue the ban on import of these two crops thus safeguarding the interest of growers and saving the foreign exchange of the country.

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The province of Balochistan is the largest province of Pakistan with 347,190 sq km of area. Balochistan is bordering with Afghanistan and Iran and in the West having the Arabian Sea heading with the hammer of Gawadar. The blessings of five different ecological zones enable the province to produce variety of fruits which made it the forerunner in fruit production. Being less precipitation recipient; high delta crops production (apples, apricots, plums, cherries and vegetables) become prone to less yield and quality. To mitigate the harshness of drought and climate change it is imperative to promote the minor crops. The olives, figs, pistachios, mulberries and saffron are the best suited low delta minor crops of the area. But these crops have been neglected due to less know how of their nutritive value or cultivation technology. Some of these crops are grown by traditional farmers or found wild in mountainous areas. These are quite important from food security and nutritional point of view and also for livelihoods of drought hit farming community. On other hand these crops remain ineffectively characterised, preserved and neglected by research and development institutes of the country as well. Another aspect i.e., postharvest losses of some of these minor fruits is also very high which needs to be addressed. But still some of them pose great importance for manufacture and medicinal industry. Thus, it is necessary to initiate competitive agribusiness in producing areas of these minor fruits for enhancement of socio-economic condition of farmers. This review summarises the nutritional and economical importance of minor crops grown in temperate regions of Balochistan, the cultivation technology and future production prospects of these crops and their respective products to the markets of Pakistan and exports.

**Post-harvest management of fruits-approaching towards food security**

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An efficient harvesting, packaging, transportation, cold storage, marketing and supply chain system of fruits is imperative for sustainable food security that has significant impacts on both producers' income and consumer' benefit. The prevailing embryonic post-harvest practices in Baluchistan cause loss of sizeable quantity of fruits. In order to assess the extent of post-harvest fruit losses and supply chain management, a study was conducted in 2017 in five districts of the apple growing areas of Baluchistan using questionnaire approach. Three hundred apple growers were randomly interviewed and data were statistically analyzed. Results revealed that 62.8 % growers harvest apple on the basis of color, while 11.0%  9.3% growers harvest keeping in view number of dropping fruit and taste, respectively. Of the total, 34.6% growers were practicing traditional harvesting cloth pouch; whereas, 28.2% used ladders for harvesting. For pre cooling, 43.0% growers used to put produce under cloth shed, 34.0 % under the tree shed while 21.3% were using proper shed house. During packaging, 65% growers were using wooden boxes while 35% were practicing corrugated cartons. Most of apple growers (73%) kept their produce at room temperature however the rest of growers (27%) used proper cold stores. Of the total, 67.3% growers sell out their produce directly in the open market while 15.0% and 17.7% growers used to sell out through middle man and contractors, respectively. Our studies reveal that a significant gap exist between technology adaption and practices being carried out by apple growers of Baluchistan, which can be decreased by adopting multifaceted interventions such as capacity building, innovative post-harvest practices, proper cold storage & transportations facilities and efficient marketing system.

**SWOT analysis of pomegranate industry in South Punjab, Pakistan**

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Pakistan has been blessed with immense agro-climatic conditions that favor the fabrication of a variety of Horticultural crops including various fruits. Fruits are cultivated over an area of 0.77 million hectares with an annual production of 6.75 million tonnes. Pomegranate (*Punica granatum* L.*)* is a high value fruit crop having significant nutritional and medicinal ingredients. Apart from the table consumption of pomegranate arils, the fruit rind and vegetative parts of pomegranate tree are also good source of secondary metabolites such as tannins, dyes, alkaloids, protein, carbohydrates, vitamins, minerals, dietary fiber, bioactive compounds and phyto-chemicals as compared to other fruits. In Pakistan, pomegranate is considered as a minor fruit due to its limited production. Tehsil Alipur remained major pomegranate producing area with best quality in South Punjab. Several issues have been faced by pomegranate growers including improper cultural and management practices, shortage of knowledge about pre and postharvest losses, lack of pruning practices, sunscald, fruit cracking, insect, pest and diseases. Besides, limited indigenous R&D based knowledge is available for crop improvement through good cultural practices, best rootstock and scion interaction, improved nutritional management plan, fruit bagging and effect of various plant growth regulators (PGRs). It has been observed that these factors are responsible for improving the fruit physiological and biochemical quality characters, development, growth and thereby, yield. Therefore, there is a dire need of time to evaluate various rehearses like cultural practices, best cultivar, improved nutritional management plan, fruit bagging, antibiotics evaluation against bacterial blight and effect of various PGRs for revival of pomegranate production in South Punjab.

## Analyzing performance of fruit sector of Pakistan

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Fruits and vegetable sector is an important component of global food supply and demand. Performance of the sector is analyzed through growth and stability in production, productivity and prices in the present study. Data set of the study comprised of fifty seven years ranging from 1960 to 2016. Data was collected from various secondary sources of Government of Pakistan. Annual growth rate was measured in these variables with semi-log model. Instability in all variables was analysed using coefficient of variation with no time trend and Cuddy Della Valle Index with time trend following Ramdas 2012. The data was distributed in decades to analyse the performance of various fruits in different years and to highlight the effects of various policies during respective decade. Results indicated production of citrus was growing at 4.31 percent per annum from 1960 to 2016. The instability index of citrus was found to be 14.99 percent. High risk fruit crops include apple, apricot and guava with coefficient of variation 92, 89 and 66 percent respectively. Relatively low risk fruit crops include almond, banana, grapes citrus and mango with cv of 33, 43, 51, 51 and 53 percent respectively. Further analysis will be helpful for planning in the development of fruit sector in Pakistan

## A well-suited supply chain management system for the success of horticultural industry

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Pakistan is one of those countries, which cover a large area of climatic and ecological benefit. Thus, having a high potential toward the production of majority of the food types and commodities. In order to make the availability of best quality products for consumers, it is highly important to organize and classify

every factor involved in the chain. The factors include, production, packing, storage, transport, distribution and effective marketing. The organizations who learn the basics of supply chain optimization and logistic process are successful in attaining loyalty, high customer satisfaction, low costs and improved market value with high profits. In this case study of emerging supply chain management in Pakistan, different principles are taken into account for the fresh fruit and vegetable industry, which is composed of a number of small growers available in different locations with variety of products and quality. The study demonstrates consumer response to product quality that help stake holders to understand and increase the management quality of the whole chain. The fruit and vegetable industries should always acquire a supply chain principle to enhance consumer satisfaction and high market value. The process must move in a flow of having different sessions, questionnaire and information from the consumers regarding every fruit and vegetable and then implement a well-suited supply chain management system to it.

**Issues and challenges in the supply chain of fruits and vegetables sector in Pakistan: A comprehensive review**

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Pakistan is big exporter of fruits and vegetables throughout the world, but the entire supply chain of fruits and vegetables is falling with various issues and challenges. It is a major business problem in the agricultural sector in Pakistan. The production of fruits and vegetables crop help farmers in creating service and improving their revenue. There is a dire need to overcome issues and challenges in the supply chain by adopting post-harvest techniques. In Pakistan, around 30-40 % of total production gets waste at different levels of the supply chain that leads to increased additional costs in supply chain which finally compel the consumers to pay high charges from his pocket. Harvesting, transportation, intermediaries, infrastructure, information regarded to post harvest techniques, knowledge of farmer's, storage and handling are the major factors that lead to losses in supply chain. Such kind of factors can be handled by giving a proper

handling after harvesting and during transportation. To cure the fruits and vegetables, we preserve them by using different techniques like drying, dehydration, blanching and pickling.

# Nursery Certification System for Horticultural Crops

## Rootstock selection criteria for table grapes

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The introduction of phylloxera from the United States of America to Europe in the 19th century decimated the grape industry of Europe as roots of *Vitis vinifera* do not have resistance to this root louse. This catastrophe initiated the breeding/development of phylloxera resistant rootstocks from American Vitis-species like *Vitis rupestris*, *Vitis Berlandieri*, *Vitis riparia* and *Vitis champinii*. Most commercial rootstocks used in the world today originate from these. It was soon discovered though that phylloxera resistance was not the only criteria to which rootstocks must comply. Other factors like resistance to lime, soil salinity, soil wetness and drought became important factors for rootstock choice. The introduction of irrigation resulted in grapevines being established on more marginal soil types which further put pressure on rootstock choice. Intensive irrigation also brought nematodes that attack feeder roots. Growers spend huge sums of money on soil preparation and trellis- and irrigation systems to establish a vineyard. This investment needs to be supported by a rootstock that can provide the necessary vigour for sustainable economic production. Commercial rootstocks in use today include Ramsey, Richter 110, Paulsen 1103, Ruggeri 140, Freedom, Harmony.

## Benefits of using high quality grapevine plant material

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*Vitis vinifera* originated in the desert-like environment of Central Asia from where it spread to other parts of the world. A deep penetrating and well branched root system enables it to resist adverse environmental conditions, making it a highly resilient plant. The introduction of phylloxera to Europe in the 19th century resulted in the destruction of the grape industry, initiating the breeding of phylloxera resistant rootstocks from mostly non-*Vitis vinifera* parentage (*Vitis*

*rupestris*, *Vitis berlandieri* and *Vitis riparia*, being the most important). The grafting of different Vitis-species onto each other resulted in the transfer of various graft transmissible diseases from one species to the next, with different symptomatic expression. Grapevine can be a symptomless carrier of various viruses, phytoplasmas, bacteria and fungi, but when grafted onto another Vitis-species can result in deterioration of vine performance with catastrophic results. Modern viticulture is a highly competitive industry with huge financial investment. Grapevine is a long term crop that requires at least 20-25 years of productive life to make economical sense. It therefore needs to comply with high phytosanitary standards as stipulated in Certification Schemes in countries like France, Italy, USA, Australia and South Africa. Certification of plant material is of the utmost importance for the sustainability of any grape industry.

## Production of certified fruit plants in Khyber Pakhtunkhwa

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Pakistan is a country of small farming households, where horticulture is the best option for enhancing the income of the under privileged. Historically, the growth rate for horticultural crops has been impressive. In Pakistan, the citrus industry has expanded more than 20 folds during past 40 years. The potato production has doubled during past 10 years. The mango acreage has also increased manifolds. Similar is the case with other fruit and vegetables/ ornamentals. According to recent statistical data, the area and production of fruit crops in Pakistan is about 764 thousands hectares and 7018 thousands tones, while that of Khyber Pakhtunkhwa (KP) is about 47 thousand hectares and 522 thousands tones. Being a third largest sector in KP after minerals and hydro power, horticulture has the potential to expand and generate more revenue to the farmers and ultimately to the province. Although, almost all regions of KP are ideal for growing different kinds of fruit plants, yet less area is under cultivation. The main constraint in growing quality fruit plants is the non-availability of improved, true to type; market oriented and registered fruit plants. Due to market pressure and dependency on farming, the rural communities had to concentrate on fruit culture.

This has resulted in the increased demand for quality fruit plant nurseries. The fruit nursery sector has been badly affected by private nursery holders and sale agents, who sell poor quality, non-registered fruit plants and seed materials. But due to very limited number of germplasm availability, no sanctions could be imposed on private nursery holders until the Govt. institution ensures the availability of quality type bud wood and seed to these nurseries. Healthy and true to type plants, bud wood/ graft wood not only provide the base for successful and productive orchards, but also develop and strengthen the fruit industry. Such activities need to be strengthening at the research stations/universities to maintain/improve the thorough supply of quality fruit plant nurseries to the growers. Currently there are about 350 fruit nurseries in KP, out of which more than 50 are registered with federal seed certification & registration department (FSRD). The nursery registration policy has recently been approved in 2016. FSRD have four germplasm units in PK at DI- Khan, Abbottabad, Sherkhani and Swat. These germplasm units will provide bud wood/planting materials to the registered nurseries, which will produce certified plants. Production of certified fruit plants will strengthen and stimulate the fruit plant nursery production, for provision to farming community in short term, while improve human nutrition and reduce poverty in the province through multiplication and utilization of indigenous and exotic germ plasm of sub-tropical and temperate fruits in long term. It will not only sensitize the farmers to establish new orchards with fruit plants of known source and origin, but will also motivate new farmers to start nursery / seed production business on scientific grounds, for enhancing their income and conserve food security in the country. It will further ensure more participation from private sector in agri-business, which will ultimately enhance the foreign exchange through the quality fruit production by establishing orchards of the improved fruit cultivars.

## Potential of healthy seed potato production in Gilgit Baltistan

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Improved imported varieties of seed potato were tested under the climatic conditions of Gilgit Baltistan in various valleys to evaluate for yield. The varieties were tested in Yaseen (Ghizar) Babusar (Diamer) and Naltar (Gilgit) during the month of June, 2017. The data on Germination%, Plant height, No of stems/plant, No of tubers/plant weight of tubers/plant, weight of tubers/plot and yield T/ha were recorded. The variety Bartina, Lady Rosita, Roko and Karoda showed the highest germination (100%) at Yaseen followed by Melanto, Astrex and Santé (99%) at Phundar, while variety Astrex and Zena Red showed (90%) at Babusar. The highest plant height was observed in variety Pameela (100 cm) followed by Roko (78 cm) at Yaseen. The maximum no of stems /plant was observed in variety Roko (70) followed by Bartina at research station Babusar and the minimum no of stems in variety Roko (3) were recorded at Phandur. The highest no of tubers per/plant was recorded in variety Melanto (12.8) followed by Lady Rosita (12.6) at Yaseen. The minimum no of tubers/plant were observed in Variety Bartina (6.6) and Astrex (7.7) at Naltar. There was a great significance among the varieties on yield. The variety Roko and Melanto showed the highest yield mt/hectare (30.9) and 30.70 at Naltar and Yaseen respectively, while variety Santé and Zena Red showed minimum yield (12.0) and (8.9) mt/hec at Yaseen respectively.

# Propagation, Varietal Improvement, Selection & Conservation of Horticultural Crops

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Polyploids produced via cell engineering are valuable germplasm resources for citrus cultivar improvement. In our program, somatic hybrids were produced from over 50 fusion combinations which are either interspecific or intergeneric, and characterized by molecular markers. Some of the somatic hybrids have already served as pollen parents for interploidy sexual crossing. Thousands of triploid plants were then recovered via embryo rescue, flow cytometry and SSR marker analysis. We also put forward a strategy for producing male sterile cybrids by symmetrically fusing the protoplasts of embryogenic callus induced from Satsuma mandarin (CMS type with sterile cytoplasm) with mesophyll protoplasts of elite seedy cultivars. As a result, the regenerated diploids which proved to be cybrids contain sterile cytoplasm from Satsuma. To date, some cybrids have already displayed male sterility and seedlessness. By Omics-based studies, the profiles of genes, proteins and microRNAs in a male sterile cybrid were uncovered, and the genes potentially responsible for the male sterility are under further investigation. We also identified plenty of doubled diploids, haploids and dihaploids which were exploited spontaneously or regenerated via anther culture. These novel citrus germplasm resources hold great potential for citrus seedless scion breeding and rootstock improvement.

## Date palm germplasm of Sindh and its propagation through conventional and non-conventional methods

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Date palm (*Phoenix dactylifera* L.) pertains to the genus *Phoenix* which is scattered throughout the tropical and subtropical areas of South Asia and Africa. Pakistan is blessed with multi-climatic environmental conditions and date palm is also flourishing well in different parts of the country. Hence, date palm is grown

in all four provinces. Every province has its own varieties. There are about 300 varieties grown in Sindh which makes Sindh a biodiversity center. The commercial varieties of Sindh are Aseel, Karbalain, Fasli, Kupro, Otakin, Kashoowari, Khar, Gajjar, Dedhi, Kurh etc. The varieties of Balochistan are Muzawati, Begum Jangi, Jaan Swore and Rabai; KP has Dhakki and Gulistan. Date Palm being dioecious crop is conventionally propagated through its offshoots. Propagation via offshoots is a slow and laborious task because only a limited number of offshoots is produced by date palm tree during its whole life. Commercial scale production of superior cultivars of date palm is therefore on the decline due to slow asexual propagation, which is the only mean of propagation. Prompt clonal propagation of date palm on the large scale is a pre-requisite for commercial production. The date palm is the "tree of life" and is just one of many examples of a tree crop that can benefit shortly from utilization of contemporary Biotechnologies of plant tissue culture and plant molecular biology. Slow growth, dioecious nature, slow and limited offshoot-based propagation system and the impossibilities of forecasting adult characteristics of the seedlings have severely cramped the advancement of this ancient tree crop. Modern scientific research has been carried out on micropropagation of date palm. Date Palm Research Institute (DPRI) at Shah Abdul Latif University, Khairpur Sindh is the contributor in date palm plants production through tissue culture. Different local and exotic cultivars of date palm have been propagated through tissue culture technique and this is the first successful trial throughout the country in the advancement of micropropagation of date palm industry. Tissue culture technology is broadly used as a biological tool for clonal propagation, disease elimination and mass propagation of several horticulture crops including date palm. This is decisive to a rational and successful employment of date palm genetic resources.

## Citrus breeding: conventional and biotechnological interventions

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Citrus is one of the world's important fruit crops and is facing several biotic (insect pest and diseases) and abiotic stresses (salinity, cold or heat tolerance etc.).

Citrus breeding is based on either conventional methods (selection, hybridization, induced mutations) or biotechnology including the *in vitro* methods of regeneration from protoplasts, somatic hybridization, mutant selection, genetic transformation and haploid production by anther cultures. Several potential and commercial citrus cultivars have been released through conventional breeding methods but the development of new and improved citrus cultivars by conventional methods is slow and costly. It takes 20-30 years to release a new cultivar from the time of making the cross as it took 20 years in case of Kinnow. Besides this several serious obstacles exists that hamper citrus hybridization like reproductive factors, generation time and genetic factors. Basic knowledge in plant genetics and biotechnology has opened the door to new concepts and methodologies, which have greatly advanced the abilities of the citrus breeders. Plant tissue culture and molecular tools are successfully being used in citrus improvement programs and resulted many trait specific new citrus scion and rootstocks.

## *In vitro* evaluation of transgenic Olive (Olea europaea L.) plants with tobacco osmotin gene for drought stress tolerance

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Olive is the most important fruit crops in the Mediterranean basin providing 95% of the whole world production. Olive is one of the tree crops that possesses capability to grow and produce adequate yields under limited water availability. In this study, the drought tolerance of an olive cultivar Canino was compared with its derived transgenic line expressing osmotin gene from tobacco, obtained by Agrobacterium-mediated transformation of Canino cultivar. Shoot cultures of both wild-type (*wt*) and transgenic lines were exposed to drought stress induced by polyethylene glycol 8000 (PEG) at different concentrations (0, 1, 2, and 4%). After four weeks the differential responses to *in vitro* induced drought stress were investigated. Most of the shoots of *wt* plants were damaged by exposure to PEG and demonstrated decreased levels of chlorophyll content, while on the other hand

the transgenic lines did not show injuries and exhibited a normal growth even when exposed to the highest concentration (4 %) of PEG. After preliminary evaluation the transgenic Canino AT17-1 was evaluated by measuring several physiological parameters, including the antioxidant enzymes (POD and CAT) activities, and malondialdehyde (MDA) content. As compared to *wt* plants both the enzymes activity and the proline content were found higher in the leaves of the transgenic shoots. Consequently, it was also observed that the MDA content was accumulated in less quantity in transgenic line which depicted that the presence of the osmotin gene protected the cell membrane from damage by lipid peroxidation. This experiment suggested that the transgenic line Canino AT17-1 was more efficient in the activation of defence responses against oxidative stress with respect to the Canino *wt*. Furthermore, the transgenic shoots also showed higher proline accumulation that support the hypothesis that the osmotin gene conferred transgenic shoots with increased tolerance to drought stress as compared to the *wt*.

## Differential responses of potato cultivars against *in vitro* drought inducing agents in relation to morphological changes, antioxidants, oxidative stress damage and osmolyte accumulation

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Potato (*Solanum tuberosum* L.) is suffering from various biotic an abiotic stresses among which drought stress is the most detrimental for its growth. Therefore to increase its productivity, there is a need to introduce potato cultivars with desirable characteristics which can perform efficiently under low water availability. Taking in to consideration the crucial and time taking procedure of breeding, *in vitro* screening of potato germplasm is recommended as feasible and cost effective technique under control conditions with limited time and space. Therefore the research study was designed to compare the morphological, physiological and biochemical behavior of potato cultivars under PEG 6000 (12, 14 and 16 %), sorbitol and mannitol (0.1, 0.2 and 0.3 M) generated *in vitro* water

stress. Results suggested that, cultivar Kashito, Sante and Lady Rossetta produced comparatively longer shoots and roots with maximum fresh and dry weight at higher water stress. Moreover they showed promising behavior in relation to relative water contents, growth rate and membrane stability index. These cultivars also triggered more strong defensive system against drought by accumulation of osmolyte (Proline), antioxidants (CAT, SOD, POD), resisting the peroxidation of lipids (MDA) and maintaining chlorophyll contents which might be due to alteration in the expression level of stress genes. These morphological, physiological and biochemical attributes were severely affected in cultivar Hermes and Kuroda whereas Yulbo and Astrix were moderately affected under higher stress. On the basis of results, it could be concluded that cultivar Lady Rossetta, Sante and Kashito are relatively drought tolerant cultivars, Yulbo and Astrix are moderately tolerant whereas, Hermes and Kuroda are drought susceptible cultivars. Relatively drought tolerant cultivars incorporated with biotechnological tools such as gene interogession and interspecific hybridization could provide a new opportunity to improve stress tolerance in potato.

**Potential of mutation breeding in guava crop improvement**

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Guava (*Psidium guajava* L.) popularity is rising in growers as a highly economical fruit crop due to its early and regular bearing nature, extended harvesting span and possibility of meadow orcharding. Breeding objectives include development of soft seeds or seedlessness, better tolerance to biotic and abiotic stress including tolerance against wilt disease, drought tolerance and better shelf life. Mutation breeding have been very useful tool in inducing variation and development of novel traits in different fruit crops including guava. Seeds of selected elite strains in ‘Pyriform’ and ‘Round’ shaped guava cultivars were gamma irradiated and sown in soil media under greenhouse conditions to develop mutant population for further selection and characterization. Seed germination and survival percentage was significantly reduced at higher doses of gamma rays (250-300 Gy) compared with untreated control. Survived young seedlings showed

reduced internodal distance (4.53 mm) and plant height (4.83 cm) at higher levels of irradiation. Leaf size was also markedly reduced with rising levels of irradiation. Further evaluation of the seedling population for phenotypic and biochemical variation is in progress. Such studies shall help developing heterozygous population with novel traits for future biotechnology applications for crop improvement.

In Pakistan grapefruit production is negligible and mainly ‘Foster’ and ‘Shamber’ seedy and seedless pink fleshed bud sports, respectively, have been cultivated which need varietal diversification. Annual grapefruit production is less than 0.5% of the total citrus production. In grapefruit flesh color enhancement, seedlessness and low furanocoumarin level has been the main objectives of breeders. Mutation breeding has played a significant role in grapefruit crop improvement and most of the commercial cultivars are either spontaneous or induced mutants which were selected and later released as a new variety. Leading grapefruit varieties have been introduced since decades, however, no significant characterization and yield data under local environmental conditions has been reported. There is need to exploit potential of the available genetic resource for identification of the parental candidates for future hybridization programs. In grapefruit mutation breeding project, the available grapefruit varieties have been collected, characterized for their morpho-physiological diversity and leading cultivars having desired traits have been identified. Several putative mutants have been developed using gamma irradiated seeds and bud wood grafts on Rough lemon rootstock. The effect of irradiation on plant morphology and biochemical properties is being evaluated. Salient findings of the research venture are discussed. The developed genetically diverse material could be useful for future biotechnology applications.

## Response of diploid and autotetraploid volkameriana lemon rootstocks under salt stress conditions

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Citrus trees are affected by different abiotic stresses such as salinity which decrease its growth and productivity worldwide. Citrus germplasm is mainly diploid (2n = 2x = 18). However, natural tetraploid lines can be selected in nucellar seedlings of apomictic genotypes. Polyploid plants are reported to have strong tolerance against environmental stresses. In the present study, diploid (2x) and autotetraploid (4x) Volkameriana lemon (*Citrus volkameriana* Tan. and Pasq.) citrus rootstocks were subjected to 0, 75 and 150 mM of NaCl stress. Leaves of diploid Volkameriana had the minimum leaf greenness (SPAD values), net photosynthetic rate (Pn), transpiration rate (E) and stomatal conductance (gs) at 150 mM of NaCl stress. Autotetraploid Volkameriana plants subjected to 150 mM of salt stress exhibited more enzymatic antioxidant activities i.e. superoxide dismutase (SOD), peroxidase (POD), catalyse (CAT), and osmoprotectants i.e. proline (PRO) and glycine betaine (GB) in their leaves as compared to diploid ones. However, hydrogen peroxide ($H_2O_2$) and lipid peroxidation (MDA) were observed the maximum in diploid plants than its corresponding autotetraploids at 150 mMNaCl stress. Total soluble proteins (TSP) were the maximum in leaves of autotetraploids at 150 mM and the minimum at 75 mMNaCl stresses in diploid plants. The results indicated that, diploid and autotetraploid volkameriana are different in their defence mechanism. Autotetraploids are more tolerant than its corresponding diploid rootstock, because autotetraploid plants exhibit more antioxidant enzymatic activities (SOD, POD, and CAT) and osmoprotectants (PRO and GB) as compared to diploid ones, which help them to tolerate against reactive oxygen species (ROS) produced under salt stress.

## Karyological studies of indigenous date palm cultivars of Sindh, Pakistan

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Date palm (*Phoenix dactylifera* L.) is a monocot and dioecious plant species having uncertain diploidy levels because of scarcity of cytogenetic knowledge. Hence, the date palm cytogenetic work was taken in hand which investigates the chromosome number and karyotype of local commercial date palm cultivars of Sindh province of Pakistan. Also, the study includes two wild Date palm varieties. The chromosome number of all the studied cultivars has been determined as 2n=36. The detailed karyotypes of given Date palm cultivars are presented for the first time which includes total chromosome length, short and long arm length, the relative length of each chromosome and centromeric index. The chromosome complement consists of metacentric, sub metacentric and telocentric chromosomes and average length of chromosomes varies in all cultivars which is ranging from 1.2 μm to 6.46 μm. It is believed that these karyological data will enhance the karyological knowledge of date palm and will prove to be an important source of information for new researches relating to the origin of this plant.

## Assessment of growth, yield and quality of newly introduced exotic apple varieties under high density plantation in Kashmir

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Jammu and Kashmir State being endowed with natural advantages of topography and climate with enormous diversity of agro-climatic conditions has immense scope for horticultural development. Horticulture industry in the state made rapid strides during the last few decades. Compared to 1954-55, the area under fruits in

the state increased by 16 times and the production has shoot up to 60 times. Among the temperate fruits, apple ranks first covering 43.30 per cent area and 80.18 per cent production. Yield of apple has shown an increase from 4.12 to 10.06 MT/ha (1975-2017). Though it appears to be highest among the apple producing states in the country, yet it is far below the level achieved by advanced countries where productivity is of 50-60 MT/ha.So to solve the problems of low productivity, poor quality, less colour and irregular bearing habits in current apple plantations in Kashmir valley, four apple varieties namely Super Chief Sandidge, Gala Red Lum, Fuji Zehn Aztec and Golden Clone B were imported from Italy on M9T337 rootstock and planted in spring 2013 at a distance of 1.5× 3m on four wire trellis system (2222trees/ha). The varieties were studied for their various morphological and quality attributes. The variety Super Chief Sandidge performed best in terms of quality parameters while as variety Golden Clone B recorded highest yield (10MT/Ha) and yield efficiency (1.42kg/cm$^2$). The overall results indicate that the introduced apple varieties on a dwarfing rootstock are characterised with different biological and quality characteristics. Most of the studied varieties show positive characteristics and can be recommended for further evaluation in Kashmir valley.

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Plants are a non-renewable biological resource and we are losing valuable plants at an accelerated speed due to certain anthropogenic and environmental pressures. Several important medicinal wild plants are at the verge of extinction. This decrease in endemic plants species will affect many rural communities because the poor families collect these plants for use in different ways. Many native plants are collected to sell in the market as these plants are considered as wild fruit, medicinal or as vegetables. Thus a large number of household economies are partially dependent on the endemic plant species. In addition, important plants of higher altitude of Pakistan are extensively collected by venders for business. Their

non-judicious collection has made them endangered. Selected medicinal plants were focused for their conservation and domestication and this paper presents the key findings. In addition, it was observed that integrated efforts are suggested to preserve these native medicinal plants for the future generations. It is recognized that a major threat to the sustainability of natural resources is the erosion of people's indigenous knowledge as observed during the present studies. It is suggested that the Governmental and local bodies be activated to motivate the local people in domesticating the high valued medicinal plants for sustainability.

Kashmir valley is rich in cherry diversity which has accumulated partly through hybridization and seed based propagation, selection and bud mutations and partly through continuous introduction of new varieties from foreign countries by various agencies from time to time. Genetic diversity exhibited by cherry in Kashmir valley provides an ideal platform on which a breeding programme for cultivar improvement can be initiated. Continuous and ruthless felling of trees on one hand and yield based propagation on the other hand have brought this fruit under stress and posed the threat of losing some valuable genotypes of cherry that besides being well adopted to the local agro-climatic conditions are also the carriers for some important traits like resistance to insect pests and diseases and high yielding. As a result, the diversity of cherry germplasm in Kashmir valley is shrinking. If this trend continues, it can result in elimination of native genotypes from commercial and home garden production. Many local types of genotypes have almost completely disappeared and many others are on the brink of disappearance. Thus need of the hour is to launch a multidimensional strategy not only to salvage this rich germplasm diversity but also identify the superior genotypes that can prove useful in achieving genetic improvement in yield and other quality characteristics of commercially grown cherry varieties through

known breeding methods and selection. This goal cannot be achieved unless and until the already existing varieties are surveyed, evaluated and standardized. Therefore, investigation was conducted in the main cherry growing belts of Kashmir *viz*. Srinagar, Baramulla and Shopian districts. The study was carried out in order to survey the available germplasm of cherry and to find out the magnitude of variability for various morphological and horticultural traits; predict the heritability and genetic advance and to estimate the divergence.

**Induction and identification of colchicine induced polyploidy in *Gladiolus grandiflorus* cv. 'white prosperity'**

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Gladiolus is one of the most important lucrative cut flower crops that is commercially cultivated worldwide due to its various spike forms, size, shape and color combinations. In order to further increase the commercial and horticultural value by improving the ornamental traits of gladiolus 'White Prosperity', polyploidy was induced by soaking gladiolus corms in different colchicine concentrations (0.1%, 0.2% and 0.3%) for 24 h. Different colchicine concentrations had a little effect on sprouting and survival percentage but it significantly delayed the emergence of sprouts. About twofold decrease in plant height along with reduction in number of leaves per plant, leaf area, length and width, chlorophyll contents, corm weight, diameter and number of cormlets per corm was observed in treated plants. Colchicine at 0.1% concentration improved the ornamental value of gladiolus by increasing vase life whereas colchicine at 0.3% was effective in increasing floret diameter. However, the colchicine treated plants exhibited delayed and reduced percentage of flowering corms. Pollen and stomatal study was done for the identification of polyploidy and it showed that both pollen and stomata size were increased while stomatal density and pollen fertility was significantly reduced in polyploid plants. Induction of polyploidy (mixoploids + octoploids) was achieved in all concentrations, however 0.2% and

0.3% concentrations of colchicine were effective for producing large number of polyploid plants. But at 0.1% concentration of colchicine, majority of plants did not show any change in their original ploidy level (tetraploid). These putative polyploids may be helpful for further improvement in ornamental and horticultural value of gladiolus.

## *In vitro* induction of polyploidy through colchicine and oryzalin to enhance the quality traits of okra (*Abelmoschus esculentus*)

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Okra *(Abelmoschus esculentus)* is a substantial crop in many developing countries that provides nutritive value to human daily diets by contributing proteins, carbohydrates, vitamins, calcium and iron in large quantities. However, okra is considered as a minor research crop and little attention has been paid for its varietal and genetic improvement. Induction of polyploidy is considered as very effective tool for the improvement of economic traits of vegetable and fruit crops. Therefore, *in vitro* mutation through colchicine and oryzalin was applied in okra with an aim to enhance its ploidy level by using seeds and hypocotyls as explants. Different concentrations of colchicine (0.0, 0.2, 0.4, 0.6 %) and oryzalin (0.0, 0.01, 0.05, 0.1%) were used for seed treatment for 12, 24 and 36 h, while for hypocotyl treatment 0.0, 0.1, 0.2, 0.4 % colchicine and 0.0, 0.01, 0.05, 0.1 % oryzalin were used for 24, 48 and 72 h. Both of the antimitotic agents exhibited dramatically diverse effects on phenotypic characteristics of okra plants, showing improved stem, leaves, flower length, pod and seed diameter. Stomatal and pollen study was done for the identification of tetraploids and it showed enhanced stomata and pollen size while stomatal density and pollen fertility was significantly reduced in tetraploid plants. Highest tetraploid okra plants by seed treatment were obtained at 0.01 % oryzalin (42.8 %) and 0.2 % colchicine (40 %) for 36 h time duration while in hypocotyl treatment, higher tetraploids were observed at 0.01 % oryzalin (50 %) and 0.1 % colchicine (44.4 %) for 72 h time duration. Thus, oryzalin treatments were found more effective for inducing

polyploidy in okra with hypocotyl explants. The female fertile seeds of tetraploids were maintained as germplasm for further polyploidy breeding.

### Improvement of quality traits in *Rosa borboniana* through *in vitro* use of colchicine

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The commercial value of *Rosa borboniana,* a fragrant rose species known for wonderful aesthetic beauty, can be substantially improved by increasing size of its different organs through *In vitro* use of colchicine. In order to improve its characters , shoot tips taken from micropropagated plants were incubated for three different periods of 5, 7 and 11 days in MS medium containing different levels (0,100, 150, 300 and 450 mg $l^{-1}$) of colchicine. Minimum plants (60.12 %) of *Rosa borboniana* survived after acclimatization but yielded maximum plant height (19.36 cm), number of nodes (6.85), internodal distance (2.82 cm), leaf area (11.20 $cm^2$) at colchicine level of 450 mg $l^{-1}$ with incubation period of 11days. However, value of color components (L*, *a**, *b**, *c** and *h*°) of leaves was decreased. Genetic variation was analyzed and dendrogram was developed to assess the relationship with parent material. The findings of this study add to the ongoing efforts to improve the characteristics of rose through induction of mutation.

### *In vitro* regeneration and development of *S. lycopersicum* and *S. pimpinellifolium* from two different explants

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The major purpose of this study was to establish a stable regeneration system for tomato cultivars in order to lay the foundations for the future genetic

transformation of the tomato. The regeneration ability of two kinds of explants (cotyledons and stem node segments) was compared for two cultivars of the tomato *Solanum lycopersicum* and *Solanum pimpinellifolium.* Explants were cultured on 5 different regeneration media (1/2 MS and BA) for stem node and MS with a combination of 6-benzylaminopurine (BAP) and indole-3-acetic acid (IAA) for callus induction. It was found that the regeneration ability was substantially dependent on the cultivars, as well as on the kind of explant. The best explants for inducing shoot regeneration were stem node, followed by cotyledons. It was noticed that the best formulation of the medium for this regeneration from cotyledon explants used is MS with 1 mg/L BA and 0.25 mg/L IAA for callus induction in *S.pimpinellifolium* and for stem node explant the best formulation used is ½ MS and 7 mg/L BA in *S. lycopersicum* was observed. All these data raised the possibility thatto preserve and propagate wide hybrids of tomato materials invitro, the regeneration ability of two explants was compared in *Solanum lycopersicum* and *S. pimpinellifolium.*

## Direct *in vitro* regeneration from leaf disc of different potato varieties, a prerequisite in genetic transformation

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Abiotic stresses such as drought, heat, cold and salinity adversely affect potato growth and productivity and leads to a series of morphological, physiological, biochemical and molecular changes to adapt and survive under stress conditions. Various modern genetic engineering methods are used to overcome these problems. Gene transformation is highly effective for adding single gene to existing potato clones which requires efficient regeneration system. Potato shows a genotype-specific and hormonal dependent response towards regeneration from various ex-plant. The present research was designed to evaluate regeneration potential of commercially grown potato varieties *viz.* Hermes, Diamant, Kuroda, Asterix, Sante and Lady Roseta and PGR combination of IAA and Zeatin along with MS media supplemented with vitamins and sucrose solidified with agar and pH adjusted to 9.5. Diamant, Kuroda, Asterix, Sante and Lady Roseta gave 93%,

100%, 73%, 86% and 73% regeneration @ 3 mg/L zeatin and 1 mg/L IAA. However, Hermes showed no response towards combination of these hormones. Maximum number of shoots/ex-plant produced in all varieties were also obtained with same hormonal concentration that were 7, 14, 8, 6 and 5 shoots/ex-plant in Diamant, Kuroda, Asterix, Sante and Lady Roseta respectively. Minimum days to shoot emergence varied among all varieties at same concentration of hormones in Diamant, Kuroda, Asterix, Sante and Lady Roseta that took 51, 30, 36, 52 and 59 days respectively. Direct regeneration was observed in almost all varieties, although compact dark green micro calli were observed in Diamant. Considering regeneration percentage and maximum shoot production, Kuroda proved as superior to all varieties tested. Findings of this study will help us to transform potato with *GSNOR* to functionally analyze its role against abiotic stress tolerance.

## Direct *in vitro* regeneration from leaves of economically important peach rootstock GF 677

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GF-677 (*Prunus amygdalus* x *P. persica*) has proved to prospective rootstock for prunus species owing to its adaptability to cope with drought conditions and poor soil fertility. However due to highly vigorous nature and poor rooting ability it does not fulfill the necessity of recent trends of high density planting systems. Rol genes have shown tremendous potential regarding the improvement of agronomic triats like dwarfism, compactness in vegetative habit, large root system and improved rooting ability of the cuttings. A prerequisite for this process is developing a successful regeneration protocol for genetic transformation. Therefore an efficient regeneration protocol was developed for GF 677 which would be helpful in future study regarding the genetic transformation with rol gene. Two culture media Murashige and Skoog (MS) media and Lepoivre (LP) supplemented with different combinations of benzylaminopurine (BAP) and naphthalene acetic acid (NAA) was examined on shoot regeneration from leaves of *Prunus* rootstock GF-677. LP medium was found to be superior producing on

average 29.85% regenerated shoot, 3.39 shoot number and 3.43 cm shoot length whereas MS medium produced 20.88% regenerated shoot, 1.90 shoot number and 2.28 cm shoot length. Moreover, LP medium produced longer and healthy shoots whereas stunted and yellow shoots were observed on MS medium. Regarding the interaction between media and growth regulators, the best interaction was found in LP medium supplemented with 2.0 mg l-1 BAP and 0.75 mg l-1 NAA ($T_{11}$) resulting in 55% regenerated shoots, 4.28 shoot number and 4.25 cm shoot length while 40% regenerated shoots, 3.20 numbers of shoots and 3.80 cm shoot length were observed on MS medium with the same combination of cytokinins and auxins.

**Silver nitrate ($AgNO_3$) boosted high-frequency multiple shoot regeneration from cotyledonary node explants of okra (*Abelmoschus esculanthus* L.)**

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Okra (*Abelmoschus esculanthus* L.) regeneration frequency to a large extent depends on its genetic structure and its recalcitricity. In present study, the influence of silver nitrate ($AgNO_3$) in combination with cytokinins such as Kinetin (KIN) and 6-benzyl amino purine (BAP) to regenerate multiple shoots from cotyledonary node explants of *A.esculanthus,* were optimized. Cotyledonary node explants were excited from 10-days old okra *in vitro* seedlings and incubated on Murishage and Skoog (MS) medium supplemented with different concentration of BAP alone or in combination with KIN. The highest percentage of shoot bud regeneration (75%) was achieved on MS medium supplemented with 2.0 $mgL^{-1}$ BAP. The highest percentage of shoot multiplication and proliferation (85%) with 6.75 shoots per explants having 3.75 cm length was achieved on MS medium containing 1.5 $mgL^{-1}$ BAP + 1.5 $mgL^{-1}$ KIN + 3.0 $mgL^{-1}$ $AgNO_3$. On the other hand, excluding $AgNO_3$, in the combination of 1.5 $mgL^{-1}$ BAP + 1.5 $mgL^{-1}$ KIN, a maximum of (53%) shoot multiplication with 2.3 shoots per explant having 3.75 cm length was recorded. Individual shoots were elongated on MS medium containing 1.5 $mgL^{-1}$ BAP + 1.5 $mgL^{-1}$ $GA_3$ (gibberellic acid) (shoot

length 5.60 ± 0.70[a] cm) and rooted on half strength MS medium + 1.0 $mgL^{-1}$ IBA (Indole 3-butiric acid) + 200 $mgL^{-1}$ AC (activated charcoal), highest root formation (83%) with 5.20 roots per shoots having 4.8 cm length was achieved. Plantlets with roots were acclimatized in plastic cups under a growth chamber at 25 ± 2 $^{o}$C with relative humidity (70%) and survival rate (87%). The current protocol can be used to develop transgenic plants of commercial variety of okra as a result of genetic transformation.

**Ascorbic acid controls lethal browning and pluronic F-68 promotes high-frequency multiple shoot regeneration from cotyledonary node explant of okra (*Abelmoschus esculentus* L.)**

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The regeneration frequency of okra (*Abelmoschus esculentus*) is greatly influenced by its genetic makeup and recalcitrant nature. Phenolic secretion, in particular, is a major problem in okra tissue culture. This study describes a reproducible, rapid, and more efficient *in vitro* regeneration method using cotyledonary node explants of okra. Explants were incubated on Murashige and Skoog (MS) medium containing different concentrations and combinations of various plant growth regulators (PGRs) (benzyladenine [BA], thidiazuron [TDZ], and α-naphthylacetic acid [NAA] and regeneration enhancers (silver nitrate [$AgNO_3$] and Pluronic F-68). Cut ends of cotyledonary node segments rapidly turned brown, and cultures failed to establish. Anti-browning additives, such as activated charcoal (AC), ascorbic acid (AA), and $AgNO_3$ at various concentrations in PGR free MS basal medium, were tested for their ability to control phenolic secretion from explants. Amongst these additives, 15 mg $l^{-1}$ AA was found to be optimal for controlling phenolic secretion, resulting in healthy explants and culture establishment. The highest number of shoots (a mean of 9.3 ± 0.9 shoots per cotyledonary node explant) was obtained on MS media containing 0.5 mg $l^{-1}$ NAA + 1 mg $l^{-1}$ TDZ + 0.1% Pluronic F-68. Individual shoots were elongated on MS medium + 1 mg $l^{-1}$ BA + 0.1 mg $l^{-1}$gibberellic acid

($GA_3$) (shoot length 5.3 ± 0.2 cm) and rooted on ½ MS medium + 1 mg $l^{-1}$ indole-3-butyric acid (IBA) and 200 mg $l^{-1}$ AC (5.3 ± 0.2 roots per shoot). Rooted plantlets were acclimatized in plastic pots inside a plant growth chamber at 25 ± 2°C and 70% relative humidity, with 85% survival rate. This optimized protocol can be employed for producing transgenic plants of commercial okra cultivars through genetic transformation.

**In vitro regeneration of selected cultivars of banana in Pakistan**

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Banana is herbaceous, monocotyledonous and evergreen perennial plant. Most of the banana cultivars are susceptible to Banana Bunchy Top Virus (BBTV) and it causes significant economic loss to banana production**.** Micro-propagation is preferred over the conventional method of propagation in banana due to faster multiplication rate, uniformity in planting materials and production of disease-free planting materials. The present study comprises of three exotic banana genotypes viz: Wiallium-8818 hybrid (Chinese variety), Pisang (Chinese variety) and Brazilian (Brazilian variety). Different combinations of IAA, NAA and BAP along with MS were prepared for optimizing tissue culture protocol. The Clorox at 50% concentration for 15 min gave minimum percentages for both fungal and bacterial contamination, and optimum survival percentage. Seven different combinations (T0-T6) of BAP and IAA and five combinations (RT0-RT4) of NAA and IAA were used to optimize multiplication and rooting protocols. It was found that BAP and IAA at 2.5 mg/L and 1 mg/L respectively (T5) gave maximum (6.53) mean number of shoots per explants while longest shoot length (7.14cm) was recorded at MS with BAP and IAA at 1 mg/L and 1 mg/L (T4) respectively. Maximum mean fresh weight value (12.96g) was recorded in MS medium supplemented with BAP and IAA at 5.0 mg/L and 1.0 mg/L (T6) respectively. The genotype Wiallum-8818 hybrid gained maximum value for mean number of shoots per explants (4.94) and longest shoot length (8.52cm) while the genotype Pisang gained maximum fresh weight value (8.95g). It was

found that NAA at 0.5 mg/L (RT4) gave maximum (5.70) leaves per shoot while mean roots per shoot (4.67) was recorded at MS with 1mg/L NAA and 1mg/L IAA (RT3). Maximum mean value (4.67) for roots per shoot was recorded in MS medium supplemented with 1mg/L NAA and 1mg/L IAA (RT3). Maximum mean value (5.58cm) for longest root length was recorded in MS medium 2 supplemented with 1mg/L NAA and 0.5mg/L IAA (RT2) respectively. The genotype Wiallum8818 hybrid gained maximum value for mean leaves per shoot (4.47) while variety Pisang showed maximum value for roots per shoot (4.11) and longest root length (5.48cm).

## *In vitro* clonal propagation technology in guava: An overview

Guava (*Psidium guajava* L.) cultivation and production is expanding despite biotic stress and growers are diverting towards high density plantations to meadow orcharding systems which demands establishment of better plant multiplication systems producing quality clonal plant material. Sixty elite guava strains in 'Round' (Gola) and 'Pyriform' (Surahi) cultivars were collected across Punjab province and were screened for morpho-physiological traits and great diversity in fruit shape, size, quality and nomenclature was observed in both cultivars. Selected plant material has been established as germplasm unit (GPU) in the Institute Experimental Gardens for further evaluations. Application of 5%-10% sodium hypochlorite controlling deep seated contamination in the nodal cuttings. Higher levels (200-300 $mgL^{-1}$) of antioxidant poly vinyl pyrrol idone (PVP) effectively reduced phenolic exudation and enhanced explant survival and bud break percentage. Explant browning was less in young juvenile tissues compared with mature woody plant material. Explant position and Genotype dependent multiple shoot induction was noted at higher levels of BAP (3-4 $mgL^{-1}$) supplemented in Murashige and Skoog media and mother plants were developed for further multiplications. Rooting was achieved either in the same media or media containing 2-3 $mgL^{-1}$ IBA. The acclimatized plant material has been transferred to green house for further plant growth and development. The

technology is also being demonstrated to the progressive growers and other stake holders using social media and published literature.

## Micropropagation of litchi (*Litchi chinensis*sonn.) from leaf and nodal explants

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Litchi (*Litchi chinensis* Sonn.) a member of family *sapindaceae*, widely grown in tropical and sub-tropical areas of world, is native to China and Vietnam. It reached sub-continent via Myanmar during late $17_{th}$ century. In Pakistan, litchi is cultivated on 278 hectares, of total land with an annual production of about 1666 tones. Litchi is a cross pollinated crop, therefore heterozygosity abounds. Hence, propagation through seeds does not conserve stable genetic makeup and limits the genetic improvement through conventional hybridization techniques. Micropropagation techniques have been extensively utilized as a valuable and viable tool for overcoming such constrains in different plants. The present investigation was done to develop protocol for *in vitro* regeneration of litchi. For this purpose leaf disks and nodal segments were chosen as explants. Different concentrations (1, 2 and 3 mg $L^{-1}$) of BAP and KIN were supplemented to Murashige and Skoog medium (MS medium). Experiment was laid out according to CRD with factorial arrangements and was analyzed using Duncan's multiple Range (DMR) test. Leaf disk explants were examined for callus induction. Maximum callus induction was obtained in higher concentration (3 mg $L^{-1}$) of BAP and KIN. While in case of nodal segment best shooting response was obtained in KIN 1 mg $L^{-1}$ + BAP 2 mg $L^{-1}$. After that the shoots regenerated from nodal segments were transferred in Murashige and Skoog medium containing IBA and NAA. NAA (1mg $L^{-1}$) was found, best root promoting factor with 30 mm long roots.

## Screening of citrus rootstoks against drought/water stress

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Drought is an environmental condition which negatively affects plant growth, yield and considered as significant cause of production loss worldwide. Water is essential for citrus trees (or for any plant) because it is an integral component of the biochemical reactions that occur within the plant. Citrus (*Citrus* spp. Family; *Rutaceae*) is the main fruit tree crop in the world normally has two tree parts; *Scion* or fruit bearing portion and Rootstock provide tree root portion. The selection of scion and rootstock combination is an essentially permanent decision with lifelong ramifications for tree health and management. The effect of rootstocks is particularly significant on tree nutrition, growth vigor, stress resistance, and fruit quality of the scion. We need to focus on citrus rootstock against the drought stress. The study was conducted to screen out different modern citrus rootstocks including commercial rootstocks against the drought. Drought was induced on the base of field capacity of citrus rootstock relative to water requirement of citrus. Relative to field capacity 75% field capacity considered as a control and develop two level of drought moderate (50% field capacity) and severe drought (25% field capacity). Three-month-old uniform seedling selected for the stress treatments. Gas exchange parameter recorded at four different times before stress (0 days), 5 days, 10 days and 15 days after stress. Horticultural parameter, Plant water status and Chlorophyll absorption at different wavelength recorded after 15 days of drought stress. Citrus rootstocks show significant response at different levels of drought stress and number of days (gas exchange) for all the traits. Relative to control plants Gas exchange parameter Photosynthetic rate and stomatal conductance reduced at both stress level respectively and badly effected in severe stress at 10 and 15 days. Leaf internal temperature increased due to drought stress. Plant water status like moisture level and water potential also reduced by the drought stress. The most promising drought tolerant rootstocks are Brazilian sour orange and keen sour orange which not severally effected by drought on physical, physiological and

morphological traits. Our commercial rootstocks Rough lemon and sour orange also negatively affected by the drought stress. Sovagecitrange and Yuma citrange is most susceptible to drought.

**Morpho-physiological responses of guava cultivars to water deficit**

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Drought is amongst the most devastating threats for agriculture in Pakistan and rising water scarcity is predicted in future. Guava cultivation is economical, more rewarding and it is considered as a relatively drought tolerant fruit crop. Morphological and physiological alterations were investigated in two-year-old 'Round' (Gola) and 'Pyriform' (Surahi) shaped guava cultivars under water deficit (WD) conditions for 16 weeks. Under WD, net plant height (16.07 cm), leaf area (17.10 $cm^2$), leaf drop (-22.15) and photosynthetic performance (6.96 µmol $CO_2$ $m^{-2}s^{-1}$) were markedly reduced in 'Round' compared with 'Pyriform' and untreated control. Higher photosynthetic performance (8.10 µmol $CO_2$ $m^{-2}s^{-1}$), chlorophyll contents (26.68 µg/g) and water use efficiency (12.97) in 'Pyriform' maintained plant growth under WD leading to better net plant height (21.41 cm) and reduced leaf drop (-18.27). Variable responses were observed for sub-stomatal $CO_2$, transpiration rate, stomatal conductance and leaf temperature across genotypes with rising WD. 'Pyriform' showed early recovery after stress and net plant growth was better including higher number of new leaves (30.47), leaf area (4.35 $cm^2$) and leaf length while 'Round' showed better net plant height (10.43 cm). Selection of cultivars against water stress using biochemical and genetic approaches would be a promising strategy to understand the mechanism of drought tolerance in guava.

## Performance of three exotic seedless grape (*Vitis vinifera*) cultivars under the climatic condition of Kalar Kahar, Pothwar

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Three exotic grape cultivars viz Sugra-one, Early White and Vitro Black were grown under Pothwar climatic condition at Izhar Farm Chakwal, Pakistan under high efficiency irrigation system. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. All the selected varieties were early fruit bearing. However, it was observed that variety Early White showed early sprouting, fruit bearing and fruit maturity followed by Sugra-one. The results indicated that maximum number of bunches was recorded in Early White followed by Vitro Black. Whereas, maximum number of berries were counted in Sugra one flowed by Vitro Black. Maximum berry size and ultimate fruit yield was obtained in Sugra-one followed by Vitro Black. The variety Early White showed poor performance in comparisons of all three varieties regarding fruit yield. From the above mentioned data it is concluded that Sugra one could be the most suitable variety for Pothowar agro-climatic condition of Pakistan.

## Performance of olive cultivar 'gemlik' at Barani Agricultural Research Institute Chakwal

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Performance of olive cultivar 'Gemlik' planted during the year 2004 in the orchard of Barani Agricultural Research Institute Chakwal was observed during five years from 2011 to 2015. Its morpho-physical characteristics and oil yield revealed that it can successfully be cultivated in the region and can give good yields to the grower. Plants of this variety were medium in vigor with elliptic shaped leaves and elongated fruit, which was round at base as well as at apex. Fruit was green in color that gradually turned dark violet at maturity. During the

period of this study, average weight of single fruit ranged from 2.9 to 5.4 g, while that of single stone ranged from 0.66 g to 0.99 g. Range of fruit length and fruit width remained from 23.0 mm to 29.0 mm and 16.1 mm to 17.8 mm respectively. As far as fruit yield was concerned, it was lowest (16.20 kg / plant) in the first year of study, while highest (37.50 kg / plant) in the fifth year. Range of leaf length was from 58.4 mm to 66.5 mm, while that of leaf width was from 19.1 mm to 20.1 mm. Oil percentage by cold press method obtained from fruit of Gemlik ranged from 11.0 % to 12.3 %.

## Morphologial characterization of different ber (*Ziziphus mauritiana* L.) varieties

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Ber is an evergreen shrub belongs to family Rhamnaceae. It is grown all over the world including Australia, China, India, Nepal, Bangladesh and Pakistan. The characterization of ber is emerging platform for the breeding programs which in result use for development of new cultivars. The objective of the experiment was to check morphological diversity in ber cultivars growing in Bahawalpur district. The morphological characters of nine ber cultivars including Ajuba, Akasha, Alubukhara, Sufan, Umran-9, Desikarela, Gorh, Sabarwali and Dilbahar were observed. The leaf length was in ranged between (6.30-3.33 cm), leaf width (5.53-2.90 cm), fruit weight (40.33- 21.00 g), fruit width (25.86-6.56 mm), stone length (25.00-13.33 mm), and stone width (13.33-7.33 mm) and stone weight (1.86- 0.56 g). A satisfactory variability among qualitative traits was observed. Particularly, data analyzed from cultivars will be used for preservation of germplasm and could be helpful for future breeding.

# Morphological characterization of Indian jujube (*Zizyphus mauritiana* L.) germplasm through digital imaging and biplot analysis

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Indian jujube (*Zizyphus mauritiana* L.) is a fruit crop mostly cultivated in harsh arid environments. It is becoming an important fruit crop due to its widespread adaptation, early age bearing, easy to manage and high nutritional value. However, wide variations occur in morphological characteristics of Indian jujube fruits. In the present study, fruits of sixteen cultivars of *Z. mauritiana* and one accession of *Z. rotundifolia* were collected for morphological characterization through digital imaging and biplot analysis. Pearson's correlation and biplot indicated high level of diversity among the genotypes based on morphological attributes. The cultivar Yazman local had the maximum fruit weight (29.35 g), pulp weight (27.93 g), fruit perimeter (15.62 cm), fruit area (14.77 $cm^2$), fruit length (4.97 cm) and fruit volume (288.93 $m^3$). Seedless had the minimum stone weight (0.20 g) among all the genotypes. Pearson's correlation revealed significant correlation of fruit weight with pulp weight, stone weight, fruit perimeter, fruit area, fruit length, fruit width, fruit thickness, fruit volume and factor from density (0.99, 0.59, 0.89, 0.94, 0.90, 0.86, 0.88, 0.94 and 0.87, respectively). Dendrogram constructed on the basis of studied morphological attributes, divided 17 genotypes into two main clusters. Among the cultivars, Foladi and Pak white shared the maximum similarity (90%). Selection of those cultivars having maximum fruit weight, fruit pulp weight, fruit length, fruit width, fruit area, fruit perimeter and fruit volume may possibly increase their selection chances as parents for development of high yielding cultivars.

**Biodiversity in physico-chemical attributes of Indian jujube (*Zizyphus mauritiana* L.) germplasm revealed through principal component analysis**

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Indian jujube (*Zizyphus mauritiana* Lamk.) is mostly cultivated in tropical and sub-tropical regions. Many native and exotic cultivars are grown for fruit production in Pakistan. However, little research work has been conducted on morphological and biochemical attributes of available germplasm. Therefore, present study was conducted to investigate the performance of 13 Indian jujube genotypes and correlation among their variables that may have greater importance for breeders during the selection of desirable genotypes. The cultivar Foladi had the maximum fruit weight (30.49 g), pulp weight (28.42 g) and fruit diameter (36.75 mm). Khobani had the maximum TSS (14.92 ºBrix). The highest level of acidity (0.74%) was recorded in Gorh. Akasha had the highest vitamin C content (72.53 mg/100 mL juice). The cultivars Sadqia, Umran-13, Mehmood wali, Yazman local and Gorh were much sweeter due to the maximum total sugars content (9.74-10.09%). The maximum antioxidant capacity was recorded in Mehmood wali (616.13 mM trolox/100 mL), Pak white (615.02 mM trolox/100 mL) and Seedless (600.46 mM trolox/100 mL). The maximum amount of total phenolic content was determined in Umran-13 and Sadqia (243.06 and 239.25 µg GAE/mL juice, respectively). Pearson's correlation and biplot analysis were made to determine the relationship among various variables of the studied genotypes. Highly significant positive correlation (0.99) was observed between the fruit weight and pulp weight. Antioxidant activity and total phenolic content were also strongly positively correlated (0.70). Dendrogram constructed on the basis of morphological attributes, divided 13 genotypes into four main clusters. Among the cultivars, Khobani and Mehmood wali shared the maximum similarity (78%). Biochemical characteristics also divided the genotypes into three main clusters. The cultivars Pak white and Seedless had the maximum similarity (75%) among all the cultivars.

## Performance of some heat tolerant tomato genotypes in central punjab

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To cope with the economic losses of tomato under heat stress, different strategies have been assessed. The present study was designed to evaluate the performance of some already screened heat tolerant tomato genotypes at two locations, i.e. at Vegetable Research Area, University of Agriculture, Faisalabad and at a local farm in Okara. Exotic and local germplasm were collected from AVRDC (Asian Vegetable Research and Development Centre, Taiwan) and AARI (Ayub Agriculture Research Institute, Faisalabad). Eight genotypes showing heat tolerance during screening experiments (i.e. Subartic, L00525, L04845, CLN-2366 A, L00493, L00602, L01214, Anahu), a heat sensitive genotype (Spekled Sibrian) and local control cultivar (Rio Grande) were transplanted on two different dates with 15 days interval. Data regarding gas exchange related attributes (photosynthetic rate, transpiration rate, water used efficiency, stomatal conductance, electrolyte leakage), biochemical parameters (protein content, chlorophyll contents and antioxidant activities of superoxide dismutase, catalase and peroxidase), yield related attributes (individual fruit weight and fruit diameter) and quality related attributes (total soluble sugars, vitamin C and titratable acidity) were collected. The results showed that, generally, the second transplanting date was better as compared to the first transplanting date and Subartic, a heat tolerant genotype, was superior in performance to all other genotypes at both locations and on both transplanting dates.

# Evaluation of potato (*Solanum tuberosum* L.) genotypes for yield and phenotypic quality traits under subtropical climate

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Although, potato has made its place in high yielding cash crops of Pakistan but its average yield is low as compared to other potato producing countries of the World. The main reason of low yield in the country is use of low yield potential potato varieties. Thus it is very important to evaluate such genotypes, which have high yield potential and are suitable to our local environmental conditions. In this regards, 42 exotic potato genotypes imported from International Potato Centre, Peru were evaluated for yield and phenotypic quality traits at National Agriculture Research Center Islamabad, Pakistan during autumn 2016-2017. The experiment was laid down in randomized complete block design with three replications. Data on quantitative traits (germination, plant height, number tubers, tuber size, average tuber weight and number of eyes per tuber) phenotypic qualitative traits were collected. Significant differences were noted in all yields and phenotypic quality traits. More germination or sprouting percentage (96.00 to 96.70%) was observed in M-05-81-43-R, CIP-1, NAZCA and TOURAGE. Maximum plant height (60.00 cm) was noted in CIP-27 while CIP-15 showed minimum height (18.60 cm). Genotypes FOCUS, ELBIDA, RED-VALENTINE, CIP-2, CIP-4, CIP-10, CIP-16, CIP-19, CIP-25, CIP-29, CIP-30, CIP-32 and CIP-33 genotypes were found good in case of tuber size, weight and average number of tuber per plant and produced less number of eyes per tuber (2.00 to 4 eyes) except CIP-4 genotypes (6.00 eyes). In case of tuber shape, 30 genotypes showed elliptic shaped tubers while11 genotypes produced round shaped tubers. All the genotypes produced smooth skin tubers. In case of flesh color, 22 genotypes produced yellow flesh color tubers and 4 genotypes produced red flesh color tubers while cream color flesh tubers were noted in CIP-3,CIP-4, CIP-6, CIP-7, CIP-8, CIP-19, CIP-29 and CIP-32. This screening is helpful to the ongoing efforts to select the best genotype for the emerging processing industry of Pakistan.

**Performance evaluation of commercial seedling mangoes towards a novel stone grafting technique**

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Mango (*Mangiferaindica* L.) is a highly cross-pollinated and heterozygous fruit crop in nature. It is mandatory to keep such fruit plants true-to-type through asexual techniques, if further propagation is required. During this era of modernization and innovative ideas; a preliminary study was conducted to search out the most economical and short term propagation technique in mango. The freshly extracted stones of commercial mango cultivars viz. Sindhri, SB Chaunsa, Dusehri, White Chaunsa, Anwar Retual and Retual #12 were planted in polyethylene bags containing the standardized pot media to also observe the performance of these cultivars as rootstock with specific scion variety i.e. Sindhri. After the emergence of seedling mango, the epicotyl grafting was practiced at various seedling ages viz. 05, 10, 15 and 20 days before the natural detachment of stone with emerging shoot. This practice was done during the month of October, 2015 when maximum and minimum average temperature was 30°C and 22°C while relative humidity of the atmosphere was recorded as 80% in the lath house of Mango Research Institute, Multan. The results elucidated that the best age of seedling mango was 10 days after its emergence for the epicotyl grafting. The maximum success by 70% was achieved in seedlings of Sindri, SB Chaunsa and White Chaunsa whereas minimum success 60% was recorded in seedling of cultivar Dusehri, Anwar Retual and Retual #12.It is concluded that as the seedling age of the tested cultivars of mango increases, the success of epicotyl grafting with cultivar Sindhri on them decreases.

## Graft takes success in pecan nut varieties at different timings

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Peanuts are nuts producing tree plants which has a high economic importance among horticulture crops. Plain and low hilly areas of Khyber Pakhtunkhwa have the highest future scope for Peanuts cultivation. For availability of good quality and maximum quantity of plants, the present study was carried out in the lathe house at Horticulture Research farm, Agricultural Research Institute, Tarnab, Peshawar during the year 2017.The aim of the study was to find the optimum time for production of nursery plants of Peanuts varieties through grafting. The experiment was laid out in randomized complete block design with two factor and three replications. There were 30 plants per treatment. Peanut varieties Mahan, Wichita, and Stuart were grafted at different dates i.e. January 15, February 1st, February 15 and March 02. During the experiment the variables studied were; sprouting percentage, days to sprouting, plant survival percentage, Number of sprouts per plant, stem length, stem diameter, sprout length, number of leaves, numbers of sprouts and Leaflet area. For Peanuts varieties, Mahan obtained maximum graft sprouting, percent plant survival, stem Length and Stem diameter. Maximum graft sprouting and percent plant survival was recorded by grafting on 1st February. As far as the interaction effects are concerned the maximum values were observed by grafting Mahan on February 15 for most of the variables studied. Therefore, Mahan can be recommended as best variety to be grafted in the mid February.

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The selection of rooting media and growth hormones/ regulators play vital role in propagation of olive through cuttings. IBA is considered to be a best root promoting hormone for different media. Semi hardwood cuttings of two varieties viz Coratina and Frantoio were planted under SPT in spring season at Barani Agricultural Research Institute, Chakwal ($32^0$ 92'82 N and $72^0$ 7201 E) at 575 m above the sea level. The experiment was laid out under complete randomized design with three replications. Three different kinds of media (Sand, Silt and Perlite) were tested for propagation under three IBA Concentrations (2000ppm, 3000ppm, 4000ppm). The results depicted that cutting of variety Coratina showed maximum sprouting and rooting percentage in sand followed by silt. However, root length was more in media silt as compared to perlite and sand. The cuttings of Frantoio performed best in media silt regarding rooting percentage along with root length. The sprouting percentage in cuttings of variety Coratina was highest in sand. In comparison of varieties the Frantoio was at top regarding total rooting percentage. The root length of both varieties was similar in media silt. As well the concentrations of IBA are concerned cuttings of Coratina and Frantoio were planted in mixture of silt and sand media with ratio of 2:1 respectively. The results showed that maximum sprouting percentage was observed in Coratina as compared to Frantoio under 3000 ppm concentration. Whereas, maximum number of rooted cutting percentage was recorded in Frantoio than Coratina under 3000 ppm. However, rooted cuttings percentage in Coratina was better at 2000 ppm concentration. As well as the root length was concerned Cuttings of Frantoio showed best results regarding maximum root length as compared to Coratina. Overall performance was best in media silt for both of the varieties with the IBA concentration of 3000ppm.. As well as the perlite media is concerned the poor results achieved in sprouting and rooting percentage along root length.

**Rooting response of selected rose varieties through semi hardwood cuttings**

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Roses are generally propagated by traditional methods like budding and grafting for commercial purpose, which is most easily and successful asexual propagation method. The objective of the study was to find out the best rootstock propagated through cutting for the quick extension of rose industry in Pakistan with cheap and easiest method. For that purpose, a study was conducted on propagation of three different rose cultivar which were considered best as rootstock (Mme Hardy, *Rosa Centifolia* and Rosa Gruss an Tepltiz) through cuttings in winter at University Research Farm Koont (33° 40' N, 73° 10' E), PMAS Arid Agriculture University, Rawalpindi. The experiment was laid under Randomized Complete Block Design with three replications. The cuttings were planted in winter on enriched silt media in open field. The result depicted that the cutting of *Rosa centifolia* performed best toward rooting percentage followed by Gruss an Teplitz. The sprouting percentage, number of leaves and root length was maximum in *Rosa centifolia.* The variety Mme Hardy was performed poor in root establishment and root length. However, Mme Hardy variety give good sprouting at initial stage in 5 to 7 weeks. But later on, the results were poor. The variety Gruss an Teplitz performed in between the *Rosa centifolia* and Mme Hardy for sprouting and no of roots and root length and sprouting percentage.

# Biotechnology for Improvement of Horticultural Crops

## QTL analysis of dormancy in a diploid potato microtuber population

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The genetic control of dormancy is still poorly understood in most plant species. Dormancy is a prominent feature of the potato for tuber storage. With the microtuber system in which the tubers were produced *in vitro* and stored at 20°C, a quantitative trait locus (QTL) analysis was performed for dormancy in an $F_1$ population consisting of 178 genotypes derived from an interspecific cross between *Solanum chacoense* acc. PI 320285 (long dormancy) and *S. phureja* acc. DM1-3 516 R44 (short dormancy). Dormancy was evaluated and compared in two replicates which were conducted separately in 2014 and 2015. Dormancy showed significant differences among genotypes of the segregating population and were continuously distributed. In this analysis, 174 markers were used to construct a genetic map with a total length of 591.8 cM. The QTL analysis identified beside 22 markers, PGSC21436_160 was most closely linked with the timing of dormancy release. The alleles from the male parent promoted long dormancy, with the largest effect at a QTL on chromosome I which explained 9.4 % of the phenotypic variation. The identified QTLs provide the physiological and genetic dissection of potato dormancy which has potentials for dormancy regulation in potato breeding.

**Isolation of mesophyll protoplasts to study the DNA integrity of olive (*Olea europaea L.*) cvs exposed to X-Rays irradiation to produce diploid and tetraploid mutated plants *in-vivo***

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The genetic improvement of olive has currently become a priority to develop cultivars suitable for both new techniques production as well as resistant to stress conditions and application of physical mutagenesis on olive could represent a faster way to obtain new genetic variability. Thus, *in vitro* cultured plantlets of CV. Frantoio (4n) and Moraiolo (2n) were exposed to mutagenic treatment of X-rays (0, 3 and 5 Gy) at 37° C with aim to recover diploid and tetraploid plants from same transition zone. High yield of isolated nuclei were obtained by using protoplast technology. The viable mesophyll protoplasts were isolated immediately after the irradiation by incubation (4 hours at 25 °C in the dark) in an enzyme solution containing DTT (2 mM), cellulase Onozuka RS (2%) and macerozyme Onozuka R-10 (1%) and 0.6 M mannitol. The isolated protoplasts were used to assess the DNA integrity and percentages and amount of DNA damage by using single cell gel electrophoresis (SCGE)/comet assay. Protoplasts from untreated Frantoio (4n) and Moraiolo (2n) expressed low tail moment values, as well as intact nucleoids confirming that the adopted procedure of protoplasts isolation did not affect the DNA integrity. However, the tail moment significantly decreased with the increase in the X-ray doses in both cultivars Moraiolo (2n) and Frantoio (4n). While DNA of Frantoio (4n) was found more stable as compared to Moraiolo (2n) at both irradiation doses. These results expressed that DNA integrity was disturbed with the increase in mutagenic treatments, but, equally, Frantoio (4n) exhibited very low DNA damage, demonstrating that olive has a greater tendency for DNA repair in stress conditions. The X-irradiated nucleoids were significantly damaged at higher doses confirming that the present approach could be a new tool for testing the DNA

integrity and selection of elite material of olive to recover diploid and tetraploid mutant plants from same transition zones in field conditions in coming future since olive is still hard to regenerate *in vitro*.

## Morphological and molecular characterization of *Pistacia* from Chiltan National Park Hazarganji Baluchistan

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The present study is carried out for the first time from Chiltan National Park Hazarganji Baluchistan using molecular markerson Pistacia atlantica Sub sp. Cabulica. Random amplified polymorphic DNA (RAPD) and Inter-Simple Sequence Repeat (ISSR) techniques are used. Samples of Pistacia spp. were collected from six different locations in study area. The collected samples were morphologically identified based on descriptors available in the literature. Unweighted pair group method of arithmetic means (UPGMA) was used for cluster analysis indicating genetic variation. Results revealed that the Morphological and Molecular characterization of Pistaci aatlantica Sub sp. Cabulica clearly indicated two clusters from A and B. There is diversity observed in this population that may indicate the variation that might have been lead to speciation of Pistacia atlantica Sub sp. Cabulica in Hazrganji area of Baluchistan Pakistan. Our molecular analysis has agreed with our morphological analysis with regard to the distinction between these two subspecies. Furthermore to confirm this assumption other SSR or co dominant marker studies and DNA sequencing of this taxa is highly recommended.

**Molecular characterization of randomly selected members of *Solanaceae* family on the basis of DNA inventories**

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The Consortium for the Barcode of existence (CBOL) has proposed two regions of DNA to be used as a twin-locus barcode *i.e. rbcl* and *mat-k* in plants. *Solanaceae (nightshade) being* large family of plants has various significant medicinal, herbal and culinary plants across the world. Some plants in this family are used as model organisms in the molecular genetics. In the current studies five economically and genetically significant cultivars were selected *viz.* tomato (*Solanum lycopersicum* L.), red pepper (*Capsicum annum* L.), potato (*Solanum tuberosum* L.), egg-plant (*Solanum melongena* L.) and tobacco (*Nicotiana tabacum* L.) for their DNA barcodes development. Amplified PCR products were commercially sequenced and their inter varietal and intra varietal coverage was monitored through *rbcl* and *mat-k* loci combinations. Sequencing results were analysed using BLAST and Bio-edit tools. The samples were later subject to multiple sequence alignment for the nucleotide comparison amongst species and then phylogenetic tree was constructed. We report a unique SNP found in the *Solanum lycopersicum* L. Of *mat-k* gene, other than this all the species of both *rbcl* and *mat-k* gene showed 100% similarity with the available database. In contrary, these species showed nucleotide variations at several positions in their multiple sequence alignment. Analysis of amino acid composition reveals that an equal proportion of amino acids monitored with non-significant variation of mat-k gene in tomato and tobacco cultivars.

**Transcriptomic analysis and comparison of genes and biological networks involved in grapevine fruit and leaf development**

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Grapevine leaf and fruit are two important organs that belong to vegetative and reproductive growths. Their growth and development controlled under both same and different mechanisms. Here, the main objectives of Transcriptomic analysis of genes and the biological networks involved in grapevine leaf and fruit development were to elevate the involvement of functional genes, which are responsible to trigger the plant growth at reproductive and vegetative stages. The identified transcripts during recent study and their functional characterization will be helpful to understand the biosynthetic pathway and its regulation during reproductive and vegetative developmental stages in higher plants. Therefore, we used gene clustering and the enrichment of Gene Ontology to analyze the different and same genes and the biological networks involved. RNA sample from four stages of fruits and leaf were indexed and total number of sequencing reads were generated for each leaf growth and developmental stage specific, the totals of 272,941,656 reads were generated from leaf at four developmental stages. KEGG annotation results depicted that the highest number of transcripts in 2963 (2Avs4A), followed by 1Avs4A (2920) and 3Avs4A (2294) out of 15,614 (71%) transcripts were recorded. In comparison, a total of 1532 transcripts were annotated in GOs, including Cellular component, with the highest number in "Cell part" 251 out of 353 transcripts (71.1%), followed by intracellular organelle 163 out of 353 transcripts (46.2%), while in molecular function and metabolic process 375 out of 525 (71.4%) transcripts, multicellular organism process 40 out of 525 (7.6%) transcripts in biological process were most common in 1Avs2A. While in case of 1Avs3A, cell part 476 out of 662 transcripts (71.9%), and membrane-bounded organelle 263 out of 662 transcripts (39.7%) were recorded in Cellular component. However in fruit total 28,808,716, 27,941,132, and 25,457,565 reads from 40 DAF, 65DAF and 90 DAF respectively clean reads

(100%) were generated. From the total reads, Total mapped reads (23.58%), total unmapped sequences reads (76.42%), unique matches (19.93%), multiple matches (3.65%) and perfect matches (13.73%) were recorded. 32 transcripts in the early stages of fruit growth including alcohol dehydrogenase (8), hydroxymethylglutaryl-CoA synthase (3), pyruvate decarboxylase (5), lipoxygenase (LOX) (3), carotenoid cleavage dioxygenase (9) were predicted. In comparison between fruits and leaf many gens showed differentially expressed during vegetative and reproductive phases. In fruits, the biosynthesis of several polyphenol oxidase compounds, tannins and hydroxycinnamoyl-Coenzyme A shikimate precursor's takes place during the intuitional growth phase, and inorganic pyrophosphatase accumulate in the vacuoles, with myb-like HTH transcriptional regulator family protein and malic acid reaching a peak concentration before veraison and then decreasing throughout the second half of the growing season. In case of leaf photosynthetic electron transfer C, myb-like transcription factor family protein, myb domain protein 12, myb-like HTH transcriptional regulator family protein, SAUR-like auxin-responsive protein family, endoplasmic reticulum auxin binding proteins were regulated during in the growth networks and development.

## Potential application of molecular markers in improvement of vegetable crops

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In order to meet the ever increasing demand for vegetable production, crop improvement is an important strategy. Crop improvement can be taken in terms of yield, quality and resistance to biotic (insects, pests & diseases) and abiotic (drought, temperature stress, salinity, alkalinity etc.) factors. Molecular markers are widely used now because of the fact that their inheritance can be monitored easily and show high level of polymorphism. They are just like tags and help in

identification of specific gene. Genetic mapping of disease resistance genes will help to improve the efficiency of plant breeding program and it will lead to better understanding of the molecular basis of resistance. Selection of efficient genotypes in any breeding program can be made possible by Marker-assisted selection (MAS). Therefore, MAS is using in the crop improvement program and also useful for the efficient selection of many resistance genes for pyramiding into a single genotype.

DNA bar coding is an innovative method that utilizes a short length DNA regions registered as DNA barcode for species investigation, by comparing the particular bar coding regions with the sequences already placed within the reference library. DNA bar coding started in 2003 and despite the knowledge about DNA bar coding, DNA bar coding of grasses was not well understood. Here in this research we used CTAB method to extract DNA from grasses sample. Those samples which showed the positive response to the CTAB protocol after gel electrophoresis were analyzed by PCR. Study showed that the *Rbcl* and *Mat-k* has the potential as the bar code markers. Seven samples showed positive results for the *Rbcl* and only 4 were positive when Mat-k was used as the primer. Out of these two primers *Rbcl* has more potential to be used as the barcode marker as it showed more positive results as compared to the *Mat-k*. Using these markers, we identified the samples up to the generic level. The samples were identified by the taxonomist. Phylogenetic and evolutionary tree analysis revealed their convergence and divergence with the closely related species. The phylogenetic tree and evolutionary trees were constructed with the aid of MEGA7 software. In this study, we concluded that *Rbcl* and *Mat-k* are the potential markers for barcodes in grasses and they resolved the grasses till the generic level. The

finding of this study suggested that *Rbcl* is an effective barcode at generic level as compared to *Mat-k*.

### Intraspecific barcodes in locally grown apple cultivars of Balochistan

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*Malus domestica* L.also termed as *Pyrus malus* and wildly known as *Malus sieversi* has been known since thousands of years, this specie has been grown in the areas regarding Asia and Europe, considered one of the ancient fruit trees. DNA barcoding an innovative scientific device that utilizes a short length DNA regions registered as DNA barcode for species investigation, by comparing the particular barcoding regions with the sequences already placed within reference library. Current study utilizes six varieties of *Malus domestica* i.e Mashadi, Red Delicious, Golden Delicious, Katy, Nazukbadan and Amrai locally grown with two regions of DNA barcoding markers viz. mat-k and rbcL. Study also involves the utilization of various bioinformatics tools like BLAST, Multiple Sequence Alignment with Bio-edit, SNPs identifier, Phylogenetic analysis with MEGA5, etc. The finding of current study suggests that mat-k is an effective barcoding locus at species and varietal level as compared to rbcL in all varieties of Apple. Whereas it also suggest that software and molecular technology can effectively use for identifying single nucleotide polymorphism (SNP) and it reveals two unique SNPs in rbcL samples and five unique SNPs in mat-k samples.

### Identification of rose mutants *via* morphological and SSR markers

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Rose is a flowering ornamental used as cut flower, indoor potted plant, in landscape designs, and for the extraction of essential oil. *Rosa borboniana*, *Rosa centifolia* and *Rosa gruss-an-teplitz* are tall rose species but have small flower

size, which is not a desirable character as the essential oil content is dependent on flower size. To overcome these problems *in vitro* mutation with gamma radiation and colchicine was induced and the surviving mutant lines were investigated using morphological and genetic markers i.e., simple sequence repeat (SSR). Remarkable variations were noticed for different morphological traits among the putative mutants. Maximum plant height and flower diameter was noticed in mutants of *R. centifolia* treated with colchicine. Fourteen SSR primers were selected to detect genetic variations among the mutants. Clusters were made using unweighted pair-group method with an arithmetic average (UPGMA) analysis on the basis of close resemblances of these genotypes based on morphological characters and SSR markers. Both SSR and morphological markers showed more diversity among mutants produced through colchicine. This approach is useful due to its simplicity and rapidity for identification of mutant lines which will be helpful for further improvement of desired characteristics in these mutants.

# Production Techniques for Horticultural Crops

**Practical strategies to sustainably plant citrus trees in huanglongbing infected region**

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Huanglongbing (HLB), first reported in China in 1919, has been the most devastating citrus disease in the world. To date, there still lacks HLB-tolerant germplasms and practical therapeutic method for HLB. Asian citrus psyllid (ACP, *Diaphorina citri*) is the vector of HLB, and then to efficiently kill the ACP is the main strategies for HLB control. Ponkan tangerine (*Citrus reticulata*) is one of the most HLB susceptible cultivars and over 80% of Ponkan orchards in Chinese Yongchun County have been ruined since HLB broke out in 2000. In the last five years, we developed practical strategies to restore Ponkan tangerine industry in Yongchun County, P.R. China. These practical strategies include using disease-free seedlings, correctly identifying HLB field symptom, frequently cleaning out the orchard, establishing ecological isolation system and completely killing the psyllid. Scouting for HLB infected trees should be done routinely so that infected trees can be removed in time and replaced with healthy trees. Moreover, it is crucial to control the psyllid at the right time by using high-efficiency insecticide-spraying technique and reliable shoot-controlling technique. By adopting this pattern, the 4-year-old tree has the height of about 2.0 m and the average yield of 30 kg per tree; the percentage of the HLB infected tree is below 1%. Moreover, over one thousand hectares of Ponkan tangerine were restored by using the current practical strategies in Yongchun County.

## Modern olive production technology

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Olive tree is cultivated primarily in the Mediterranean basin but now its cultivation is expanding to other new countries, including Pakistan, due to the health benefits of extra-virgin olive oil. In Pakistan, *Olea europaea* var *sativa,* can be cultivated, as it possess the same environmental requirements like local wild species, *Olea cuspidata*. Olive industry is easy to be achieved in the new areas where it performs several functions beyond the production of fruits. Preliminary specific trials are required to start its cultivation in new areas, by using several varieties in different micro-climatic zones. It is fundamental for new areas to pay attention for the emerging problems, like *Xylella fastidiosa*. Propagation should be focused on rapid and economical plant production through uni-nodal cutting or micro propagation and possibly to avail genetic and phytosanitary certification. Currently the extensive plantation is almost abandoned, and the new olive culture is focused on the intensive and super-intensive plantation systems. Thus, it is prerequisite to establish genetic improvement programs to produce new varieties and rootstocks. Proper irrigation, for both intensive and super-intensive orchards, is essential for a rapid development of foliage in the early years of planting, for early onset of fruit and to reduce alternate bearing. In order to improve the water use efficiency and optimize fruit and oil quality, the deficit irrigation strategies are recommended. It is very important to adopt balanced and appropriate fertilization by considering: the real nutrient needs at different stages; soil nutrient availability, fertilization techniques and organic or conventional management. Mechanization of olive orchards has rapidly increased in recent years with the increase of high and super-high density systems. Currently the implementation of modern machines, like for plant protection, designed both for sloppy and flat soil, have not only changed the fate of manual cultural practices but also the plant training, pruning and harvesting systems.

**Identification and allelopathic mechanism of green garlic volatiles on cucumber seedlings**

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At present, the research on plant volatiles has been on the rise in the world. It has become a new trend to study the mutual response and its mechanism with neighbouring plants, microorganisms and insects. Volatile route is an important way to release allelochemicals. The allelopathic effect of garlic has been widely used in the field of curtailment of crop continuous cropping obstacle. Scientists studied systematically the transformation of garlic allelopathy from bulb extract, garlic seedling volatiles, root exudates, straw extract and decomposed matter. Allelochemicals in different garlic parts were identified, but mostly extracted by solvent extraction method. The identification of natural volatile allelochemicals of green garlic has not been reported, and its allelopathic effects were relatively few. In this study, Green garlic (Garlic cv. Gailiang) volatiles was collected by headspace solid-phase microextraction method and analyzed by gas chromatography-mass spectrometry (GS/MS). The results show that diallyl disulfide (DADS) is the main compound of green garlic volatiles. Studied the allelopathic activity of green garlic volatiles and DADS on cucumber (cv. Changchunmici, CCMC) leaves. The results show that DADS is the main allelochemical of green garlic volatiles. On this basis, we further studied the allelopathic mechanism of green garlic volatiles and DADS on the growth and physiology of cucumber seedlings. Both of them can promote the growth of cucumber seedlings and increase the antioxidant enzyme activities and the accumulation of active oxygen.

**Heavy metals contamination in vegetables grown in peri-urban areas**

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There is shortage of fresh water in Pakistan to irrigate agricultural lands. This shortage is being met by continuous application of waste or sewage water for raising vegetables near cities that may lead to the accumulation of heavy metals in soils and edible parts of vegetables. The intake of excessive levels of heavy metals causes gastrointestinal, pancreas and urinary bladder cancer in humans. The current safety status of vegetables in Pakistani thus ranks much below as compared to international standards. Therefore, accumulation of heavy metals in different plant parts of some selected vegetables (tomato, okra, spinach, cauliflower and carrot) grown around Multan city was assessed and quantified. Data were also collected on various growth yield parameters of these vegetables. The samples of roots, fruits/pods, leaves, curds and other parts of these vegetables were collected from different sites. All the vegetable samples were processed using standard procedures and analyzed for lead (Pb), nickel (Ni), copper (Cu), cadmium (Cd), iron (Fe) and chromium (Cr). The results revealed that growth and yields of all the studied vegetables were increased with using sewage water compared with canal and tubewell water. Sewage water application also resulted in greater accumulation of heavy metals in all edible parts of the vegetables and in most of the samples, the contents of these metals were above the maximum permissible limits set by WHO. Whereas, lower heavy metals content contents were recorded in tubewell water-irrigated vegetable samples, which were within safer results. It was concluded from the present study that the vegetables grown with sewage water were contaminated with heavy metals and are not safe for human consumption. Consumption of these metals beyond the recommended limits causes toxicity and human health risks.

**Effect of different sources of irrigation water on fruit quality and heavy metal contamination in mango**

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In peri-urban areas, waste water is used to irrigate orchards due to scarcity of fresh water which increase the heavy metal contents in soil and fruits which are toxic for human health. Due to excessive waste water irrigations, heavy metals enter into the food chain and eventually cause chronic and metabolic disorders in humans. Farmers still prefer waste water because it is also a rich source of plant macro and micro nutrients which decrease the fertilizer cost and produce better quality fruits. The present study was carried out to determine the effect of various irrigation water sources (canal, tubewell, sewage) on quality of mango fruits and accumulation of heavy metals in soil and fruits. Soil, water and fruit samples of seven cultivars of mango (Anwar ratul, Dusehri, Safed chaunsa, Samar bahisht chaunsa, Kala chaunsa, Anwar ratul late and Mehmood Khan) were collected from different mango orchards located in peri-urban areas of Multan and analyzed for some physical and chemical attributes and heavy metals contents. Fruit fresh weight, dry weight, peel and pulp color, texture, aroma, flavor, eating quality and shelf-life were not affected by the water of different sources. However, TSS, pH, TA, ascorbic acid content, total phenolics, total carotenoids, total flavanoids and antioxidant activity were greater in sewage irrigated fruits. The analysis also depicted that copper and nickel content was higher in sewage water and its accumulation was greater in sewage water irrigated soil and fruit samples as compared to canal and tubewell water irrigated ones. Regarding the mango cultivars, Samar bahisht chaunsa accumulated more copper content, followed by Safed chaunsa and Dusehri as compared to other cultivars. Zinc and cadmium remained undetectable being very minute in quantity.

**Effect of seed priming on germination and seedling growth of papaya (*Carica papaya* l.)**

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Seed priming before sowing is well documented to improve germination and emergence rate of diverse crop species. A pot experiment was conducted to observe the efficacy of seed priming on germination and seedling growth of the Papaya. Seeds of three different Papaya varieties including White beauty, New sunrise and Mango were used in the current study. The seeds of all investigated varieties were soaked in distilled water, 1%, 2%, 3% and 4% potassium sulphate solution (w/v) for 18 hours. However, seeds that were not primed were taken as control. All primed and unprimed seeds were planted in earthen pots containing potting medium. The potting medium was prepared by mixing equal ratio of sand, farmyard manure and garden soil. The results revealed that all the observed parameters in the current study were significantly influenced by seed priming treatments. However, interaction of seed priming and varieties was found non-significant for most of the parameters. The results exhibited that germination and other germination related attributes of the papaya seeds were observed decreased with the increasing concentration of potassium sulphate i.e. from 1% to 4%. However the length and weight of shoot and root were observed increased with the increasing concentration of potassium sulphate solution. The best results for most of the germination related parameters obtained from the priming treatment where potassium sulphate was used at 1% with germination percentage (74.45), germination index (2.25) and seedling vigour index (983.91). The minimum days to germination (3.45) was observed from the treatment where distilled water was used alone. The maximum shoot length (6.27 cm), root length (16.22 cm), fresh weight of the shoot (0.7556 g) and fresh weight of the root (0.0776 g) were observed from the priming treatment where potassium sulphate was used at 4%. The varietal comparison showed that White beauty had the highest germination percentage (65.56), germination index (1.51) and seedling vigour index (739.45). However maximum shoot (6.30 cm) and root length (14.12 cm) were observed in

New Sun rise as compared to White beauty and Mango. There was no significant differences among varieties for mean germination time, fresh weight of shoot and root.

## A case study of China

Farmers aim to ensure that the safety and quality of their products will satisfy the highest expectations of the food industry and consumers. In addition, on-farm practices should ensure that arable and vegetable crops are produced under sustainable economic, social and environmental conditions. Good management of a farming system constitutes the grassroots of the system's economic, environmental and social sustainability. Farmers shall have taken into consideration applying the principles and practices to the whole farm system within a philosophy of continuous improvement. The application of modern farming techniques to fruit production will ensure good yield with quality products to consumer. The current study include case study of Republic of China for production of various fruits, observed during training under scholarship of Chinese Academy of Agriculture Sciences. Scientists and farmers employ the modern farming and cultivating techniques which results into good yield with high quality products. They ensure the freshness of fruits during ripening and produce many varieties of a fruit keeping in mind the market demand. The varieties of pear observed include, Dangshansuli, Yali, Chil, Pingguoli, Quibaili, Nangouli, Jingbaili, Baozhuli and Dongguoli. Further, they produces many products from these varieties like, juices, syrup and cane products which give more benefits to producer. For the production of world class apple varieties they utilize world six leading production system. They also control different diseases by various modern techniques to get disease free fruits and to get more yields. The workers are properly trained to harvest fruits in best possible way. The

application of modern techniques not only ensures good quality products but also improve the living of poor farmers by more benefits.

**Evaluation of novel specialty cut flowers in Punjab Pakistan**

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Favorable agro-climatic conditions and comparatively cheaper and readily available human resources offer a promising business opportunity to cut flower production in Pakistan. Presently, growers are limited to traditional cut flower crops such as rose (Rosa hybrids), gladiolus (*Gladiolus* hybrids), marigold (*Tagetes erecta*), and tuberose (*Polianthes tuberosa*) because of unavailability of improved new species and cultivars. To diversify cut flower production in Pakistan, a study was conducted to evaluate the production performance of different cultivars of novel specialty cut flower crops, viz. delphinium (*Delphinium* hybrids), lisianthus (*Eustoma grandiflorum*), ornamental kale (*Brassica oleracea*), snapdragon (*Antirrhinum majus*), stock (*Matthiola incana*), sunflower (*Helianthus annuus*), statice (*Limonium sinuatum*) and zinnia (*Zinnia elegans*) in Punjab, Pakistan. Seeds were imported from Ball, Sakata, Syngenta and Takii, USA, sown in 128-cell plastic germination trays, transplanted at 2-4 true leaf stage in thoroughly prepared flat beds in open field and evaluated for stem length, number of marketable stems per plant, and production time (days). 'Guardian White' delphinium had the shortest time to harvest first marketable stems (160 days) with comparatively shorter stems (87.7 cm). Whereas 'Aurora White' and 'Aurora Blue' were high-temperature tolerant and produced attractive racemes with longer stems; 112.0 and 99.7 cm, respectively. All cultivars lasted about 7 days in distilled water (DW). 'Cheerful White' stock had the shortest cropping time and produced highest quality double flowers with longest stems (51.8 cm) compared with other cultivars tested. 'Lucinda Dark Rose Double' stock produced shorter stems than 'Cheerful White'. 'Appleblossom' snapdragon produced >10 marketable stems per plant with highest quality attractive flowers. Tested exotic cultivars of lisianthus, ornamental kale, sunflower and zinnia also performed well, however, nursery raising of lisianthus proved difficult compared

to all other tested species. Among tested species/cultivars, all exotic species/cultivars produced uniform high quality stems resulting in higher productivity and were favourably appraised by flower growers/retailers and are best suited for diversification of local cut flower industry.

**Application of biochar in potting substrate for the sustainable production of *Syngonium podophyllum***

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Peat usage as organic component in potting substrates is deteriorating the wetlands that are the potential source of ecological services for the environment. Biochar amendment in potting substrate as organic component has sought to be the potential to replace peat for the sustainable potted plant production. In the current investigation, we evaluate the potential of 5% wheat straw biochar in the different media mixes on the growth parameters of *Syngonium podophyllum.* The experiment was planned according to Complete Randomized Design (CRD). Different parameters including plant height (cm), number of leaves, leaf area ($cm^2$), stem diameter (mm), number of side shoots, intermodal distance (cm), leaf visual quality, leaf fresh weight (g), leaf dry weight (g), root length (cm), roots fresh and dry weight was measured. The results indicated that biochar amendment significantly influenced the selected parameters. The maximum plant height (33.5cm) and number of leaves (18.67) were observed in the media mixes containing the soil + leaf compost along with the biochar amendment compare with the control (Garden soil). The leaf fresh, dry weight and intermodal distance were maximum in the potting mix comprising of soil + farmyard manure + leaf compost + biochar. The media mixes comprising of soil + biochar attain minimum root fresh, root dry weight and number of side shoots. The minimum value for the leaf visual quality was observed in the treatment comprising of soil + leaf compost. It is concluded that biochar amendment has the potential to replace peat and for the quality production of *Syngonium podophyllum*.

**Influence of seasonal variations on fruit quality of raspberries cultivated in open field, high tunnels and greenhouse**

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The shift of berry production from open field to new growing techniques (Often covered with plastic or under green house) have begun more strongly due to uncertain climatic conditions especially in north Europe where the climatic conditions are not favorable for open field production. The production under these growing systems and cultivation methods may affect the synthesis of primary or secondary plant metabolites due to pre-weather conditions available during fruit growth. In the present study, significant differences were found for different years, times of harvest, and their interactions with storage time. The content of total sugars increased from early to late harvest by 16% and 62% in the two investigated years in GH production, and by 24% and 48% in OF production, though it decreased by 30% and 15% in HT production. Anthocyanin content varied significantly with time of harvest, though no consistent pattern was found, and it increased in general during storage. The ellagic acid content in general decreased from early to late harvest time in all production systems, while the vitamin C content was lower in HT and OF raspberries at the end of the season. The content of total phenolics in the OF raspberries was twice in one of the investigated years as compared with the other, while smaller differences between years were found in GH and HT production. In average for both years, no changes during storage were found in the content of vitamin C, total phenolics and ellagic acid. In conclusion, the sugar concentrations showed the greatest variability, with differences between years, within season, and during storage. Time of harvest seemed often to influence the size of the changes in sugar content during storage. Storage led to sweeter fruit with higher color and in general with no negative consequences on the content of bioactive compounds.

**Leguminous cluster bean affects the performance and economics of intercropped non-leguminous okra and chilies**

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Mixed cropping system has been introduced in areas where water availability is low than desired level for crop production. Intercropping enhances economic insurance by growing more than one vegetable per unit land with efficient use of resources. An efficient intercropping system depends on the selected crops having competitive ability regarding time or space as well as choices on time of planting, density and arrangements. Therefore, present study was conducted to find out the effects of cluster bean (a leguminous vegetable) intercropping on the biological efficiencies, yields and economics of okra and chilies (non-leguminous vegetables). Significantly taller plants (79.57 cm) of cluster bean were observed when cluster bean was grown alone as compared with when intercropped with okra and chilies. The significant increase in the number of pods (49.47) of cluster bean was noticed when cluster bean was grown alone or intercropped with chilies (45.53). The maximum number of pods per plant (12.40) of okra was counted when okra was grown as a sole crop and the minimum number of pods (11.17) was recorded when okra was grown with cluster bean. Higher number of fruits (44.65) and the maximum fresh fruit weight per plant (62.45 g) of chilies were recorded when it was grown alone as compared with when intercropped with cluster bean. Economic analysis showed that the maximum marginal rate of return was achieved when cluster bean was intercropped with okra, while the least marginal rate of return was observed when cluster bean was intercropped with chilies, which was still better than cluster bean alone.

# Foliar application of oxalic acid improves plant growth and fruit quality of strawberry

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Strawberry (*Fragaria x ananassa* Duch.) is a high-value fruit crop and a rapidly expanding farming business in Pakistan. It produces aggregate fruits that are highly perishable but scrumptious and rich in vitamin C, unsaturated fatty acids and minerals like Fe, Mg and Mn. Herbaceous small plant and low-lying fruit of strawberry is very much susceptible to high temperature stress and fungal infection. So, extensive spray program of insecticide, fungicides, nutrients and phytohormones is practiced to reduce yield and quality loss and earn maximum profit. In this scenario, there is great need to explore better and economical strategies with least residual threats to consumers. Even though, oxalic acid has long been known to enhance plant biomass and fruit size and improve fruit textural properties in various crops but its potential use as foliar application on strawberry cultivation in Pakistan has not been evaluated under field conditions. In this study, field-grown strawberry plants cv. Chandler were foliar sprayed with 1, 2 or 3 mM oxalic acid at flowering stage at 15 days intervals. Though, oxalic acid enhanced root-to-shoot ratio (0.44-0.63) and root weight ratio (0.10-0.19 g/g) of all treated plants compared to control but other vegetative growth-related attributes of strawberry plants were influenced differentially by different concentrations of foliar-applied oxalic acid. Specific leaf area (0.25 $m^2$/g) and leaf area ratio (0.15 $m^2$/g) were enhanced only when oxalic acid was sprayed in lower concentration i.e. 1 mM whereas higher doses of oxalic acid (2 mM and/or 3 mM) suppressed leaf chlorophyll (1.04-0.57%) development, leaf area (12.04-0.88 $cm^2$) and leaf area ratio (0.08-0.06 $m^2$/g) and number of flowers (51.66-36.65) on strawberry plants. From yield perspective, number of fruits (23.64-39.50) and harvest index (0.0006-0.003 g/g) were also improved regardless of the

concentration of oxalic acid. Biochemical analysis revealed that all oxalic acid applications enhanced pH (3.13-3.19), ascorbic acid (83.56-116.62%) and non-reducing sugar (0.89-58.29%) contents in strawberry fruits whereas increase in fresh fruit weight (14.94-9.35 g) and total titratable acid (0.31%) contents were negatively impacted by 2 mM and/or 3 mM of oxalic acid. Leaf weight ratio, stem weight ratio, and fruit dry weight were not influenced by oxalic acid treatment. These findings suggest that foliar application of 1 mM oxalic acid favours vegetative growth, and enhances yield and fruit quality of strawberry cv. Chandler. It would be intriguing to further explore its use in other high-value crops and integrate with commercially available growth promoting formulations.

**Soil and petiole micronutrient content of grape orchards of Kashmir and their relationship with quality and yield of grape berries**

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Micronutrient deficiencies have an impact on the quantity and quality of grapes and nutrition is therefore the key component in viticulture. Since micronutrient status of main grape producing area of Kashmir has not been documented so far, therefore a systematic investigation was carried out to study the micronutrient status of grape orchard soils of Kashmir. Fifteen orchards with uniform age and vigor were selected and surveyed (simple random survey) for the purpose of collection of soil, petiole and fruit samples. The soil samples were collected from three depths viz; 0-30 cm, 30-60 cm and 60-90 cm. The samples were processed and analyzed for different parameters. The soils belonged to three textural classes viz; silt loam, loam and clay loam. The available iron, manganese, zinc, copper, boron and molybdenum content of surface soils ranged statistically from 32.16 to 35.51, 33.55 to 36.74, 1.28 to 1.36, 1.58 to 1.66, 0.55 to 0.62 and 0.19 to 0.26 ppm with mean values of 33.84, 35.14, 1.32, 1.62, 0.58 and 0.22 ppm, respectively and 30.67 to 33.48, 32.15 to 34.69, 1.15 to 1.24, 1.36 to 1.42, 0.45 to 0.50, 0.12 to 0.15 ppm with average values of 32.08, 33.42, 1.20, 1.39, 0.48 and 0.14 ppm, in sub-surface soils, respectively. Further it was observed that majority

of soils were high in available iron, manganese and zinc and medium in available copper, boron and molybdenum content. Iron, manganese, zinc, copper, boron and molybdenum content of vineyards varied statistically from 131.88 to 139.19, 35.70 to 40.90, 29.68 to 37.00, 11.40 to 12.73, 22.95 to 26.07 and 0.33 to 0.42 ppm with mean values of 135.53, 38.30, 33.34, 12.06, 24.51 and 0.37 ppm, respectively. The total soluble salts, total sugars, acidity and anthocyanin content of grape berries varied statistically from 22.06 to 23.12, 13.84 to 14.69, 0.35 to 0.43 and 0.02 to 0.03 per cent with average values of 22.59, 14.27, 0.39 and 0.03 per cent, respectively. The yield of grape orchards statistically showed a variation from 1.80 to 1.84 t $ha^{-1}$ with an average value of 1.82 t $ha^{-1}$.Soil potassium, sulphur, iron, zinc and boron and petiole potassium, manganese and boron contents revealed significant and positive correlation with total sugars. Available iron, manganese, zinc, copper and boron showed positive and significant correlation with acidity. Anthocyanin content indicated positive and significant correlation with available boron and petiole born. Available petiole manganese and boron contents showed significant and positive correlation with grape yield, the present investigation though first of its kind is believed to be useful for researchers and farmers to earn profitable returns from grape cultivation.

**Aggregate associated and mineralizable carbon under different agricultural land use systems of Central Kashmir, India**

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The investigation was carried during 2015-16 in soils of central Kashmir; two districts (Gander bal and Srinagar) and four land-use systems (crop land, agro-forestry, grassland and forestry) were selected to study the effect of land-use on soil carbon sequestration. Under different land-use systems, macro-aggregate associated C in the soils of Gander bal and Srinagar varied from 173.0 to 7378.2 and 706.3 to 10203 mg $kg^{-1}$, respectively, and micro-aggregate associated C ranged from 986.9 to 2123.6 and 2549.7 to 5065.0 mg $kg^{-1}$, respectively. Macro-

aggregates were richer in aggregate associated carbon at both the locations as compared to micro-aggregates. The proportion of macro aggregates (0.25 to 2 mm) and associated C was higher in grassland and proportion of micro aggregates (0.1-0.25 mm) and associated C was higher in agro-forestry, in soil Gander bal, and in Srinagar, among the different land-uses, the macro-aggregate (0.25 to 2mm) proportion and associated C was higher in grassland, and the proportion of micro-aggregates (<0.25 mm), and associated C was higher in agro-forestry followed by forestry, cropland and grassland. The cumulative carbon mineralized ($C_{min}$) in 43 days of incubation under different land-use systems of Gander bal and Srinagar, respectively, ranged from 133.4 to 548.6 and 142.8 to 885.8 mg $kg^{-1}$ of soil. Amount of C was mineralized was highest in the grassland followed by forestry at Gander bal, and the agro-forestry followed by forestry at Srinagar. Therefore land-use change has great potential to sequester carbon and thus change from cropland to forest or grassland has a high global sequestration rate.

## Studies on honey bee pollination for enhancing fruit set and production of apple in cold arid conditions of India

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Apple orchards are one of the major attractions in hills and contribute to farmer's economy. However, due to climatic variations and poor pollination, quantitative and qualitative production is still not been achieved. Research has indicated that honey bees are significant pollinators for temperate fruit crops by influencing fruit setting pattern and reducing premature fruit drop. The area under apple has increased consistently but the production and productivity has not shown a proportional trend. Several factors have been identified that affect apple productivity in the state. Apple being cross-pollinated depends upon insects for pollination and maintaining apple productivity. The problem of inadequate pollination and poor fertilization due to lack of pollinating insects, pollenizer cultivars and inclement weather conditions are considered to be some of them. Studies conducted on the role of honeybees in the pollination and fruit set in apple revealed that *Apis mellifera* played a significant role along with pollenizer

cultivars and favorable weather. Due to paucity of pollen sources in the orchard, it is desirable to plant at least three pollenizers like Golden Delicious, Red Gold, Starkrimsom, Tydman's Early Worcester, Granny Smith, Lord Lambourne, and McIntosh. Honeybees are known to be the most important pollinating insects in apple orchards as they form the great majority of pollinating insects. The recommended proportion of the pollinizing trees in apple orchards is 33.33 per cent. However, most of the orchards in the country especially cold arid region are having low pollenizer proportion. In orchards with low population of native pollinators, introduce *Apis mellifera* colonies at flowering for adequate fruit set (more than 5%) and yield. There was significant increase in apple yield in the orchards where bees were kept. At Leh, an increase of 123.8 and 56.3 per cent in apple yield respectively was recorded during 2012 in the orchards having sufficient and insufficient pollenizer proportion due to placement of honeybee colonies. In 2013, an increase of 47.50 and 34.40 per cent was recorded, respectively in apple orchards with sufficient and insufficient pollenizers. These studies suggested that for enhancing the productivity and improving the quality of apple fruits, pollination services through bees is of significant value.

## Influence of soil properties on boron adsorption and desorption in temperate soils of lesser Himalayas

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Boron adsorption on soil particles reduces its concentration in the equilibrium solution. The adsorption isotherm was curvilinear that could be resolved into two linear parts, and fitted to Langmuir equation that indicated first adsorption maxima (b1) 34.84 g B $g^{-1}$ soil in Sagipora soil and the bonding energy (k) constant at 0.313 ml $g^{-1}$in Anantnag soil. The Langmuir isotherm best explains the adsorption trend at low concentrations of the adsorbent, which of course was different for different soils. There was significant correlation between b1 and clay ($r \neq 0.565^{*}$), organic matter contents ($r \neq -0.412$), and cation exchange capacity (CEC; $r \neq 0.506$) of soils. A linear affiliation was observed in all the soils at all

concentration ranges between 1 and 100 mg B $L^{-1}$, indicating that boron adsorption data conform to the Freundlich equation. Soils that have a higher affinity for boron adsorption, like Sagipora , tended to desorb less amount of boron, that is, 25.5%, whereas Kangan desorbed 53.2%, Shopian soil 42.7% and Shalimar desorbed 42.6% and of the adsorbed boron. Boron desorption by these soils is positively and significantly correlated with the sand content ($r \neq 0.662$) and negatively with clay content ($r \neq -0.479^{*}$) and CEC ($r \neq -0.587$). The maximum value of 50.76 mg $g^{-1}$ for desorption maxima (Dm) was observed in Sagipora soil and also a constant related to B mobility (Kd) was found to be maximum in Khag soil (0.412 ml $kg^{-1}$) soil. Note: * $P<0.05$; ** $P<0.01$.

**Soil health management through carbon sequestration under climate change**

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The increase in atmospheric concentration of carbon dioxide from fossil fuel combustion and land use change necessitates identification of strategies for mitigating the threat of the attendant global warming. Since the industrial revolution, global emissions of carbon (C) are estimated at 270±30 Pg (Pg = petagram = 1015 g = 1 billion ton) (IPCC, 2000) due to fossil fuel combustion and 136±55 Pg due to land use change and soil cultivation. Soil organic C (SOC) plays an important role in the global C cycle. It is generally assumed that soils are the largest C sinks in terrestrial ecosystems. Soils act as a source or a sink of atmospheric CO2 and contain approximately twice the amount of C in the atmosphere, and about three times the amount in vegetation. Soils have the ability to store C for long periods of time; thus, changes in the size of the soil C pool could significantly modify the atmospheric carbon dioxide concentration. Carbon sequestration is a crucial strategy for reducing atmospheric carbon dioxide concentration, contributing to climate change mitigation. Globally, soil C pools

contain approximately 1550 Gt of organic C in the top 1 m (from a total of approximately 2500 Gt C), and SOC sequestration is estimated at 0.4 to 1.2 Pg C $yr^{-1}$ , equivalent to 6–20 % of the annual release from fossil fuel combustion. Projected climate change may affect soil moisture and temperature regimes. At the ecosystem level, the soil affects vegetation through its influence on water availability, elemental cycling and soil temperature regime. A considerable part of global warming can be restored through conversion of marginal lands into restorative land uses, adoption of conservation tillage with cover crops and crop residue mulch, nutrient cycling including the use of compost and manure, and other systems of sustainable management of soil and water resource. The soil C sequestration is a truly win–win strategy. It restores degraded soils, enhances biomass production, purifies surface and ground waters, and reduces the rate of enrichment of atmospheric carbon dioxide by offsetting emissions due to fossil fuel.

## Impact of nitrogenous fertilization and boron on growth, flowering, fruiting, yield and yield efficiency of plum tree cv. Santa rosa under rain fed conditions of Kashmir valley

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The aim of the study was to examine the impact of nitrogenous fertilization and boron on growth, flowering, fruiting, yield and yield efficiency of plum tree. The experiment was carried out in a 7 year old private plum orchard near SKUAST-Kashmir, Shalimar Campus Srinagar, J&K during 2012 and 2013. Thirty six trees of uniform growth and vigor were selected for experimentation. The effect of four nitrogenous fertilizer treatments at different times of applications was studied on plum. The treatments were replicated thrice in Factorial Randomized Block Design. The results showed that various growth parameters like incremental tree girth, shoot extension growth, plant height, plant spread, and leaf area were significantly influenced by the treatment of urea 500g full dose in spring.

Commencement of flowering and date of full bloom were recorded in 3rd and 4th week of March under the treatment of calcium nitrate 1450g + 50g borax full dose in spring during both the years of studies. Maximum fruit set and minimum fruit drop were recorded under the treatment of calcium nitrate 1450g + 50g borax full doses after harvest and urea 500g full dose in spring respectively. Whereas the maximum harvest/maturity period of 106.33 days was recorded under the treatment of calcium nitrate 1450g + 50 g borax full doses after harvest. The highest fruit yield of 20.46 kg/tree and highest yield efficiency of 0.44 kg/$cm^2$ was recorded under the treatment of Calcium nitrate 1450g + 50g borax full dose after harvest during the studies. Thus, it may be concluded results showed that among various sources of nitrogenous fertilizer and boron can be considered as best fertilizer application in plum orchards for improving the growth, flowering, fruiting, yield and yield efficiency of plum tree.

## Effect of malathion on yield and AMF colonization in *coriandrum* (*Coriander sativum)*

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Malathion is a non-systemic broad spectrum organophosphate insecticide which is used for controlling sucking and chewing insects on fruits and vegetables. It has been analyzed that effects of different concentrations of malathion on yield and AMF colonization in *Coriandrum sativum*. It was found that, at recommended and low dosages, coriander does not show any significant reduction in yield and AMF infection percentage, but higher concentrations reduced yield and AMF infection percentage of coriander.

# Effect of environment on flowering, quality and production in temperate fruits

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Plants are affected by the environment during all stages of growth and development. So far as fruit crops are concerned Environmental factors affect more on Flowering, Quality and Production. Having a profound effect on plant phenotype, environmental factors determine the extent to which genotypic potential is expressed. An understanding of the response of fruit crops to environmental variables (i.e., Temperature, Light, Moisture, Wind, Hailstorms, Relative Humidity, Frost and Rainfall etc.) is crucial to minimize the deleterious impact of suboptimal environmental conditions and to manage crops for maximum productivity.These factors determine the suitability of a crop for a particular location, cropping pattern, management practices, and levels of inputs needed. A crop performs best and is least costly to produce if it is grown under the most favourable environmental conditions. Increased environmental variability in terms of rise in temperature, shifting rainfall pattern, and incidences of extreme weather events like severe drought, flooding, etc., have now started posing a real threat to the production of agricultural/horticultural crops and natural resource management. Unfavorable environmental condition at global and national level is certainly impacting horticulture and affecting temperate fruit production and quality and have important impacts on pollination, bee activity, fruit set efficiency, fruit retention, fruit quality and production which surely affect both growers and consumers. Environment also poses a great influence on the severity of various physiological disorders and diseases in fruits crops. In this regard all the possible efforts should be taken into consideration while strengthening mitigation strategies like crop improvement, diversification with other high value fruit crops like peach, apricot, walnut, kiwi and olive. It is therefore clear that the Development of new genotypes having resistance to such stresses will help to minimize the effects of environmental stress at farm, regional,

national and international level which can go a long way in area expansion under fruits.

## Mechanism of reduction of creasing in sweet orange

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Creasing (albedo breakdown) is a serious physiological disorder in many orange producing countries. We investigated how putrescine (PUT), aminoethoxyvinylglycine (AVG) and cobalt sulphate ($CoSO_4$) applied at golf ball or ripe stage reduces the incidence of creasing in Washington Navel and Lane Late orange fruit. The level of total and water insoluble pectins significantly increased with the exogenous application of PUT, AVG and $CoSO_4$ at the golf ball or the ripe stage in both cultivars compared to the control. Whilst, the water soluble pectins significantly decreased in the treated fruit compared to the control, in both cultivars. The activities of PE, *exo*- and *endo*- PG and EGase were significantly reduced with the exogenous application of PUT, AVG and $CoSO_4$ than the control fruit at the golf ball or the ripe stage in the both cultivars. The activities of PE, *exo*-PG, *endo*-PG, and EGase were higher in the albedo tissues than the flavedo tissues at the ripe stage in both cultivars. In conclusion, the application of PUT, AVG and $CoSO_4$ significantly elevated the levels of total and water insoluble pectin, reduced water soluble pectin through decreased activity of cell wall degrading enzymes in the albedo and flavedo tissues of the fruit as compared to the control consequently reduced incidence of creasing.

## Impact of climate change on citrus (kinnow) fruit production in the Punjab, province Pakistan

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Citrus fruits are prominent crop of tropical and sub-tropical region which require suitable climate for quality production and Kinnow Mandarin is dominant cultivar

of citrus mostly growing in the plain of the Punjab, Pakistan. Being a perennial crop, citrus is more vulnerable to changing environmental conditions and both physical and biochemical quality parameters are deteriorated by erratic behavior of weather around the year. The present study is designed to investigate physiological and fruit quality assessment of Kinnow Mandarin under varying environmental conditions of three main citrus groves in the province Punjab. Rise in temperature in the month of April-May has affected fruit setting and reduced yield while high wind velocity has caused wind scare on fruit which damaged fruit outlook. Late season rainfall in the months of September has increased the incidence of citrus scab and citrus melanose diseases. Recent trend of fog in the month of November has led to more fruit drop and increased incidence of stem-end rot.Fruitfly damaged has increased due to high temperature in late October and early period of November months. Climate change has adversely affected Kinnow fruit marketing as fruit mature late and harvested earlier due to temperature rise before staring and end of harvesting period. High temperature and shift in rainfall has deteriorated both physical and chemical quality of fruit. In scenario of climate change inputs cost increased while return remained low with inferior quality. In order to mitigate challenges of climate change, along term planning is direly needed to introduce new citrus cultivars with resistance rootstocks while timely management practices will avoid major disaster in present scenario.

## Improved fruit set and retention in fruit crops: role of boron and zinc A review

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Low fruit set and retention significantly affects mango breeding efficiency and contributes to low yield of commercial mango orchards. Fruit setting and retention are multidimensional processes which are directly or indirectly governed by nutritional factors. However there is less literature available on effects of micronutrients on fruit set and retention in fruit crops particularly. This review paper discusses the importance of micronutrients (boron and zinc) and their possible roles in fruit set and retention in fruit crops.

## Effect of $GA_3$ and salicylic acid on plant growth in 'round' guava

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Young vegetative shoots are quite valuable in guava when it starts blooming. One-year-old seedlings of guava (Psidium guajava L.) cv. Round (Gola) were treated with gibberellic acid (GA3) and salicylic acid (SA) solutions at different concentrations to note its effect on plant growth and flower induction. Both GA3 and SA showed a profound effect on vegetative growth of the juvenile, however, GA3 have been better in enhancing plant growth. Net shoot length (16.61 cm), number of new leaves (69.60) and leaf area have been more in plants treated with GA3 compared with plants treated with SA. Leaf chlorophyll content was enhanced at higher levels of both GA3 (400 ppm) and SA (600 ppm) compared with untreated control. Further fine tuning of these growth regulators could be

effective in enhancing induction of new shoots and flowering at early stage in guava cultivars.

## Effect of plant growth promoting rhizobacteria (PGPR) on growth of fenugreek (*Trigonella foenum-graecum* L.) under chromium (Cr) contaminated soils

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Chromium is one of the heavy metals which have toxic effects on human health, plant growth and soil biodiversity. The higher concentration of Cr (VI) in soil may affect many physiological and biochemical procedures and as a result, inhibits plant growth. However, PGPR which are involved in regulation of growth, seed germination and other physiological and biochemical activities of plants can reduce the Cr (VI) to Cr (III). The present study was planned to evaluate the effect of PGPR on the growth of fenugreek (Kasuri methi) in Cr contaminated soil. A pot experiment was conducted in the wire house of the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. The soil was spiked with three different concentration of $K_2Cr_2O_7$ (10, 15, 20 mg $kg^{-1}$) before sowing. 8MBR (b), 9MBR (a) and MBR (b) strains were used for growth promotion of fenugreek. Recommended doses of fertilizers were applied. At maturity, the plants were harvested and analyzed for chemical and biochemical parameters of plant. The results showed that the Cr contamination in soil significantly reduced the growth parameters of plant. However, inoculation with PGPR improved plant growth. The strains 8MBR (b) and MBR (b) showed significant increase in plant growth as compared to control. But the strain 9MBR (a) showed better results as compared to strain 8MBR (b) and strain MBR (b) in promoting the fenugreek growth. Maximum increase in shoot length, root length, shoot and root fresh weights was recorded 54, 43, 67 and 59% in case of 9MBR (a) strain as compared to control treatment.

## Effect of different concentrations of tea waste, eggshell and herbal extract on growth performance of chilli

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With the introduction of industries large number of pesticides and chemical fertilizers are used which are a big threat for human health as well as for crops and cause environmental pollution. Tea waste, egg shells and herbal extract increased the concentration of essential nutrients needed for plant growth as compared to the regular soil tea waste and eggshell increase the fertility of soil and herbal extract is rich in micronutrients, which helps in the availability of macronutrients. For this purpose a research was conducted to elucidate the effect of different growth media and herbal extract on growth and yield response of chilli. Three different medias with four different concentrations: tea waste (0, 250g, 500g and 750g), egg shell (0, 250g 500g and 750g), herbal extract (0, 250ml/L, 500ml/L, and 750ml/L) were used. The results showed that among all treatment applied, eggshell powder increased all parameters including vegetative (plant height, number of branches, and chlorophyll content), reproductive (number of flowers and fruits, fresh and dry weight of fruit and total yield) and biochemical (vitamin C and protein content) followed by herbal extract and tea waste The study will be helpful in future research focusing on reducing the residual effect of chemicals.

## Biofortification of tomato using boron enriched organic amendments

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Tomato (*Lycopersicon esculentum* Mill.) is vegetable affluent in vitamins sources and minerals. To amplify the output of tomato it is important to decide the micronutrient necessities, particularly for boron (B). Micronutrients are near in lower concentrations in soil than macronutrients but are regularly significant in plant food, since plants developed in micronutrient-deficient soils explain comparable reductions in output as those grown in macronutrient-deficient soils.

Biofortification is currently one of the most cost-effective strategies to address global malnutrition. This strategy for supplying micronutrients to the poor in developing countries involves making the staple foods they eat more nutritious by using agronomic practices, conventional plant breeding and biotechnology. In this regard an experiment was conducted in Pir Mehr Ali Shah Arid Agriculture University Rawalpindi. There were eight treatments which were used as follows: $T_1$: Control, $T_2$: Boron @ 10 mg/kg of soil weight, $T_3$: Farmyard manure @ 1% of soil weight , $T_4$: Compost @ 1% of soil weight, $T_5$: Biochar @ 1% of soil weight, $T_6$: B enriched farmyard manure @ 10 mg/ kg of soil weight, $T_7$: B enriched compost @ 10 mg/kg of soil weight, $T_8$: B enriched biochar @ 10 mg/kg of soil weight. The result of this experiment showed that organic amendments have beneficial effects on fruit growth and yield and other soil properties. Maximum boron contents in fruits were 27 ppm where boron enriched poultry compost was applied and minimum were 17 ppm where no amendment were applied.

**Effect of different growing media on cucumber transplant production**

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Cucumber is an important salad crop that is cultivated in all provinces of Pakistan. It is generally grown by direct seeding in field but due to advancement in transplant technology and high price of hybrid cultivars, transplant system is also becoming popular. This study was conducted to ascertain the effect of various locally available growing substrates on cucumber transplants production as well as growth, yield and quality of cucumber. Experiment was conducted at Vegetable Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. The media for transplants were prepared by mixing silt with different kinds of organic substrates such as spent mushroom compost, press mud, FYM, non-granular compost and granular compost. These substances were added in different proportions with silt @ 25%, 50% and 75%), including control (100% silt). Application of silt + non-granular compost (@ 50:50) showed significant enhancement in root length, shoot length, weight of the biggest leaf, seedling

length, fresh weight of seedlings and number of flowers per plant. Similarly application of silt + FYM (@ 25:75) showed significantly highest number of fruits and yield per plant. Overall yield parameters of cucumber were enhanced with application of compost (granular and non-granular) with silt. So, depending on availability, FYM or compost can be utilized as growing media (in plug culture/polypacks) for production of high quality cucumber transplants which in turn give high yield of cucumber.

## Effect of AMF and trichoderma on habanero pepper plants (*Capsicum chinense* Jacq.) under protected conditions

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The cultivation of habanero pepper (*Capsicum chinense* Jacq.) has a high worldwide demand due to its smell, taste, pungency. The use of symbiotic fungi, called *mycorrhiza*, represents an alternative to reduce the use of chemical fertilizers[1]. Inoculation of AMF and bacteria strains has an ability to promote plant growth e.g. plant height, stem diameter, and root volume of *C. chinense* seedlings[2].The objective of the work was made to evaluate the growth of *Capsicum chinense* plants and damping of due to the addition of AMF and *Trichoderma* under protected conditions.Two arbuscular mycorrhizal fungi (AMF) species *Zac-19* and *Rhizophagus intraradices* with *Trichoderma* spp.strain Clombta were evaluated on the effect of general agronomic parameters of *Capsicum chinense* Jacq. The selected seeds of *Capsicum chinense* were seeded onsphagnum substrate along with AMF strains of consortium *Zac-19* and *R. intraradices* at the rate of 10g soil per cavity (200-300 spores) on well expanded polyethylene trays with 200 cavities. Two applications of the *Trichoderma* spp. Clombta was applied 1 g per litre having concentration of $1\times10^{10}$ after 7 and 14 days after the sowing and evaluated stem diameter, number of leaves, height of

the seedling, Number of inter-nodes and root length at 35 days after sowing.*R. intraradices* promoted a significant increase ($p<0.05$) in height of the seedling (14.62 cm), the diameter of the stem (2.51 mm) and root length (7.04 cm) with respect to the other two treatments while consortium*Zac-19* increase the number of leaves (10.87) and inter-nodes (7.12). However, it is recommended that further research is required to study the effect of AMF and *Trichoderma* strains on phenological and physiological parameters in habanero pepper production.

**Application of mycorrhiza on different cucumber rootstocks for high yield and good quality under controlled conditions**

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Present day study was conducted to evaluate the effect of Arbuscular mycorrhizae (AM) fungi on plant growth and yield of grafted cucumber seedlings. The experiment was performed in a plastic greenhouse and graded seeds of rootstocks (Desi cucumber, Pumpkin and Squashes) were sown in plastic trays. Three types of grafted seedlings were simultaneously produced in equal number as inoculated and non-inoculated with arbuscular mycorrhiza. The combined effects of grafting rootstocks and arbuscular mycorrhiza application on the growth parameters during the nursery period as well as growth rate and yield after transplanting were tested under controlled conditions. The different rootstocks of cucumber seedlings have significant effects on seedlings growth attributes. Physical parameters include maximum plant height and number of female flowers and fruit yield was noted in pumpkin rootstock. The qualitative parameters include total soluble solids, which were higher in pumkin rootstock.

## Response of bottle gourd (*Lagenaria siceraria L.*) to various levels of gibberellic acid and boron application

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Bottle gourd (*Lagenaria sicerarta* L.) belongs to the family Cucurbitaceae.The experiment comprised of five treatments: $T_0$ (Control), $T_1$ (GA3 50ppm), $T_2$ (Boron 0.05%), $T_3$ (GA3 100ppm) and$T_4$ (Boron 0.05% + GA3 50ppm).In this study we check the effect of plant growth regulators and micronutrient (boron) on growth and yield of bottle gourd. Plant growth regulator is an organic compound. The Gibberellins causes cell elongation at apical regions. The main functions of boron relate to cell wall strength and development, cell division, fruit and seed development, sugar transport, and hormone development. A research trial was conducted at Ghazi University, Dera Ghazi Khan. Experiment was laid out according to RCBD and replicated thrice. The best result for parameters: main vine length (cm), number of branches vine$^{-1}$, number of leaf vine$^{-1}$, first male flower initiation, first female flower initiation, number of female flower vine$^{-1}$, number of male flower vine$^{-1}$, number of node vine$^{-1}$, fruit length (cm), fruit diameter (cm) and number of fruit unit area$^{-1}$were studied., showed by $T_4$(Boron 0.05% + GA3 50ppm).But the maximum inter-nodal length was observed in $T_0$ (control). As a result, the plant growth regulators and boron showed a positive effect on growth, and yield of bottle gourd.

## Effect of sowing dates on growth and yield of spinach (*Spinacea oleracea*)

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Spinach (*Spinacea oleracea* L.) is the most important highly nutritious green leafy vegetable belonging to the family chenopodiaceae. Several factors are responsible for good spinach production but sowing time and plant spacing are the most important. The present research was conducted to observe the performance of

spinach cultivars Desi palak and Kandiari, planted at different intervals under agro-climatic conditions of Multan, Pakistan. Date of sowing has significant effect on final germination percentage, chlorophyll contents per plant, final soil coverage per plant, number of leaves per plant, leaf area per plant, fresh leaves weight per plant, fresh weight of root per plant and total biomass on fresh weight basis per plant. November for cv. Kandiari and August to mid-September for cv. Desi Palak were found as the most appropriate and suitable sowing time for cultivation of spinach.

## Response of okara (*Abelmoscus esculentus* L.) to various levels of foliar application of gibberellic acid and naphthalene acetic acid

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Okra (*Abelmoschus esculentus*L. Moench) is the crop of warm season and in rain it grows wildly. Okra plant is semi woody, indeterminate, with height of about 2 meters or more. Okra is planted throughout the world and used as a vegetable crop. The experiment comprised of seven treatments: $T_0$ (Control), $T_1$(NAA 30 ppm), $T_2$(NAA 60 ppm), $T_3$($GA_3$ 50 ppm), $T_4$($GA_3$ 100 ppm), $T_5$(NAA 15 ppm + $GA_3$ 25 ppm) and $T_6$(NAA 30 ppm + $GA_3$ 50 ppm). In this study wecheck the effect of plant growth regulators on growth, productivity, yield attributing characters and yield of okra. Plant growth regulator is an organic compound. The Naphthalene Acetic Acid stretches cell wall, thus causing entry of more water inside cell resulting cell enlargement, whereas Gibberellins causes cell elongation at apical regions. A research trial was conducted at Ghazi University, Dera Ghazi Khan. Experiment was laid out according to RCBD and replicated thrice. The best result for parameters: germination percentage (%), plant height (cm), number of node plant$^{-1}$, leaf area (cm$^2$), fruit length (cm), fruit diameter (cm), individual fruit weight (g), number of fruit per plant$^{-1}$, number of seed fruit$^{-1}$, thousand seed weight (g), fruit yield (g) and yield (t/ha), showed by $T_4$( $GA_3$ 100 ppm).As a result, the plant growth regulators showed positive effect on growth, productivity, yield attributing characters.

# Influence of different growing media on morpho-physiological characteristics of turnip (*Brassica rapa* L. cv. golden ball) in Thal desert environment

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Turnip (*Brassica rapa* L.) is one of the important and popular root vegetable grown all over the world. The present study was conducted in Thal desert environment where effect of different growing media was studied on morpho-physiological characteristics of turnip cv. 'Golden ball'. Six growing media treatments such as $T_0$: soil (S), $T_1$: saw dust (SD), $T_2$: peat moss (PM), $T_3$: farm yard manure (FYM), $T_4$: sugarcane press mud (SPM) and $T_5$: combination of all (S+SD+PM+FYM+SPM) were used. Experiment consisted of four replications arranged in completely randomized design. All treatments significantly affected morphological characteristics under study whereas only chlorophyll contents were found to be statistically non-significant. Greatest root diameter (23.6 cm), leaf fresh weight (61.2 g) and root fresh weight (61.5 g) were observed under $T_4$ (SPM). Likewise, $T_4$ (SPM) and $T_2$ (PM) produced statistically similar results in case of plant height (27.9 and 24.4 cm) and root length (25.2 and 21.9 cm). The similar trend was also noticed for leaf area (79.2 $cm^2$ and 72.8 $cm^2$) and number of leaves (15.4 and 14.5) where maximum results were obtained under $T_4$ (SPM) followed by $T_1$ (SD). The highest value of total soluble solids (9.12 %) was observed in $T_3$ where farm yard manure was used. Overall results regarding different growth attributes indicated that all growing media showed better results than control (local soil). Media containing sugarcane press mud ($T_4$) was found superior for production of turnip crop. From this study it can be concluded that, as application of sugarcane press mud provided suitable growing conditions for growth of plants, therefore, recommended as a standard growing media for commercial production of turnip. In addition, it is also a suitable media for Thal area of Southern Punjab in terms of availability of abundant sugar mills of this region which are producing tons of press mud each year that can be used efficiently by farmers to boost the turnip yield.

**Response of lettuce for different concentrations of exogenously applied amino acids on growth characteristics of lettuce (*Lectuca sativa* L.)**

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Lettuce (*Lactuca sativa* L.), one of the most widely consumed leafy vegetables worldwide, is a significant source of antioxidants and bioactive compounds such as polyphenols, ascorbic acid and tocopherols. Many studies have focused on the uptake, metabolism and distribution of nitrogen in plants, but few have investigated the nutritional performance of plants supplied with organic nitrogen. A completely randomized design (CRD) with three replications and three plants per replication were grown for 9 weeks during winter in greenhouse. Lettuce plants were hydroponically grown with two amino acids (L-Methionine and L-Tryptophan) having 3 concentrations (2.2g/L,0.22g/L and 0.002g/L) compared with control (without any amino acid) to evaluate best concentration among two different amino acids. Four weeks after transplanting supplemental amino acid Hoagland's nutrient solution as a root medium for plants, renewed after 7 days. The results indicated that plants performed best in 0.22g/L in Tryptophan and 0.002g/L in case of Methionine as compared to control. There were (0.22g/L Tryptophan and 0.002g/L Methionine) highly significant difference from all other treatments (i.e. Tryptophan 2.2g/L and 0.002g/L; 2.2g/L and 0.22g/L Methionine) in leaf number per plant, plant height, leaf area, SPAD values of leaves, shoot and root length, fresh weight, dry matter production and yield of plants. This study indicates exogenous amino acids' concentrations supplemented to improve growth physiological characteristics of hydroponically lettuce, which could potentially improve human nutrition.

# Response of eggplant (*Solanum melongena* L.) to various levels of foliar application of gibberellic acid and NPK

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Eggplant has been thought to develop from the wild ancestor, *Solanum insanum* that has small, green, round, bitter taste and thick-skinned fruits. It is a good source of minerals, vitamins, proteins, body-building factors, dietary fibers, and antioxidants. It is also used as raw material in pickle making and dehydration industries and is an excellent remedy for those suffering from liver complaints. Plant growth regulators may be considered as a new generation of agro-chemicals after fertilizers, pesticides, and herbicides. In this study, we check the effect of plant growth regulators on growth, productivity, yield attributing characters and yield of eggplant. The experiment comprised of six (6) treatments: $T_0$ (control), $T_1$ (50%NPK+GA3 0ppm), $T_2$ (100%NPK+GA3 0ppm), $T_3$ (0%NPK+GA3 100ppm), $T_4$ (0%NPK+GA3 200ppm), $T_5$ (25%NPK+GA3 50ppm) and $T_6$ (50%NPK+GA3 100ppm). A research trial was conducted to check the Response of Egg-plant (*Solanum melongena L.)* to Various Levels of Foliar Application of Gibberellic Acid and NPK at Ghazi University, Dera Ghazi Khan. The experiment will be laid out according to randomized complete block design replicated thrice. The best result for parameters: plant height (cm), Number of leaf plant$^{-1}$, Number of branches plant$^{-1}$, leaf area (cm$^2$), fruit length (cm), fruit diameter (cm), diameter of plant (cm), days of fruit setting and days to 50% flowering, showed by $T_6$ (50%NPK+GA3 100ppm). As a result, the plant growth regulators showed a positive effect on growth, productivity, yield attributing characters and yield of eggplant.

## Response of cauliflower (*Brassica oleraceae* L.) to foliar application of fertilizers

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The research projected was executed to evaluate the Response of Cauliflower (*Brassica oleraceae* L.) to the foliar application of fertilizers with different concentrations and combinations. These fertilizers were obtained from NFC (Institute of Engineering and Fertilizer Research) Faisalabad. The experiment was arranged according to Randomized Complete Block Design (RCBD) with eight treatments and four replications. The vegetative and reproductive parameters were recorded and statistically analyzed at 5% level of significance. The treatment means were compared by DMR test. After the statistical analysis it was found that as compared to controlled treatment when different doses of nutrients were applied by foliar method, the plants showed variations in their vegetative and reproductive parameters regarding as, plant height, number of leaves of per plant, number of days taken from transplanting to crud formation, foliage fresh weight, foliage dry weight, crud weight, crud diameter, chlorophyll contents, leaf area, vitamin C and curd nutritive value (N: P: K). The treatments $T_6$ (N: P: K (18:18:18) = 1% Solution) indicated the maximum average values in maximum parameters among all other treatments. N: P: K (18:18:18) with 1% solution is recommended as a best concentration and combination of nutrients for foliar application in Cauliflower.

## Effects of thermal decontamination of crude oil polluted soil on the

Crude oil contamination of soil has been olden phenomenon and a serious subject of concern. The effect of oil on soil depends on the size, quantity and grade of oil spilled. Crude oil changes the porosity of soil because it forces the soil particles to

bind together that tend to decrease the pore size. The aim of this study was to examine the effects of thermal decontamination of crude oil polluted soil on growth of lettuce. The experiment was conducted in the glass house of the main campus of PMAS Arid Agriculture University Rawalpindi. Two varieties of lettuce were sown to evaluate the results. The soil sample was polluted with 16% and 8% crude oil. Three methods of soil decontamination were used (i.e., combustion method by Kiln, microwave heating and bioremediation through biochar). Various parameters were studied, dealing with Morphological features (i.e., root and shoot length, fresh and dry weight of root and shoot), physiological analysis (e.g., leaf water potential, leaf chlorophyll contents, membrane stability index) and soil nutrient analysis (viz., N, P and K contents). It was observed that development of plant was significantly affected in decontamination treatments, with improved morphological, physiological and biochemical characteristics of plant. Significant results were obtained by thermal decontamination through kiln as compared to microwave heating and variety Boston shows better results than the other variety. However, thermal decontamination had been effective in reducing pollutants and contaminants from the soil and plant will show better growth after cleaning up the soil.

## Effect of fertilizer management on growth of okra (*Abelmoschus esculentus* L.*)* under agro climatic conditions of Rawalakot

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Okra (*Abelmoschus esculentus*) belongs to the family Malvaceae. It is amongst the world's most popular vegetables. Fertile soils gave maximum production for this crop. A field experiment was conducted at Farm of Department of Horticulture, The University of Poonch Rawalakot, to evaluate the yield parameters of okra in response to different inorganic and organic fertilizers containing phosphorous. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. Different parameters such as germination percentage, plant height, leaf area, chlorophyll contents and number of pod per plant were observed during this study. Data was analysed by using the

statistical software and the means were compared by Duncan's Multiple Test (DMRT). The results obtained showed that farm yard manure gave the best results in terms of okra germination. It is concluded that farm yard manure is the best source of phosphorus and can be used for commercial purposes. However, further studies are required to confirm the phosphorus percentage in farm yard manure.

## Inoculation of rhizobacteria in plant growth medium to induce lead stress tolerance in tomato (*Solanum lycopersicum* L.)

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Current study was established to assess the lethal impact of lead on tomato growth, physiology and productivity or induce lead stress tolerance by introducing plant growth promoting rhizobacteria (LTPGPR). Study was conducted in pot by using inert material sand as a growth medium and half strength Hoagland solution was used as a nutrient source. Four different levels of lead (0.00, 100, 200, 300, 400 and 500 mg kg-1) were established by using lead nitrate salt as source of lead. For induction pre-characterized LTPGP strains "S5 Pseudomonas fluorescens A506" and "S10 Pseudomonas fluorescens LMG 2189" were applied in growing medium. Experiment was designed according to completely randomized design with factorial arrangements. Data regarding various growth attributes (root shoot length, root shoot fresh and dry weights), yield per plant, physiological attributes (Chlorophyll content, cell membrane stability), antioxidant activities (Superoxide dismutase, peroxidase catalase, and proline contents and lead content in root, shoot and fruit of tomato were recorded. Data were analyzed by standard statistical procedures. Results presented that lead contamination decreased the plants growth, physiology and productivity. But application of LTPGPR in growth medium improved plant growth, physiology, productivity, and antioxidant activities, proline, and reduced the electrolyte leakage (that is reduced by the application of different strains in lead contaminated environment) of tomato as compared to plants grown in control condition (without inoculation). Inoculation also reduced the uptake of lead in

root, shoots and in tomato fruit as compared to plants in lead contamination without inoculation.

### Evaluation of exotic castor bean (*Ricinus communis*) for production under semi-arid conditions

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Castor bean (Ricinus communis) locally known as “arind” or “arindi” bears potential for industry, agriculture and medicine sectors due to presence of tremendous amount of oil content in seeds. The research was planned to evaluate castor beans oil production under semi-arid conditions. Three cultivar’s seed (DS-30, FS-2000 and FS-90) brought up from Ayub Agriculture Research Institute and three local cultivars (Highly spiny, Spiny and Spniyless) were grown. Oil extraction was done by means of soxhlet apparatus then by gas-chromatography fatty acid percentage was estimated. Results depicted that from local cultivars highly-spiny reflected highest mean values followed by DS-30. In case of fatty acid proportion observed by using gas chromatography, DS-30 cultivar proved to be most flourishing among all cultivated varieties in expressions to maximum percentages of overall fatty acids in its oil. So, DS-30 showed best performance against semi-arid environmental conditions among all grown cultivars.

### Triacontanol improves the salinity tolerance in hot pepper (*Capsicum annum* L.) by amplifying phenotypic traits and alleviate the salinity induced oxidative damages

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The response of exogenously applied triacontanol with three concentrations (25, 50 and 75 $\mu M$) on Hot pepper (*Capsicum annum* L) under salt stress (75 m$M$) was studied in pots under field conditions. Salinity stress presented a significant impact on morphological, physiological and biochemical traits, including

increasing the status of lipid peroxidation in relations of malondialdehyde and reduced the cell membrane stability in hot pepper leaves. However, triacontanol spray significantly improves the vegetative, physiology and biochemical attributes. Furthermore, salt stress brought antioxidant enzyme activities, but exogenously applied triacontanol @ 75 $\mu M$ was more responsive in mitigating the lethal impact of saline stress on hot pepper plants via controlling the ROS generation and increment in antioxidant enzyme activities.

**Comparing conventional and nonconventional systems of growing tomatoes**

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The present study was carried out to grow tomatoes for kitchen gardening purpose using various growth medias like hydroponics, soil, compost and different combination of soil and compost. Treatments included hydroponic solution (Hoagland's solution), control (soil), soil: compost (75:25), soil: compost (50:50), soil: compost (25:75), compost (100 %) and soil with recommended NPK fertilizers. Tomato seedlings were obtained from commercial nursery and sown in December, 2016. These seedlings were raised for 120 days. For conventional cultivation, soil, compost and mixture treatments were applied in pots. Soil sampling was done before and after crop harvest while plant sampling was done at maturity stage. It was noted that the highest soil nitrogen, P and K contents (22.1, 38.5 and 139.9 mg $kg^{-1}$) were noted in C100 + S0. The highest contents of micronutrients (Cu 0.78, Zn 0.94 Fe 38.4 and Mn 29 mg $kg^{-1}$) were also noted in the treatments with the highest rate of compost application. However the highest uptake of N, P and K (N 3.62, P 0.93 and K 5.1 %) and micronutrients (Cu 80.2, Zn 283.1, Fe 103.6 and Mn 103 mg $kg^{-1}$) was noted in plants grown in hydroponic solution. The highest tomato yield $pot^{-1}$ ((2231.1 g) was noted in hydroponics followed by C100 (1738.8 g) and C75 + S25 (1289.4 g). Recommended NPK treatment gave 1187.1 g yield. Compost is easy to manage with better tomato

yield however the yield from hydroponics was 28 % and 87 % higher than full compost and recommended NPK treatment.

**Formulation of zeolite based macro and micro nutrient fertilizers and their impact on lettuce and marigold plants**

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Zeolites are hydrated crystalline alumino silicates which are used as fertilizer carrier. They can hold nutrients and make them slowly release and decrease the losses of nutrients from soil. Nitrogen leaching is a major concern now days. Therefore, study was conducted in PMAS- Arid Agriculture University Rawalpindi by applying zeolite based fertilizers on two plants i.e. lettuce and marigold by growing in soilless media in comparison with commercial fertilizers. The objectives were i) to characterize zeolite based macro and micro nutrient fertilizers and ii) to analyze the effects of zeolite based fertilizers on plant growth and nutrient retention. Five nutrient treatments *i.e.* i) control, ii) SSP + CAN + trace elements, iii) DAP + Urea + trace elements, iv) zeolitic urea + zeolitic rock phosphate + zeolitic micronutrient mixture, v) zeolitic urea + zeolitic rock phosphate + mixture of individual zeolitic micronutrient fertilizers were arranged in complete randomized design (CRD) with three replicates. Plant parameters including plant height, root and shoot fresh weight, root and shoot dry weight, number of leaves and leaf area index was measured. It was concluded that SSP + CAN + trace elements as well as zeolitic urea + zeolitic rock phosphate + zeolitic micronutrient mixture showed better performance then all others.

## Effects of green house shading and planting dates on plant growth and flower quality in the gladiolus (*Gladiolus grandiflorus* L.)

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Gladiolus (*Gladiolus grandiflorus L.*) is an important ornamental plant used as cut flower extensively, but little is known about whether it can be grown in a season with relatively high temperature and shaded conditions. In this study, effects of sowing dates viz; March 1st, April 1st, May 1st and June 1st under green house and open field conditions on plant growth and flower quality in the gladiolus cv., White Prosperity were assessed over two consecutive years (2014 and 2015). The treatments were arranged according to randomized complete block design (RCBD) replicated thrice and LSD was used to test significance of means. The results showed that *G. grandiflorus* most of morphological parameters were higher in plants grown under green house during the month of March followed by April, compared to those grown in open field conditions. However, opposite trends were observed for the days taken to flowering and electrolyte leakage of the plant. Compared with open field sun exposure, shade provided conditions in the month of March follower by April enhanced physiological characteristics. These results could provide us with a theoretical basis for further production of *G. grandiflorus* in the shaded microclimatic conditions.

## $GA_3$-mediated growth and quality improvement of carnation (*Dianthus caryophyllus*) cv. Tabasco

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Current study was conducted to evaluate the effectiveness of gibberellic acid optimum concentration for the betterment of carnation plant growth and to enhance its cut-flowers quality attributes. Five levels of $GA_3$ viz., 25, 50, 100, 200 and 400 ppm were used via pre-harvest foliar treatments. Transplants were sprayed with $GA_3$ solutions three times starting from one month after

transplantation following 2nd spray after 15 days of 1st application and 3rd spray just before bud initiation stage. $GA_3$ at 400 ppm demonstrated profound results regarding plant height, number of leaf pairs, leaf chlorophyll contents and number of side shoots as compared to control, while it manifested positive influence on early flower initiation. Meanwhile it also increased the flower yield, flower diameter, flower stalk length and diameter, flower fresh and dry weight. $GA_3$ at 400 ppm promoted the augmentation of antioxidant enzymes viz., superoxidase, peroxidase and catalase in petal cells. Maximum vase life of carnation cut-flowers (13.6 days) were recorded at the same level of $GA_3$ due to increased antioxidant enzymes, reduction in ethylene production and by improved membrane integrity. Due to optimum emission of ethylene gas from cut-flowers high percentage of flowers opening was measured with 400 ppm $GA_3$ in post-harvest stage. Minimum measurements regarding quality attributes were recorded in controls. $GA_3$ at 400 ppm may be suggested as a potential level for carnation growth and quality improvement.

**Effects of nutrients on nodule differentiation in *Acacia modesta***

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Nodules are found in symbiotic association with the roots of *Acacia modesta* (Phulai) tree which help in nitrogen fixation. *Acacia modesta* is a multipurpose tree used as fuel wood, fodder and medicine. Stunted growth of *Acacia modesta* Phulai has been reported in District Shangla, tehsil Besham Maira village. To address this problem study was carried with the objectives: isolation of bacteria from roots of *Acacia modesta*, counting of nodules in roots of *Acacia modesta,* diameter measurement of root nodules and inoculation of Rhizobium for tree growth enhancement and growth parameters were recorded. Different nutrients are required by the plants for its growth. Use of fertilizers to enhance growth and increasing soil fertility is a traditional method while Plant Growth Promoting Rhizobacteria (PGPR) was used as an alternative to chemical fertilizers. Pot experiment was conducted to know the affects of PGPR and Nitrogen at four

different levels (0, 10, 20 and 30) g $kg^{-1}$ of soil. Six treatments of the nutrients were checked with three replicates. Data was analysed by using single factor ANOVA. The study was helpful to find out the type and amount of nutrients promoting the growth and number of root nodules, ultimately enhancing the yield of *Acacia modesta.*

**Comparative influence of gibberellic acid, humic acid and ascorbic acid on growth and flowering of gazania (*Gazania rigens* L)**

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Gazania has been cultured as for as ornamental garden plant for its attractive flower and hence broadly used in urban ornamentation. Emergent of ornamental performance is a major concern especially in severe urban conditions. Therefore, foliar application of different growth stimulants as gibberellic acid ($GA_3$) (50, 100 and 150 mg $L^{-1}$), humic acid (HA) (100, 300 and 600 mg $L^{-1}$) and ascorbic acid (AA) (50, 100 and 200 mg $L^{-1}$) compared to distilled water (control) was done to enhance the growth and flowering of Gazania 'New Daybreak Mix' cultivar. The study was comprised of pots as experimental units in randomized complete block design (RCBD) and replicated four times with total number of 10 treatments. Results showed that $GA_3$ 100 mg $L^{-1}$, HA 300 mg $L^{-1}$ and AA 200 mg $L^{-1}$ were significantly improved physiological parameters such as stomatal conductance, photosynthetic rate and transpiration rate. Both HA and $GA_3$ at different levels were highly responsive to vegetative growth (number of leaves per plant and leaf area) compared to AA treatments and control. Maximum number of flowers per plant were recorded in AA 200 mg $L^{-1}$ and $GA_3$ 100 mg $L^{-1}$ while significant increase in plant height, peduncle length and flower diameter was observed in all applied levels of $GA_3$ compared to other treatments. The flower display time was increased in all treatments of $GA_3$, HA and AA compared to control. The finding concluded that $GA_3$ 100 mg $L^{-1}$ was best treatments which increase growth and flowering attributes of gazania plant.

**Optimal mowing height and frequency for C*ynodon dactylon* 'fine dacca' and *Zoysia japonica* 'korean' grasses**

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A study was conducted to optimize mowing height and frequency for *Cynodon dactylon* (L.) Pers. 'Fine Dacca' and *Zoysia japonica* Steud. 'Korean' under agro-ecological conditions of Faisalabad. Various mowing heights, viz. 1.25, 2.50, 3.75 and 5.00 cm and frequencies, viz. 3, 6 and 9 d intervals were assessed for selecting optimal cutting height and frequency for both tested turf grasses, which are most popular and commonly used in Pakistan. Experiment was set in a randomized complete block design with factorial arrangements having three replications. Among grass species, 'Fine Dacca' produced greatest tiller height (5.2 cm), leaf area (22.0 $cm^2$), length of leaf blade (20.1 mm), canopy chlorophyll index (2.0 SPAD) and internodal distance (15.8 mm), while 'Korean' had highest number of leaves per tiller (9.8), number of tillers (51.8), stolon diameter (1.1 mm) and fresh and dry weights (6.0 g and 3.0 g, respectively). Among mowing frequencies, grasses mowed at 3 d interval exhibited maximum leaves per tiller (10.3), while those with 6 d interval resulted in highest fresh and dry weights (6.6 g and 3.2 g, respectively). Grasses mowed at 9 d interval showed maximum tiller height (5.9 cm), number of tillers (55.7), leaf area (24.5 $cm^2$), length of leaf blade (22.6 mm) and canopy chlorophyll index (2.3 SPAD). For mowing heights, maximum tillers (47.3) and internodal distance (14.3 mm) were recorded for grasses mowed at 2.50 cm height, while highest fresh weight (5.7 g) was recorded, when grass was mowed at 3.75 cm height. Mowing at 5.00 cm height produced maximum tiller height (5.9 cm), length of leaf blade (21.7 mm), leaf area (24.3 $cm^2$) and chlorophyll index (2.2 SPAD). Overall, grasses mowed at 5.00 cm height with 3 d interval produced best quality fine, uniform and dense turf, while 'Fine Dacca' was more adapted to wide range of mowing heights compared to 'Korean', which required higher mowing height for producing good quality turf due to its coarse leaf texture and higher shoot density.

**Comparison of impact induced by different priming techniques on germination and plant development in lisianthus (*Eustoma grandiflorum*)**

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Lisianthus (*Eustoma grandiflorum*) seeds exhibited cold-related dormancy and slow germination rate. Seed priming techniques have been utilized to increase germination attributes and improve germination uniformity. The present study was conducted to enhance germination uniformity and plant development in Lisianthus by using different priming techniques. The effect of different concentrations of gibberellic acid (250, 500 and 1000 ppm GA3), potassium nitrate (0.1, 0.2 and 0.3% KNO3), hydro priming (DW, CDW, WDW) and control will be examined on germination and other physiological parameters. Complete Randomized Design (CRD) will be used for nine treatments and five replications. Plants treated with GA3 of concenteration 1000 ppm had a positively impacted all parameters ( mean germination time, germination index, plant height, number of leaves, stem length, number of flowers, size of flower fresh and dry plant weight). It seems that GA3 and KNO3 can be replaced partly to improve seed germination of lisianthus seeds. Therefore, it is concluded that for best germination and plant growth parameters of Lisianthus seeds, harmonal (GA3) and halo priming (KNO3) can be used.

## Cotton waste augmented with banana peel alters nutritional profiles of king oyster mushroom

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An experiment was conducted to check the efficacy of cotton waste (CW) augmented with banana peel (BP) against nutrition value of two strains of king oyster mushroom (P10 and P11). Different combinations of CW and BP were used i.e. T0: CW, T1: CW + BP (9:1), T2: CW + BP (8: 2), T3: CW + BP (7: 3), T4: CW + BP (6:4) and T5: CW + BP (5:5). Biochemical attributes such as total soluble solids, sugar contents (reducing, non-reducing and total), pH of mushroom, ascorbic acid, moisture percentage and nitrogen, potassium and phosphorus contents of substrates before and after cropping were studied. Results showed that TSS, reducing and non-reducing sugars were significantly affected by T4 and nitrogen contents of substrates were influenced by T5. Furthermore, T3 significantly affected the ascorbic acid, potassium and phosphorus contents of substrates. Overall results showed that cotton waste augmentation with banana peel gave positive result as compared to control.

## King oyster mushroom production by utilization of banana peel and cotton waste as a basal medium

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A study was conducted to evaluate the efficiency of cotton waste (CW) and banana peel (BP) for growth and development of two strains of king oyster mushroom P10 and P11. Different treatments of substrates were applied i.e. T0:

CW (100%), T1: CW + BP (90% + 10%), T2: CW + BP (80% + 20%), T3: CW + BP (70% + 30%), T4: CW + BP (60% + 40%) and T5: CW + BP (50% + 50%). Experiment was designed according to two factor factorials under CRD with five replicates. Various parameters i.e. initiation of spawn running and mycelium growth, no. of days to complete mycelium growth, no. of flushes ($1^{st}$, $2^{nd}$, $3^{rd}$) and pinhead formation, number of pinheads, fresh weight of mushroom, biological efficiency and yield per bag were studied. Data was analysed by ANOVA technique and means were compared by LSD at 5% probability level. Results showed that treatment (T4) significantly affected the mycelium completion duration and flushes formation duration, pinhead formation and pinheads number as compared to control. Furthermore, treatment (T3) significantly affected the number of pinheads/bag, while yield per bag and biological efficiency were high at treatment (T2). Overall results showed that banana peel can be used as alternate substrate for king oyster mushroom cultivation.

**Comparative study for yield performance of oyster mushroom (*Pleurotus ostreatus*) spawned on different substrates under Rawalakot conditions**

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The popularity of Oyster mushroom (*Pleurotus ostreatus*) is due to its cap stability, high nutritive value and consumer preference. But currently this mushroom is not cultivated on a large scale due to fast depletion of nutrients. Hence due to increasing consumer demands best yield and best quality of oyster mushroom can be achieved with different substrates for cultivation. The plant substrates used for the under study were wheat straw, newspaper and pine needles. The experiment was designed in a complete randomized design (CRD) Polypropylene bags were used for the bagging of each treatment. Three species of oyster mushroom were spawned on three different substrates at 22-25 °C and 75-85% relative humidity. The significant ($P < 0.05$) difference was observed in growth parameters (mycelia growth and pin head formation) in all the substrates used. The fastest spawn development (75 days) and pin head formation (80 days)

were observed in the substrate composed of newspaper. In general, the newspaper provides a positive effect on growth of mushrooms while pine needles had a no effect in all the growing stages under observation.

## Evaluation of different local materials as peat substitute in soil-less potting media

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Soilless potting media has numerous advantages over soil for container plants such as better portability due to light weight, control of plant nutrition, and reduced incidence of weeds, diseases and pests. However, in Pakistan, main ingredients such as peat and coco-coir are imported at the expense of foreign exchange. This study assessed the possibility of using rice hulls, date palm coir, and sawdust and corn cob as local alternatives to peat. The experiment was set up in completely randomized design (RCD) with lattice as test plant. The measured parameters included plant height, number of leaves, leaf area index, roots weight and shoot weight of lettuce plant. On the basis of results rice hulls appeared to be the best alternative to peat.

# Pre and Post Harvest Techniques for Horticultural Crops

## Controlled atmosphere storage delays pericarp browning, inhibits lipid peroxidation and maintains antioxidative activities of litchi fruit

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Litchi pericarp browning is the major issue which adversely affects its market potential. So, the influence of controlled atmosphere (CA) storage on pericarp browning, biochemical quality and antioxidative enzymes of 'Gola' litchi fruit was investigated. Fruit were stored under air or 3% $O_2$ + 4% $CO_2$ and stored at 5±1°C with 90±5% relative humidity for 28 days. CA-stored fruit showed reduced weight loss and pericarp browning index. Similarly, CA-stored fruit exhibited reduced malondialdehyde contents and membrane leakage with higher anthocyanin contents in peel tissues. Soluble solid contents and titratable acidity were substantially higher in pulp tissues of CA-stored litchi fruit. Activities of catalase and superoxide dismutase enzymes were also found significantly higher for the fruit kept under CA-conditions in peel tissues. On the other hand, activities of peel polyphenol oxidase and peroxidase enzymes were found substantially lower in CA-stored litchi fruit. In conclusion, 3% $O_2$ + 4% $CO_2$ combination of CA-storage significantly delayed pericarp browning and exhibited higher biochemical attributes with maintained antioxidative enzymes activities of 'Gola' litchi fruit for 28 days.

## Foliar application of putrescine maintains peach fruit quality and alleviates chilling injury during storage

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Peach industry faces serious economic losses due to short postharvest life of the fruit. The present research was conducted to investigate the effects of putrescine (Put) application on Quality, ripening and postharvest life of 'Flordaking' peaches. Different levels of Put i.e. 0, 1, 2 and 3 mM were used to treat the peach

trees on three different stages of fruit growth and development. Tween 20 was used as wetting agent. After harvesting the fruit at commercial maturity stage the fruits were stores at controlled conditions (1 ± 1 ºC with 90 ± 2 % relative humidit) for 42 days. Data regarding fruit firmness, total soluble solids (SSC), titratable acidity (TA), vitamin C contents, ethylene biosynthesis, chilling injury index (CI) and color were recorded on the day of harvest and then subsequently on seven days intervals. Results showed that all Put sprays significantly reduced CI during storage, the effect was more pronounced with higer levels of Put. Put treated fruit exhibited higher level of firmness, lesser weight loss and disease/decay incidence. Changes in fruit firmness, SSC, TA, AA contents and skin color were delayed significantly by all Put applications. The results clarified that on tree application of Put @ 2 mM significantly enhanced fruit quality at harvest, suppressed chilling injury incidence, lowered ethylene production during storage, hence, prolonged storage life of 'Florida king' peaches.

## Post harvest shelf life of potato genotypes/varieties during ambient and cold storage

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It was found that sprouting, number of sprouts, dormancy days, rotting, physiological weight loss and total weight loss varied significantly among genotypes in ambient storage. The correlation study showed that total weight loss demonstrated positive correlation with rotting (r = 0.9614), sprouting percent (r = 0.8715), number of sprouts per tuber (r = 0.6677) and physiological weight loss (r = 0.8154). Range of dormancy days was 85.00 (393574-61) to 68.00 (396206-72), sprouting 67.55 (396206-72) to 51.10 (393574-72) and total weight loss was from 15.58 percent (396239-131) to 6.703 percent (393574-72). In cold storage, most of genotypes did not show sprouting and rotting of autumn and spring crop, some genotype showed significant sprouting and rotting. Significantly the highest total weight loss of autumn and spring crop was in NARC 2-2006/1 (3.65%) and in 396206-52 (2.39%) respectively. The lowest total weight loss of autumn and

spring crop was exhibited by 393574-61 (2.75%) and 393574-61 (1.21%) respectively.

**Effect of chitosan based coatings on nutritional quality and storability of kinnow mandarin (*Citrus reticulata*) NIAB Kinnow**

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Kinnow mandarin (*Citrus reticulata* Blanco) is one of the major citrus cultivars grown in Pakistan. Being non-climacteric, Kinnow fruits are highly perishable and have short storage life. Chitosan has been proven one of the best edible and biologically safe coatings for perishable fruits because of its non-toxic, biochemical and biodegradable properties. The present investigations were carried out to evaluate the effects of chitosan based coatings on nutritional quality and storage life of Kinnow mandarin cv NIAB Kinnow. Fresh harvested fruits were coated by immersing in aqueous solutions of chitosan (0, 0.1, 0.3, 0.5, 1, and 2%) for five minutes followed by storage at 4±1°C, 90-95% RH for 60 days. The observations on various physiochemical quality traits of the fruits were recorded at 15 days storage intervals. Results revealed that the chitosan based coatings proved to be considerably effective in improving the overall quality and extending storage life of fruits. Fruits coated with chitosan (1%) had significantly decreased weight loss (6.86%), chilling injury (<1) and decay incidence (<10%), while maintaining fruit quality traits in terms of juice contents (50.24%), shape index (0.81), total soluble solids (10.78%), titratable acidity (1.02%), maturity index (10.57), ascorbic acid (39 mg/100ml juice), and firmness (1.23 Kg/cm$^2$) throughout the storage compared to control. Sensory evaluation results also confirmed the efficacy of chitosan based coatings. These findings suggest that chitosan based coatings could be used commercially for improving nutritional quality and prolonging the storage life of NIAB Kinnow fruits.

**Fortification of chitosan based coating with calcium and ascorbic acid increases cold storage life of low-chilling strawberry cultivar fruits**

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Strawberry is highly perishable fruit with storage life of few days. Low chilling cultivars are harvested during hot spring season that exponentially increases strawberry fruit weight loss and deteriorate fruit quality. Edible coatings are mainly used to minimize the post-harvest losses in perishable fruits. Current study was conducted to enhance the shelf-life of strawberry under cold storage conditions (10 °C ±2). Strawberry fruits were treated with i)- control (non-coated), chitosan 1% + acetic acid 0.75% + calcium chloride 0.75%, ii)- ascorbic acid 1% + citric acid 0.20%, **iii)-** potassium metabisulphite 0.75% and **iv)-** sodium metabisulphite 0.75%. Fruits were evaluated on the basis of weight loss (%), color, aroma, firmness, fungal infestation, overall acceptability, pH, total soluble solids, titratable acidity, vitamin C content, sugar content, antioxidants activity and total phenolic content. It was observed that fruits coated with calcium and ascorbic acid fortified chitosan showed the minimum change in fruit quality attributes. Potassium metabisulphite treated fruits were better in fruit quality after chitosan treated fruits. Non-treated fruits showed very rapid structural and textural degradation along with the biochemical changes as compared to the coated fruits indicating significant effect of coatings on strawberry fruits.

**Harvest location, cultivar and storage duration influence postharvest fruit quality, softening and anti-oxidative enzymes activities of peach**

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A study was conducted to observe the effect of harvest locations (Sillanwali and Soan Valley) and cultivars ('Early Grand' and 'Florida king') on peach fruit softening and quality under cold storage conditions for 28 days (0±1°C, 80-85% RH). Harvest location and cultivar significantly influenced various physiochemical attributes including activities of various fruit softening and anti-oxidative enzymes in peach fruit during low temperature storage. During cold storage, fruit harvested from Sillanwali exhibited significantly higher fruit weight loss, ascorbic acid contents, activities of fruit softening enzymes viz. *endo*-polygalacturonase (*endo*-PG), *exo*-polygalacturonase (*exo*-PG] and significantly lower fruit firmness, ground colour, soluble solid contents (SSC), SSC:TA, total phenolic contents (TPC), antioxidant scavenging activity (ASA), activities of catalase (CAT), peroxidase (POD), superoxide dismutase (SOD), and pectin esterase (PE) enzymes as compared to fruit harvested from Soan Valley. Peach cv 'Early Grand' showed significantly higher ascorbic acid contents, activities of CAT, *endo*-PG and *exo*-PG enzymes; whereas, lower fruit weight loss, fruit firmness, SSC, SSC:TA, TPC, ASA, activities of POD, SOD, PE and enzymes than 'Florida King'. Conclusively, 'Florida King' peach harvested from Soan Valley exhibited superior fruit quality during cold storage as compared to 'Early Grand' peach harvested from Sillanwali.

**Post-harvest exogenous application of various bacterial strains improves the longevity in cut tulips (*Tulipa gesneriana* L.)**

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Tulip holds spectacular and colorful bright floral buds that are widely adorned like no other flower, across the globe. Just like other cut flowers, persistent and prolonged display life is the matter of concern for florists as well as consumers that decides the quality. Endophytic bacteria, taken up by the plants and colonized, can act as sink for ACC hence delay senescence. These bacteria, when used as suspension solution for cut flowers, increase the vase life manifolds which signify their application to commercial floriculture. Keeping in view, the exalted status and market value of cut tulips, an experiment was conducted to study the response of different bacterial strains in concentrated and diluted forms to estimate the postharvest longevity. Treatments were comprised of four different bacterial strains viz. *Burkholderia phytofirmans* strain PsJN, *Caulobacter* sp. strain FA-13, *Enterobacte*r sp. strain MN-17 and *Bacillus* sp. strain MN-54 in concentrated and diluted forms along with control treatment (non-treated stems). In this experiment, 25 mL of bacterial culture were sprayed on cut tulip stems, under controlled conditions in laboratory. In this experiment, PSJN in concentrated form, performed best and resulted in maximum in enhancing Vase life (13.2 days), delayed leaf yellowing (8.8 d), more water uptake 76.33 (mL), less stem elongation (5.14 cm), more days to open flower bud (2.47 d), maximum flower diameter (50.79 mm) and enhanced quality of flower. Whereas MN-17 in concentrated form performed best in fresh and dry mass ratio and reduced stem bending. It is concluded that use of plant growth promoting bacteria (PGPB) is a useful tool in escalating vase life of cut tulips with improved floral attributes.

## Fruit softening and phytochemical changes of 'samar bahisht chaunsa' mango under different storage temperature regimes

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Physiological mature 'Samar Bahisht Chaunsa' mango fruit after harvest were stored at different low-temperatures (10, 12 and 14°C) for 28 days and were evaluated for various physio chemical changes during storage period. Fruit firmness as well as biochemical fruit quality characteristics were determined at 7-day intervals during cold storage period. Mango fruit stored at 10°C maintained higher fruit firmness through delayed fruit softening during the cold storage period. Total phenolic and antioxidants contents were significantly higher in fruit stored at 14°C during the entire cold storage period. SSC and SSC:TA ratio was lower in fruit stored at 10°C, while, TA and ascorbic acid content showed the reverse trend. In conclusion, among different cold storage temperature 12°C was found to be good for delaying the fruit softening, while, at 14°C total antioxidants and phenolic contents were higher in 'Samar Bahisht Chaunsa' mango fruit during cold storage. However, the fruit skin color development in cold stored mangoes was an issue which needs to be addressed.

## Effect of storage time interval on the quality of virgin olive oil extracted at different fruit maturity levels

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Olive fruits of Pendallino olive cultivar were harvested at three different maturity indices (maturity index zero, three and six) from olive orchard located at district Nowshera. The olive fruits were mechanically pressed and three-phase vertical decanter was used for the extraction of virgin olive oils from the paste. The

influence of fruit ripening process and storage intervals (stored for three months at room temperature in the dark) on the quality of virgin olive oil in terms of peroxide value, iodine value, acid value, chlorophyll contents, UV absorbance at 232 and 270 nm, carotenoids and fatty acid profile was investigated. Different quality parameter such as peroxide value, iodine value, chlorophyll contents, UV absorbance at 232 and 270 nm, carotenoids and oleic acid were decreased during ripening process. Linolenic acid increased during ripening; while a very slight rise was observed for the acid value as ripening proceed further. Total phenolic contents were present at higher concentration at the zero maturity index, which were progressively decreased for three and sixth maturity index. Changes in Linolenic, linoleic and palmitic acids were observed while the other fatty acid contents did not change during ripening process. Acid value, peroxide value and UV absorbance at 232 and 270 were increased with the progress in storage time. Iodine value, chlorophyll contents, carotenoid pigments and total phenolic substances were decreased during three months of storage. All of the above analyzed quality parameters were under the acceptable range established by European regulation for extra virgin olive oil. Among fatty acid contents, oleic acid was increased while a slight reduction was noticed in linoleic, linolenic, palmitoleic, palmitic, stearic and arachidic acid The International Olive Council's (IOC) criteria for pureness and excellence was used as a standard for the calculated values of the samples. However, throughout maturity process and storage duration, peroxide value, free fatty acid value and UV absorbance (K232 and K270) values were under the acceptable limits established by IOC (2010) for the best category of EVOO.

**Influence of hexanal vapor on the storage life and pericarp browning in litchi cv. 'gola' fruit**

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Litchi is highly perishable fruit having very short shelf life and pericarp browning is the major factor affecting its postharvest quality. Therefore, this study was conducted to investigate the effect of hexanal fumigation on pericarp browning, changes in activities of antioxidative enzymes and biochemical quality attributes of litchi cv. 'Gola' fruit under cold storage conditions. Fruit harvested at physiological maturity were fumigated with different concentrations (0, 250, 500, 750 and 1000 µL $L^{-1}$) for 45 min and then stored at 5 ± 1°C with 90 ± 5% RH for 28 days. Postharvest fumigation of hexanal could not control pericarp browning and resulted in lower anthocyanin and increased weight loss than control fruit. Maximum SSC, lowest TA and highest SSC: TA was observed in 1000 µL $L^{-1}$ hexanal-treated fruit, while ascorbic acid was higher in 250 µL hexanal-treated fruit. Control fruit exhibited higher total phenolics and total antioxidants in peel and pulp tissues, as compared to hexanal-treated fruit. Activities of antioxidative enzymes (SOD and CAT) and level of total phenolics and total antioxidants in litchi peel and pulp tissues were low in hexanal-treated fruit. On the other hand, activities of PPO and POD enzymes in litchi peel tissues were higher in hexanal-treated fruit. Conclusively, postharvest fumigation of hexanal could not control pericarp browning, but comparatively maintained fruit quality of 'Gola' litchi longer than control during cold storage.

## Physical and biochemical analysis of persimmon fruits collected from different locations of Rawalakot

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Persimmon (*Diospyros kaki*) is fleshy fibrous, deciduous fruit belonging to *Ebenaceae* family. Compared to apples, persimmons have higher levels of dietaryfibres and some dietary minerals. They are grown wildly in few selected areas of Azad Jammu and Kashmir. However, due to the lack of awareness, attention towards its proper harvesting, storage and utilization, most of the fruit is wasted every year. In this regard, the present study was designed to evaluate the various characteristics of persimmon collected from different locations. Samples of persimmon fruits were collected from selected locations of Rawalakot, and analyzed for physical parameters (fruit diameter, total weight of fruit, fruit colour, fruit firmness), biochemical parameters (pH, acidity, total soluble solids, lycopene, vitamin C, total sugars) and antioxidant properties (total phenols, antioxidant activity). The results showed that the different locations have some positive effect on the quality and storage life of persimmon fruits. Moreover, based on the results obtained during this study, it can be suggested that some locations are more suitable for growing persimmon fruits as compared to the others. However, detailed studied are needed to explore its potential for distant as well as foreign markets.

## Precision agriculture and post-harvest process management

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Precision agriculture is a farm management that uses information technology to ensure that the crops and soil receive all that they need for optimum health and productivity. The purpose is to ensure profitability, sustainability and protection of the environment. Precision agriculture is also known as satellite agriculture, as

it needs site-specific crop management. Postharvest process management is a part of precision agriculture technology with the development of numerous technologies to measure various parameters related to crop quality and the use of precision agriculture technology with the help if this producers are able to classify their crops at the harvest level. The existence of different sensors for measuring moisture during crop harvesting is an important factor in the maintenance of the product quality in cereals including parameters such as proteins and oil. A storage facility can be provided on the basis of the measured parameters. However precision farming cannot be utilized completely in every crop as the farmers need to know various technological, technical, and economical conditions before the adoption of this technology. Thus, creating awareness among farmers is necessary.

**Post-harvest application of combined bio-stimulants enhanced shelf life and preserved quality of peach fruit cv. 'Florida King'**

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Peach fruit (*Prunus persica L.*) is one of the most admired fresh form fruit because of its flavor, dietary value, attractive color and medicinal worth. However, like other climacteric fruits, peach is highly perishable and soon after harvest quality losses occur. In order to control these losses peach fruit cv. 'Florida King' was immersed in treatment solutions of 2 % $CaCl_2$, 2 mM PUT, 3 mM SA, 2 % $CaCl_2$ + 2 mM PUT, 3 mM SA + 2 mM PUT, 2% $CaCl_2$ + 3 mM and 2 % $CaCl_2$ + 2 mM PUT + 3 mM SA for 10 min, packed in soft board cartons and stored in cold storage (0 ± 1 $^oC$ and 90 ± 5% RH). The physiochemical analysis i.e., weight loss, firmness, fruit skin color, chilling injury index, ethylene production, $CO_2$ production, ascorbic acid contents, titratable acidity, total soluble solids, total phenolic contents, total flavonoids, and sugars were determined at an interval of one week. Combinations of Bio-stimulants, $CaCl_2$ + PUT, SA + PUT and $CaCl_2$ + SA gave significant results as compared to their separate use as these increased shelf life up to four weeks and maintained maximum quality of the fruit.

However, $CaCl_2$ + SA treatment was found to be the most acceptable combination as per physiochemical analysis but in case of chilling injury SA + PUT performed well. The effect of $CaCl_2$ + PUT + SA has not been evaluated significant.

**Effect of different concentrations of vegetables extract on berry quality and postharvest performance of grapes cv. perlette' and 'king's ruby**

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Although table grape is a non-climacteric fruit with low physiological activity, it is however prone to weight loss, softening and fungal infection during postharvest period. The whole vine especially fruits were sprayed with vegetables extract (0, 0.25%, 0.3% and 0.35) at 15 days interval after fruit set before harvest. Different fruit characteristics were analyzed after harvest and remaining fruits were stored at 0.5 ± 0.5 °C and 90 % RH for 28 days. Pre-harvest parameters including photosynthetic rate (A), transpiration rate (E), stomatal conductance (gs) and sub-stomatal $CO_2$ concentration (Ci) were recorded 48 hrs. after each foliar spray. The data were recorded for weight loss, colour, total soluble solids (TSS), titratable acidity (TA), vitamin C, sugars, total phenolic contents and antioxidants on zero day and for four weeks at weekly intervals. Vegetables extract with 0.25% and controls remain less photosynthetically active in both cultivars. While, photosynthetic activity varied significantly among both cultivars 'Perlette' exhibited 12.95% higher photosynthetic activity, as compared to cv. 'Kings Ruby'. Grape cv. 'Perlette', showed 13.45% higher stomatal conductance with 0.44% in vegetable extract treatments 0.25% and 0.30% whereas, cv. 'King's Ruby' exhibited 20.21% higher stomatal conductance in 0.3% vegetables extract. The cultivar 'Perlette', showed 12.04% higher sub stomatal $CO_2$ concentration with 0.35% vegetables extract whereas, cv. 'King's Ruby' exhibited 14.12% higher sub stomatal $CO_2$ concentration in 0.3% vegetable extract treated grape vines. At harvest, total soluble solids (TSS) were significantly improved compared to control fruit. During the storage period, total phenolic content was significantly reduced in control fruit compared to fruit which were sprayed with vegetable extracts. The highest levels of total polyphenol contents were in

vegetable extracts sprayed fruit and the lowest was in control fruit. In general, foliar application of vegetable extracts resulted in improvement of postharvest characteristics of grapes. Thus, application of vegetables extract is recommended as treatments for increasing postharvest life of grapes Perlette' and 'King's Ruby.

**Advances in quality and shelf life of fresh grapes with edible coatings**

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Edible wax coating is eco-friendly technology which is applied to several agricultural products to regulate moisture content, and oxidation processes consequently improving its quality and shelf life. To elucidate the effects of different edible waxes such as Carnauba, Paraffin, Shellac and Bee wax on the quality and shelf life of table grapes of cv. Kishmishi (*Vitis vinifera),* these waxes were dissolved in five different solvents viz Methanol, Ethanol, Chloroform, Hexane, and Distilled water. The grapes bunches were coated with dissolved edible waxes. Coated samples were kept under both laboratory (25 $C^0$ ±) and cold store (1 $C^0$) conditions. Results revealed that uncoated bunches, under laboratory conditions, showed rapid reduction in berries weight, size, and color compared to coated bunches which slowed down these traits with estimated shelf life of 12 days. In contrary, coated treatments enhanced shelf life and quality of table grapes up to 30 days under cold store condition compared to control treatments. Grapes samples coated with Paraffine+ distilled water, Shellac+ Methanol and Shellac+ Ethanol significantly showed maximum berries weight (95.75g, 62.25g & 60.50g), Size (13.50mm, 13.25mm & 12.75mm) with extended shelf life of 30 days. The total soluble sugar (26.80 °Bx, 29.50 °Bxand 30.50 °Bx) was significantly affected with these three coating treatments, respectively. It is concluded that coating with edible waxes can enhance the quality and shelf life of table grapes and would be applied at commercial scale for reducing losses and the use of post-harvest chemicals.

**Sodium alginate coatings fortified with ascorbic acid and calcium improves the storage life and postharvest quality of strawberry fruits**

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Strawberries are highly perishable and susceptible to water loss, pathogenic attach, bruising and mechanical injuries due to their smooth texture and lack of a protective peel that leads to very short shelf-life. Therefore, this study was designed to evaluate the effectiveness of sodium alginate based edible coatings with either ascorbic acid or calcium chloride to maintain its quality and prolong post-harvest life during cold storage. The five treatments included $T_0$ = control (no coating), $T_1$ = 1% sodium alginate + 1% vitamin C + 1.5% glycerol, $T_2$ = 1.5% sodium alginate + 5% vitamin C + 1.5% glycerol, $T_3$ = 2% sodium alginate + 2% calcium chloride, $T_4$ = 2% sodium alginate + 1% vitamin C + 2% calcium chloride. After applying coating fruits were stored at 4 °C. Results indicated that $T_4$ coated strawberries showed less decay, weight loss, minimum decrease in length and polar diameter, while effectively maintained firmness, colour and overall appearance of strawberries for longer duration as compared to other treatments. Moreover, $T_4$ was effective in maintaining total soluble solids and ripening index of strawberry fruits. Therefore, $T_4$ (2% sodium alginate + 1% vitamin C + 2% calcium chloride) coating may be used to maintain strawberry fruit quality and improve its storage life in cold storage.

**Efficacy of calcium chloride and salicylic acid to assess the post-harvest longevity of cut tulip (*Tulipa gesneriana L.*) cv. barbados**

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Tulip, a perennial geophyte from Liliaceae family, is amongst unaccustomed ornamental crop though a delicacy among the cut flowers in Pakistan. It possesses ranked stature on basis of its brilliance and attraction. Its multifaceted uses as bedding plant, pot plant and a specialty in the landscape make it an eminent plant. Prolonged display life is always desirable in its cut stems like other cutflowers and important factor to persuade the quality index. Therefore a study was conducted in which two chemicals; salicylic acid and calcium chloride were used in different concentrations. Salicylic acid a phenolic compound inhibited ethylene production, delayed wilting of florets and senescence in tulips. The use of calcium chloride in vase solutions hastened the water flow through the stems by association with pectin in the xylem cell walls. It minimized the bacterial colonies in vase solution which impedes the uptake of solution, hence improved the post-harvest longevity. The best doses of salicylic acid and calcium chloride were (50, 75 mg $L^{-1}$) respectively. Results showed that calcium chloride at 75 mg $L^{-1}$ performed better than all other treatments. Calcium chloride improved the following parameters like stem elongation, water uptake, bud diameter, days to senescence, tepal area, flower quality, flower diameter, less stem bending and minimum leaf yellowing were observed. Therefore calcium chloride and salicylic acid can be used as an ingredient in vase solution to prolong the display life of cut tulips.

**Comparison between alginate, aloe vera and chitosan edible coatings for maintaining biochemical and nutritional profile of stored strawberry fruits**

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Strawberry, anon-climacteric plant, is highly perishable consequently; has low post-harvest life. High respiration rate, metabolic activities and sensitivity to microbial attack contribute to minimize its shelf life. Therefore, an experiment was conducted to enhance the storage life of strawberry fruit and to maintain its sensory and nutritional quality attributes. For this purpose, three different edible coatings viz., Aloe vera gel, sodium alginate and chitosan were applied and fruit was stored at 10 ±2 °C temperature and 35-40% humidity. Data were collected regarding different fruit quality parameters i.e., weight loss, disease incidence, sensory evaluation(color, firmness, appearance, aroma, and overall acceptability) and ripening index while biochemical and nutritional attributes included pH, TSS, TA, , vitamin C contents, phenolic components, anthocyanin, antioxidant activity and antioxidant capacity were also estimated. Results indicated that weight loss was significantly reduced with retained color and aroma by alginate coating followed by chitosan .However, fruits coated with aloe vera gel were more resistant to disease incidence and maintained all biochemical parameters in comparison of other treatments. It was concluded that sodium alginate had significant effect to reduce weight loss (%) color and aroma while; aloe vera edible coating was effective in maintaining nutritional profile of stored strawberry fruits.

## Pakistan: Post harvest management in citrus

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Post-harvest losses are damaging the national economy of the developing countries. These losses are so high needed to be minimized to improve the socio economic condition of producer. Citrus is major fruit produced mainly in the Sargodha, Layyah, Vehari, Mandibahudin and Toba the Singh district of Punjab Pakistan. In Punjab total area under citrus cultivation is 183.2 thousand hectare, Sindh 6.9 thousand hectare, Khyber Pakhtunkhwa 5.1 thousand hectares and Baluchistan 1.1 thousand hectare. Sargodha district covers about 51 % of total cropped area. Citrus crop is affected by the pre and post-harvest losses. These losses are up to 38 % while developing countries have only up to 10 %. Among the factors of post-harvest losses in citrus includes physiological, pathological, mechanical and environmental. Climate change also contributing in post-harvest losses in citrus. In Pakistan lack of adoption of modern technologies in harvesting, transportation, processes and packaging contributing towards these losses. On farm and off farm facilities should be improved to decrease the magnitude of post-harvest losses. Post-harvest nonconventional preservation technologies are in need to be opted to minimize these losses. One of the emerging green technologies is application of edible coating (Polysaccharides).Edible coating will not only improve the quality of fruit produced but also ensure the preservation. Storage facilities should also need to be focused to minimize losses.

**Effect of chemicals on postharvest longevity, vase life quality and water uptake of *Gladiolus grandiflorus'* white prosperity**

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Gladiolus is highly valued speciality cut flower after roses in Pakistan. Short vase life of cut flowers are the major problem. Extension in the display life of cut flowers is a pre-requisite of floral industry to meet with the demands of growers, wholesalers and consumers. Various chemicals preservatives and growth regulators are currently in use to enhance the shelf life and decorative life of gladiolus flowers. In this study well established plant growth regulators salicylic acid (SA) 300 $mgL^{-1}$, naphthalene acetic acid (NAA) 100 mg $L^{-1}$ and various chemical preservatives citric acid 300 $gL^{-1}$, Sucrose 2%, 2 Tablets of disprin in 1000mL of water and the soft drink with the brand name of Fanta 250 ml were used as vase solutions. Tap water was used as a control treatment. Flower longevity, water uptake, vase life, transpiration rate and percent fresh weight change were investigated in this study. The highest flower longevity, water uptake and vase life of cut gladiolus were recorded with the soft drink Fanta due to having carbohydrate source (sucrose), low pH (due to citric acid) and salicylic acid treatments. The study concluded that the soft drink Fanta and salicylic acid application is helpful in enhancing the vase life of gladiolus cut flowers.

**Post-harvest salicylic acid application controls fruit rot, improves storage life and antioxidant profiles of kinnow mandarin fruits during long term cold storage**

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Fruits and vegetables are rich source of phytochemicals which play important role against cancer and cardiovascular diseases. The demand for the food free from pesticide and fungicides is increasing day by day around the globe. Salicylic acid (SA) is an important plant molecule which is proven to have antimicrobial properties along with extends the storage life of different fruits and vegetables. Hence, the present study was conducted to investigate the effects of SA on the fruit quality as well as antioxidant profiles of mandarin during storage in two consecutive years (2015-16). In first experiment, three different concentrations of SA (4, 8 and 12 *m*M) were applied; while based on the first year results, in second experiment, fruits were treated with 2, 4 and 6 *m*M concentrations of SA. The fruits were stored at 5°C for 90 days and data were collected regarding different fruit quality parameters *i.e.,* weight loss, fruit rot, ascorbic acid, total antioxidants, total phenolic contents and antioxidative enzymes. Results revealed that maximum antioxidant activity, total phenolic contents, activities of peroxidases (POD) and superoxide dismutase (SOD) enzymes were found in fruit treated with 4 *m*M SA. All applied concentrations of SA had significant effects to prevent fungal attack in comparison to untreated control fruit during 90 days storage. Overall results suggest that pre storage application of 4 *m*M SA can be used safely to minimize the decay % and to maintain the highest level of bioactive compounds in Kinnow mandarin fruit for three months under cold storage.

**Effect of carboxymethyl cellulose (CMC) coating on shelf life and quality of pear fruit (*Pyrus communis* L) during Storage**

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The pear is an important pome fruit very popular among the consumers for their thin peel, crisp flesh, rich juice and good taste. However, pear is perishable and is susceptible to deterioration accompanied with shriveling, softening and decay. Edible coatings represent a promising technology as they can improve quality and extend shelf life of fruit. Carboxymethyl cellulose (CMC) is a water-soluble cellulose derivative and used for edible coating of fruit that is an effective way to enhance the shelf life and to avoid postharvest losses. Postharvest biocontrol is especially feasible for inhibiting postharvest fruit pathogens by the inoculation of antagonists. The main objective of this study was to investigate the effect of different concentrations of CMC on shelf life and quality of pear fruit during storage at room temperature. For this purpose, thin film forming solution was prepared by dissolving CMC powder in distilled water and heating at 45 °C with continuous stirring until the homogenous solution was prepared. Polyethylene glycol (1.5 g/100 mL) and food grade ethanol (95 mL/100 mL) was added and mixed thoroughly. Thereafter, citric acid (1 g/100 mL) was added and mixed to obtain the desired concentrations of 0.5 %, 1.0 %, 1.5 %, 2.0 %, 2.5 % and 3.0 % was applied on post-harvest pear. Fruit was evaluated for weight loss, total soluble solids, pH, ascorbic acid and sensory parameters such as color, flavor, texture, taste and overall acceptability at nine days intervals during 45 days of storage. Minimum loss was observed in $T_6$ (3.0 % CMC + Polyethylene glycol (PEG) + Ethanol + citric acid) and effective in the withholding of higher contents of vitamin C, total soluble solids, titratable acidity, pH and sensory parameters like texture, taste, flavor, color and over all acceptability with minimum weight loss during storage. TSS decreased with passage of time in all treatments and maximum value was noted in $T_6$ during storage. The data obtain was analyzed by using the analysis of variance (ANOVA) technique and difference among treatment means was compared by using LSD (least significant difference test).

**Investigating production and quality responses in phalsa in relation to managementof pruning and mineral nutrition**

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As phalsa (*Grewia asiatica* L.) fruit is incorporated with range of beneficial and healthy minerals, and biochemical accumulations, there is need to improve its production and quality. Field investigations were conducted to enhance production and quality of phalsa fruit by utilizing strategical combination of pruning practice and essential mineral nutrition. The NPK compound fertilizer (17:17:17) application and pruning practice plant-1 was done as treatment *viz.* (T1 = pruning at ground level + 600 g NPK fertilizer as a control, T2 = pruning at 3 ft + 600 g NPK fertilizer, T3 = pruning at 3 ft + 1800 g NPK fertilizer, T4 = pruning at 3 ft + 900 g + 900 g NPK fertilizer, T5 = pruning at 3 ft + 600 g + 600 g + 600 g NPK fertilizer). Data on vegetative growth (No. of new emergences plant-1, shoot length, leaf No. shoot-1, leaf area), reproductive expression (clusters shoot-1, flowers cluster-1 and fruit set %), and fruit quality attributes (fruit size, average fruit weight, seed weight, total soluble solids (TSS), juice pH, titratable acidity (TA), sugar acid ratio (TSS: TA), vitamin C and sugars) was collected and analyzed in experimental field and laboratory respectively. Among different treatments significant influence of T5 followed by T4 was visualized in terms of maximum new sprouting, flowering, higher fruit set percentage resulting in enhanced fruit production. Hence, a significant improvement in TSS, TSS: TA ratio, vitamin C and reduction in pH and TA percentage was also noted owing to pruning at 3 ft + 1800 g NPK plant-1 as compared to rest of the treatments. However, good quality fruit production trend in phalsa can be achieved through application of 1800 g NPK compound fertilizer plant-1 in three splits (sprouting, bud initiation and fruit set stage) and pruning practice at 3ft height.

# Calcium, boron and zinc foliar application depress physiological disorder and improve tomato fruit quality and yield

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A field experiment was carried out to study the effects of calcium, boron, and zinc foliar application on yield and quality of tomato. Four levels of Calcium (0, 0.3, 0.6 and 0.9%), three levels of Boron (0, 0.25, and 0.5%) and three levels of Zinc (0, 0.25, and 0.5%) were applied as foliar spray three times (before start of flowering, at the time of fruit set and 15 days after fruit set). Calcium application at 0.6% increased the yield. Likewise, calcium application at 0.9% resulted in higher fruit Ca content, decreased blossom end rot, fruit cracking and Zn content. Foliar spray of B at 0.25% produced higher yield and reduced fruit cracking. Similarly, 0.5% B application significantly increased fruit Ca content and fruit B content, lowest blossom end rot, and fruit Zn content Likewise, Zn application at 0.5% resulted in higher yield, fruit B and Zn contents while the incidence of blossom end rot, fruit cracking and fruit Ca content were lower with 0.5% foliar Zn application. The interaction between Ca, B and Zn also showed that combined application of these nutrients were more effective in comparison with sole application significant results for most of the reproductive attributes and physiological disorders. Therefore, it is concluded that foliar application on Ca, B, and Zn can be used alone or in combination to minimize the physiological disorders, increase yield and improve fruit quality of tomato.

**Wind blemishes development influenced by wind speed and management strategies for the minimization of wind blemishes in kinnow mandarin**

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The study was conducted with the objective to evaluate the role of wind speed in the development of wind blemishes and windbreaks and pruning as a management strategy for reduction of wind blemishes. The Kinnow trees were subjected to varying wind velocities for different durations with the help of an industrial fan and the effect of windbreaks were assessed on the extent of blemishes in the trees. The fruit were analysed for extent of blemishes at commercial harvest. Wind intensities of 10 km $hr^{-1}$ for 30 minutes and 30 km $hr^{-1}$ for 30 minutes produced significantly higher percentage of wind blemished fruit. Impact of windbreak was evaluated on development of blemishes in Kinnow fruit and results revealed that, significantly higher percentage of wind blemished fruit were found in orchards with no wind break while minimum wind blemished fruit were found in orchard with bamboo (*Bambuseae*) wind break. Regarding wind blemishes in different tree position (top, mid and bottom), results were found non-significant to each other. Significantly higher percentage of mites blemished fruit were found in orchard with bamboo (*Bambuseae*) wind break followed by orchard with simal (*Bombax cieba*) wind break, while lower incidence were recorded in orchard without wind break. In case of citrus canker, significantly higher percentages of cankered fruit were found in orchard with bamboo (*Bambuseae*) windbreak, while other two orchards (orchard with simal windbreak and orchard with no windbreak) were found at par to each other. Removal of 8-10% of total bio-mass of tree) significantly increased the percentage of a grade fruit (no blemish or < 1 $cm^2$ area covered with blemish on skin of fruit) and improved fruit diameter as well.

## Effect of foliar spray of potassium sulfate with and without urea on fruit retention, quality and yield of "dhakki" dates

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Studies were carried out to investigate the impact of bunches spraying with $K_2SO_4$ along with 2%urea on fruit drop, fruit retention, yield, and quality of dhakki dates during the 2015 and 2016 at D.I.Khan (31°49′53″N 70°54′7″E). Bunches were sprayed with one litre solution having 1%, 2%, and 3% $K_2SO_4$ along with 2% urea. Solutions were sprayed at two stage of fruit development i.eKimri and Khalal. Trial was carried out in Randomized Block Design with three replications. It was observed that Potassium in the form of $K_2SO_4$ significantly reduced the fruit drop and resulted in higher percentage of retained fruits at the time of harvesting as compared to control and all other treatments. All the studied parameters i.e. fruit weight, fruit size, fruit length, fruit Diameter, and flesh weight were significantly improved by applying 2% Potassium sulfate along with 2% of urea. Quality of fruit was also improved by the same concentration. Since application of Potassium sulfate along with Urea increased the retained fruits, fruit size and fruit weight it also helped in increased yield at the time of harvesting. Similar trend was observed in both years of study.

## Pre and post-harvest application of bio- stimulants improves growth, yield and quality of bell pepper cv. yolo wonder

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Bell pepper (*Capsicum annuum*) is a high demand vegetable since ever. High quality of fruit and increased yield are desired characters both for the researchers and the growers. The impact of foliar application of Chitosan (CHT), Salicylic Acid (SA) and Putrescine (PUT) on fruit yield and physio-chemical characteristics of “Yolo Wonder” bell pepper cultivar was studied for two

consecutive years (2012 and 2013). Results indicate application of Chitosan, Putrescine and Salicylic Acid increased fruit weight, fruit diameter, and yield as compared to control and other treatments. Fruit firmness, ascorbic acid contents, total sugars, free radical scavenging activity, pH and fruit color was improved as compared to control. While membrane leakage, weight loss (%), fruit softening enzymes (PE and PG) activity and fruit chilling injury was reduced. Present research proves SA and PUT sprays more effective than CHT for improving fruit physical and chemical characteristics such as fruit size, titratable acidity fruit weight, yield, fruit firmness, free radical scavenging activity and vitamin C content. Finally, pre and post application of biostimulants used in this study can easily be used to improve yield and quality of bell pepper without compromising the food safety standards.

**Effect of ascorbic acid on pericarp browning, biochemical quality and activities of antioxidative enzymes in litchi**

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Postharvest pericarp browning reduces the quality and visual appearance of litchi fruit. Therefore, in this study influence of different ascorbic acid concentrations (0, 15, 30, 45 or 60 m*M*) on pericarp browning, biochemical quality, antioxidative and enzymatic changes in litchi cv. 'Gola' fruit under extended cold storage was investigated which has not been studied extensively. Fruit dipping in 45 m*M* ascorbic acid maintained higher anthocyanin contents by reduced browning index and fruit weight loss. Activities of antioxidative enzymes (SOD and CAT), level of TPC and total antioxidants contents were significantly higher in peel as well as pulp tissues of 45 m*M* ascorbic acid-treated fruit. Whereas, activities of PPO in litchi peel and POD enzymes in peel as well as pulp tissues were reduced in 45 m*M* ascorbic acid-treated fruit. Conclusively, application of 45 m*M* ascorbic significantly delayed pericarp browning and maintained better quality of 'Gola' litchi fruit during cold storage.

# Dietetics and Pharmaceutical Values of Horticultural Crops

**Regulating horticultural practices for plant based medicines; ethical and moral dilemmas**

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Plant based medicines have received prominence and enhanced approvals due to severe adverse events linked with conventionally synthesized or traditionally used drugs. Several medications used to treat infectious and non-infectious ailments were initially originated from a variety of plants followed by the preparation of their synthetic derivatives. In the current times, the opiates are the most prominent plant based drugs used and abused in North America including the global spread. On the average, a death rate of 140 people/day due to opioid usage in the United States of America is in the current reports according to the Center for Disease Control (CDC). The opportunistic entrepreneurial communities have developed synthetic derivatives of plant based opioids challenging the health of people across the globe. Historically, there is empirical evidence that the most abused products are having euphoric effects have their origin from plant products. In the wake of all these issues, we propose a Global Horticultural Guidelines for performing and promoting research on plant based medicine. In the backdrop of above findings in this presentation, we report a proof of concept example for ethical usage of plant based medicines that could be potentially adapted as a model. Our laboratories are involved in evaluating the antiviral/antifungal potential of medicinal plants. The latest example to be detailed in this presentation is exploring the Cholistan Desert plants for overcoming Avian Flu in birds caused by the Avian Influenza Virus (AIV). Among the eleven plants evaluated in our recently accepted study in a prestigious pharmaceutical journal, it was observed that methanolic extracts of these plants inhibited replication of AIV H9N2 except *S. baryosma*. Cholistani plants including *O. compressa*, *N. procumbens*, and *S. surattense* were found to be the most potent in inhibiting viral replication followed by *O. esculentum*, *H. salicornicum,* and *S. fruticosa*. The extracts of *H. recurvum, P. antidotale, S. icolados* and *A. aspera* showed relatively lesser

potency to inhibit AIV replication. These results led us to conclude that the medicinal plants of Cholistan region are a rich source of antiviral agent(s) against AIV H9N2, a potential threat to the poultry industry of Pakistan and could be a source of cost effective alternate methods to treat this deadly infection in poultry. Besides overcoming a national problem, this piece of research has a potential nexus between the organized horticulture and saving highly lucrative poultry industry. Based on these findings we suggest the establishment of Global Horticultural Regulatory Authority for defining research avenues related to plant based medicines, so the research avenues related to plant based medicine and organized cultivation of these plants should benefit the humanity and livings instead of inflicting harms.

**Ripening-dependent accumulation of lipophilic and hydrophilic antioxidants in 'red rose' tomato fruit grown under the protected environment**

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Consumption of the diet rich in antioxidants offers protection against the incidence of many chronic diseases in human being but the use of chemical/synthetic antioxidants have been associated with serious health and environmental issues. Search for natural, non-toxic and effective antioxidants has, therefore, been exaggerated in recent years. Tomato is a rich source of dietary antioxidants. Proper intake of tomato fruit helps reduce developing many types of cancers, and cardiovascular diseases. During the ripening process, the fruit undergoes a series of physiological, biochemical and compositional changes that affect its functional properties. The present study was aimed at investigating the accumulation of various lipophilic and hydrophilic antioxidants at six well-defined stages of fruit maturity (i.e. mature green, Breaker, Turning, Pink, Light Red, and Red) in 'Red Rose' tomatoes, grown under controlled conditions. DPPH free radical-scavenging capacity of the fruit was also monitored during the course of the present investigation. The results revealed that the hydrophilic antioxidants such as ascorbic acid, phenolic compounds and flavonoid content peaked between

the ‘Pink’ and the ‘Light red’ stages of maturity whereas the lipophilic antioxidants including β-carotene and lycopene peaked at the ‘Red’ stage of fruit maturity. Strong and positive correlations were established between the DPPH free radical-scavenging capacity of tomato fruit and the individual dietary antioxidants.

## Morphological, physicochemical and nutritional study of fig (*Ficus caric* L.) collected from District Kotli, Azad Jammu and Kashmir

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These studies were carried on morphological, physicochemical and nutritional characteristics of fig (*Ficus carica* L.), collected from District Kotli, Azad Jammu and Kashmir during 2015-16, in the Laboratory of Department of Horticulture, Faculty of Agriculture, The University of The Poonch Rawalakot. The objective of research was to explore morphological, physicochemical and nutritional value of wild edible fig (*Ficus carica* L.) growing at Kotli, Azad Jammu and Kashmir. Climatic condition of District Kotli, Azad Jammu and Kashmir are suitable for the cultivation of fig. Wild edible fig samples was collected from six locations of district Kotli including (Dhanna, Nakkyal, Kotli, Fagoosh, Khuiratta and Charohi). Data was recorded for various morphological parameters (plant height, leaf area, number of branches plant-1 , number of fruits plant-1 , fruit diameter, total weight of fruit), physicochemical parameters (chlorophyll contents and mineral content) and nutritional values like (crude fiber, crude fat, total ash content, carbohydrate content, total soluble solids (mg/g), total acidity and pH). The experiment was laid out in complete randomized design (CRD) with two Factors. The data thus obtained were statistically analyzed and means were compared by using least significant difference (LSD) (Steel *et al*., 1997). Results were recorded for various morphological parameters (plant height 5.63±4.23, leaf area 27±21, number of branches plant-1 72.83±44, number of fruits plant-1 946.83±773.94, fruit diameter 38.35±5.96, total weight of fruit 34.97±6.11), physicochemical parameters (chlorophyll contents 27.06±18.28 and mineral content N 0.30±0.13, P 0.32±0.13 and K1.93±1.09 ) and nutritional values like

(crude fiber 1.86±1.34, crude fat 0.33±0.05, total ash content 0.85±0.40, carbohydrate content 30.36±15.48,moisture 77.50±68.16, total soluble solids 20.00±8.00 (mg/g), total acidity 0.94±0.50 and pH 5.0±4.34).

**Irrigation water quality affects fruit physico-chemical attributes and heavy metals contents in jaman and falsa**

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Around the urban areas of Multan, sewage water is commonly used to irrigate the crops and orchards along with canal and tubewell water. Farmers utilize sewage water to irrigate their orchards as it saves the cost of pumping out ground water and contains naturally organic materials that results in proper growth and development of plants with better yields. However, sewage water has also harmful aspects because it contains pollutants that may pose negative environmental and health impacts. Besides pollutants, sewage water also contains heavy metals in excess amount. In sewage water irrigated orchards, plants uptake and accumulate heavy metals in their fruits, which are not good for human's health upon consumption. The present study was conducted to examine the quality of jaman (*Eugenia jambolana*) and falsa (*Grewia asiatica*) fruits irrigated with different water sources (canal, tubewell and sewage) and accumulation of heavy metals in the fruits. Soil and fruit samples of jaman and falsa were collected from different orchards located in peri-urban areas of Multan. Fruit fresh weight and dry weight of jaman was observed the maximum in sewage irrigated water. However, different irrigated water has no effect on fruit weights of falsa. Whereas, peel and pulp color, texture, aroma, flavor, eating quality and shelf life were not affected by the different water sources in both fruits. Total soluble solids, pH, titratable acidity, vitamin-C, total phenolic, total carotenoids, total flavonoids and antioxidant activity were observed greater in fruits irrigated with sewage water. Copper and nickel were found more in soil irrigated with sewage water as compared to those irrigated with canal or tubewell water. Falsa fruit exhibited more nickel contents as compared to jaman. However, copper contents

were only detected in the fruits of falsa. Cadmium and zinc remained undetectable in the both fruits, being very minute in quantity.

**Differential pH-induced biosynthesis of steviol glycosides and biochemical parameters in submerge root cultures of *Stevia rebaudiana* (Bert.)**

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The major objective of the current study was to investigate the potential effects of differential pH levels on culture development and production of steviol glycosides and other polyphenolics content in submerge root cultures of *Stevia rebaudiana*. *In vitro* grown cultures require an optimum pH level for rapid growth and uniform production of secondary metabolites. Herein, varying media pH levels (5.0, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9 and 6.0) significantly influenced fresh and dry biomasses of adventitious root cultures. Among tested levels, adventitious root cultures favored high media pH (6.0) for accumulation of maximum fresh biomass (112.86 g $l^{-1}$) and dry biomass (8.29 g $l^{-1}$). In this study, we observed that lower pH level (5.1) strongly supported the production of steviosides (79.48 mg/g-DW) and rebaudioside-A (13.10 mg/g-DW) contents but reduced the polyphenolics content in adventitious cultures. However, dulcoside contents (2.57 mg/g-DW) in adventitious root cultures were found in higher quantities at pH level 5.8. Similarly, maximum total phenolics (70.06 mg/g-DW) and flavonoids (50.19 mg/g-DW) were observed on media having 5.8-pH level. The same pH level also improved DPPH-radical scavenging activities (92.67%). This study will offer an approach to enhance medicinal products in the *in vitro* tissues, rather than to over-exploit the wild plants and ultimately putting them on the brink of being endangered. Furthermore, the consistent production of secondary metabolites in these cultures could be scaled-up on bioreactor level, which will ultimately affect the society by potential introduction of cost-effective and biologically stable medicinal drugs.

## Walnut: house of Omega 3 and their significance

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Walnut is one of the most important nutritive nut crops and widely grown in Galliat, Abbottabad, Swat, Dir, Shangla, Buner, and Chitral region of Pakistan. Walnut fruit keeps essential foods that people need to have healthy nourishment. Walnut is a seed and all seeds are extremely rich with nutrients. Raw walnut of 100 g a day largely provides the 15.2 g protein, 65.2 g fat, and 6.7 g dietary fiber, antioxidant, vitamins and minerals. It is considered as an enriched food in terms of valuable substances for health. Walnut is a rich source in terms of Omega 3 which play important role in maintain a regular health, reduction of cholesterol level in the body, improve metabolism and control of diabetes. It also possesses anti-inflammatory properties which aid in weight management and help as a mood booster and reduce the risk of cancer. In this review, we mainly focus on the chemical properties of walnut which play important role for control different diseases and improving health.

## Determination of capsaicin and dihyhrocapsaicin from (*Capsicum annuum* L.) germplasm using high performance liquid chromatography (HPLC)

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A simple, precise and rapid method involving extraction with methanol followed by separation, identification and quantitation of capsinoids, from diverse pepper germplasm by using high performance liquid chromatography (HPLC) procedure has been developed. The main capsinoids in pepper are capsaicin and dihydrocapsaicin, were estimated by comparison with standards injected under

identical conditions. Their identification was based on the retention time (RT) whereas quantification was carried out by using the areas of respective peaks. The capsinoids concentrations in pepper samples were expressed as µg/g. We have undertaken the examination of previously uninvestigated germplasm of *Capsicum*. As expected hot pepper showed varied concentrations of capsaicin and dihydrocapsaicin, whereas sweet pepper genotypes devoid did not show any of capsinoids. According to results of this investigation, this method can be used for quantification of capsinoids in pepper fruit and can be applied easily for crop improvement program.

**Development and nutritional evaluation of low calorie cookies fortified with date paste (*Phoenix dactylifera.* L).**

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Low calorie based foods are in high demand to meet the present lifestyle with a managed healthy diet. An increasing interest has developed in food products having a reduced caloric content, and especially in low-calorie baked goods which are desirable for reducing the caloric intake to prevent obesity, unwanted weight gain and diseases associated with them. Out of many available approaches, one is to reducing the caloric value of baked goods has been to replace part of the sugar component with agents which are substantially less digestible, and therefore less-caloric. Out of various substitutes like honey, low calorie sweeteners, the present investigation was carried on sugar replacement by date palm (Phoenix dactylifera.L) paste in on 10, 20 and 30% w/w basis. A plethora of carbohydrates, dietary fiber, enzymes, protein, fat, minerals, vitamins, phenolic acids and carotenoids are related to its chemical composition providing the date fruit with antioxidant, antimutagenic, anti-inflammatory, gastro protective, hepatoprotective, nephroprotective, anticancer and immune stimulant activities. The value-addition suggested the replacement at intermediate levels keeping in view the desired mouth feel and calorie intake. Accordingly, it is an object of this investigation to provide highly palatable baked goods wherein essentially most of the compositional sugar is replaced by date palm paste.

## Food allergies – causes and symptoms

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Food allergy is a physiological reaction to specific foods or ingredients triggered by body's immune system. Various foods that may trigger food allergies include eggs, peanuts, milk, fish, soy, wheat or some other specific food. Food allergy occurs when the immune system responds to a harmless food as if it were a threat. Our body produces specific antibodies to the allergen as a result of previous exposure or sensitisation, which cause a variety of symptoms when the food is consumed, including gastrointestinal disturbances, skin rashes, asthma, and, in severe cases, anaphylactic shock, which may be fatal. The diagnosis of food allergy is arduous and may not be as simple as it might seem at the first sight. The diagnosis includes detailed personal and family history, physical examination, tests for IgE mediated reactions and atopy patch test (APT).

## Potential native ornamentals of Pakistan with pharmaceutical importance

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Pakistan is enriched with diverse flora, which is well suited for commercial production as ornamentals as well as for value addition as medicinal plants, but majority of these valuable species have not been explored yet to their potential. These ornamentals can not only generate local employment & improve economic livelihood of growers, but also lower import budget and save foreign exchange. Some potential native ornamentals of Pakistan, which can be commercialized include iris (*Iris songarica*), a member of family Iridaceae, whose roots are used in powdered form to cure diarrhea; khaskhash (*Papaver somniferum*), member of family Papveraceae, used to cure diarrhea, diabetes and rheumatism; and chambeli (*Jasminum officinale*), member of family Oleaceae, whose essential oil is used in aromatherapy, or in dermatology as either in antiseptic or anti-inflammatory agent. Moreover, gul-e-rehan/sage flower (*Salvia cabulica*), member of family Lamiaceae, leaves are soaked in water and decoction is used to cure stomach ache, fever and liver disorders; Silene (*Silene conoidea*), member of family Caryophyllaceae, is used as soap; amaltas (*Cassia fistula*), member of family Caesalpiniaceae, is used as sweeter to diabetic patients and crushed external parts of legume mixed with milk are

useful to relieve throat inflammations and diphtheria, and gul-e-babuna (*Matricaria chamomile*), member of family Asteraceae, is boiled in water and decoction is used for jaundice, long standing fever and colic pain. Overall, there are several ornamental species of Pakistan which can be used in pharmaceutical industry to save foreign exchange.

## Litchi fruit-a wonder fruit in nature

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Litchi *Chinensis sonnnerat* (Sapindaceae) known as Chinese Cherry is a strange and wonderful fruit with a wealth of health benefits. Mainly distributed in Southeast Asia especially in China, Vietnam, Indonesia, Thailand and Philippines. Litchi is soft and pulpy; fruit has bright red and attractive pericarp surrounding a white and translucent fleshy aril, having a sweet odor of rose, delicious and sweet in taste. Oligonol a key component of litchi; is a flavanol-rich litchi have proanthocyanidins used to improve bioavailability. Plenty of flavonoids, tannins, anthocyanins, phenolic acids, triterpenes, sterols and other bioactive compounds also present. Numerous health benefits exhibited including protection against oxidative stress. Moreover, leaves have been used also for the treatment of flatulence, heat stroke, and detoxification, prevention and treatment of hyperuricemia, reduction of fatigue andvisceral fat. *L. chinensis* has been found to be involved in a number of biological activities, including its anticancer, hepato-protective, antioxidant, anti-platelet, antiviral, antimutagenic, antimicrobial, antihyperlipidemic, antipyretic, and anti-inflammatory, antithrombotic, antidiabetic, antiobesity and immunomodulatory activities. From the most recent findings, it is a useful medicinal and nutritional agent for treating a wide range of human disorders and aliments. In this review, we will focus on the chemical and biological properties of leave, peel and fruit and further investigations to fully understand the mode of action of the active constituents to fully exploit its preventive and therapeutic potentials.

## Jug lone as therapeutic drug against UVB - induced damage to skin cells

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Walnuts are known for their health benefits since very long. Juglone is a naturally occurring compound present in walnuts and is the inhibitor of Pin1. Jug lone was once assumed to be lethal for humans. But it is now known that juglone has anti-cancer, anti-aging, anti-proliferative, anti-microbial, and anti-inflammatory properties. The major causative agent of skin cancer is solar ultraviolet radiations (UVRs) that lead to DNA mutation and cellular damage. Increasing number of skin cancer incidences worldwide prompted numerous recent studies focusing on natural or synthetic substances that can protect against deleterious effects of UVRs. In this study, we aimed to investigate the protective potential of juglone, a Pin1 inhibitor found in walnut against UVB-induced skin cell damage via targeting Sirt1. We observed the potential effects of juglone on Sirt1 expression, cell viability, apoptosis, and the generation of reactive oxygen species (ROS) in normal and UVB-irradiated dermal fibroblasts (NHFs) and epidermal keratinocytes (HaCaT) using flow cytometry. DNA fragmentation and western blot were used for monitoring the expression key proteins related to this processes. Treatment with juglone, in particular at 5 μM, enhanced growth and viability of skin cells by preventing ROS generation and apoptosis. Our results show that juglone is a novel Sirt1 activator that promotes growth and viability of UVB-irradiated skin cells, by reducing cellular damage and up regulating Sirt1 expression. Thus juglone could be used against UVB induced damage in the skin cells in future.

## Indigenous fruits and the dilemma of malnutrition

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Numerous indigenous fruit species worldwide have been reported to be rich in minerals and other micronutrients, suggesting that they have the potential to play

a role in addressing hidden hunger. However, considerable barriers exist to unlock the full potential of these fruits. Therefore, this study was designed to evaluate the nutritional value of some selected edible species of indigenous fruits (Apple, Pear, Persimmon, Fig) grown under sub-humid temperate climate of Rawalakot, Azad Jammu and Kashmir. Various samples of selected fruits were collected from different villages of district Poonch. Data was analysed for physical parameters such as, fruit diameter, total weight of fruit, fruit colour, fruit firmness, chemical properties such as vitamin C, total soluble solids, total ash content, titratable acidity, pH and antioxidant properties such as total antioxidants and total phenolics. The results showed that there is a huge potential of these crops to be promoted for commercial scale cultivation. However, further studies are needed to establish a complete supply chain system for these crops and also to develop some value added products.

**Medicinal and nutritional attributes of date seed powder**

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Date pits also known as date stones or seeds are basically waste product of date processing plants. These waste seeds can be used to add nutritional value in different foods. They have several functional and nutraceutical properties. Date seeds are rich in carbohydrates (71.9- 87.0%) which include reducing and non-reducing sugars. The good nutritional value of date seeds is based on their dietary fiber content (22.5-80.2%) which includes cellulose, hemicellulose, pectins, hydrocolloids and lignin. It is also a good source of fat (5.0 -13.2 %) which contain saturated fatty acids (lauric, myristic and palmitic acid) and unsaturated fatty acids (oleic acid). Antioxidant content in date seed oil can be used for fulfillment of dietary requirements. The protein (6.4-2.3%) is also present in date seed powder which includes albumin, globulin, prolamin and glutelin. Date seed is also a rich source of phenolic contents (4430 mg/ 100 g).Date seed contains mainly water-soluble vitamins (B-complex and C).The minerals content of date seed includes sodium, potassium, calcium, iron, copper and calcium. Consumption of date seed powder is associated with a reduced risk of several

chronic diseases, such as coronary heart disease, cardiovascular disease, cancers, atherosclerosis, neurodegenerative diseases (such as Parkinson and Alzheimer), inflammation and aging. Date seeds are beneficial for brain due to neuro-protective properties. Thus, it can be used for development of new value added product as well as nutritional improvement of existing products.

**Effect of different locations on physico-nutritional composition of quince**

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Quince is an important fruit of human diet in temperate region, because it is highly rich in essential nutrients. It grows successfully in different Districts of Azad Jammu and Kashmir. However, most of the fruit is wasted every year due to lack of awareness and attention towards its proper harvesting, storage and utilization. In this context, present study has been designed to evaluate various characteristics of different landraces of quince grown at various localities of Rawalakot, Azad Jammu and Kashmir. Samples of fruits were collected from selected locations of Rawalakot, and analyzed for physical parameters (fruit diameter, total weight of fruit, fruit colour, fruit firmness), biochemical parameters (pH, acidity, total soluble solids, lycopene, vitamin C, total sugars) and antioxidant properties (total phenols, antioxidant activity).The results showed that the different locations play an important role in physical and nutritional composition of different quince landraces. Moreover, based on the results obtained during this study, it can be suggested that some locations are more suitable for growing quince fruits as compared to the others. However, detailed studied are needed to explore its potential for distant markets.

**Salinity induced morphological, biochemical and antioxidant (1, 1-diphenyl-2-picrylhydrazyl-scavenging activity) variations in adventitious root culture of Stevia rebaudiana in invitro**

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Salinity induced morphological, biochemical and antioxidant (1, 1-diphenyl-2-picrylhydrazyl-scavenging activity) variations in adventitious root culture of *Stevia rebaudiana* were examined under *in vitro* conditions. Adventitious roots developed under various salt concentrations (0, 25, 50, 75 and 100 mM), amended in media. Salinity significantly altered the morphological, biochemical trails and antioxidant potential of adventitious roots. Little brownish coloured adventitious roots were obtained in moderate salinity level (0-50mM), while at higher salinity (100mM) dark brown adventitious roots obtained. Maximum fresh and dry root biomass were accumulated under 50 mM NaCl concentration. Antioxidant and biochemical assay (Total Phenolic, Flavonoid, Stevioside, Rebaudioside and Dulcoside contents) revealed that salinity stress can effectively be used to scale up biochemical compound and antioxidant potential of *in vitro* grown adventitious root culture of *Stevia rebaudiana*.

**Phytochemical screening of selected plants from district Nowshera, Khyber Pakhtunkhwa, Pakistan**

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Medicinal plants contain some organic compounds and secondary metabolites, which provide definite physiological action on other living organism. The present study was aimed at preliminary phytochemical screening of the whole plant of *Olea ferrugenia, Chenopodium album, Plantago lanceolata, Lactuca serriola, Partheniumhysterophorus, Carthamusoxycantha, Chrozophoratinctoria,*

*Achyranthusaspera, Wiathania somniferum*, and *Cichorium intybusat* two (2) phenological stages. The dried whole plants were powdered and were subjected to successive extraction using methanol, chloroform and n-hexane. These solvent extracts were subjected to a preliminary phytochemical screening to detect the different chemical viz., alkaloids, tannins, sugar, saponins, flavonoids, Terpenoids, cardiac glycosides, phenolics and anthraquinones.The phytochemical evaluation revealed the presence of these chemical compounds. The diversity of phytochemicals found suggests that and methanolic solvent extracts of these tested plants contain more medicinally important bioactive compounds and it can be justifies their use in the traditional medicines for the treatment of different diseases.

**Chemical nature, stability and bio efficacies of jamun fruit (*Syzygium cumini*)**

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Jamun commonly known as *Syzygium cumini, Syzygium jambolanum* and *Eugenia cumini*, other common names are Jambul, Black Plum, Java Plum, Indian Blackberry, Jamblang, Jamun etc. It belongs to family Myrtaceae, and an important medicinal plant in various traditional systems of medicine. Jamun which is a minor fruit in Pakistan growing in sub-tropical and tropical regions of the world. It is a seasonal fruit, purplish black in color, utilize fresh in market, and rich source of anthocyanin the fruits also used in the processed industry for jellies, squash, vinegar, and for jam. This tree most parts has vital role like there seed, fruits, bark, and leaves are used as a medicine for many diseases as a traditional medicine is using to control diabetes, polyuria, diarrhea, renal stones and blood sugar of patients. Used as a nutraceutical this is rich source of terpenoids, gallic acid, glycoside jambolin, tannins, anthocyanins, and important minerals. In this article, we mainly review the importance of bioactive compounds and future prospects and key success factors for this ignore fruit in Pakistan.

## Comparative analysis of physical, biochemical and antioxidant properties of wild edible fig

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Edible wild plants are nature's gift to mankind. Considering the growing need to identify alternative bio-nutritional sources, some underutilised species of figs of the family Moraceae were evaluated as wild edible fruits to study their nutritive and mineral composition in order to prioritise their edibility for indigenous people. Different samples of fig fruits were collected from selected villages of district Kotli, Poonch and Bagh. The experiment was laid out in Complete Randomised Design (CRD). Data was analysed for physical parameters such as, fruit diameter, total weight of fruit, fruit colour, fruit firmness, chemical properties such as vitamin C, total soluble solids, total ash content, titratable acidity, pH and antioxidant properties such as total antioxidants and total phenolics. The results showed that there is a huge potential of this crop to be promoted for commercial scale cultivation. However, further studies are needed to establish a complete supply chain system for this crop and also develop some value added products.

## Physiochemical characterization of different ber (*Ziziphus mauritiana* L.) varieties

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Ber (*Zizipus mauritiana* L.) is a delicious sweet fruit belongs to family Rhamnaceae. It is rich source of vitamins, minerals and is used against different diseases like cancer and ulcer. The objective of the experiment was to determine different physiochemical properties of different local ber cultivars. Nine cultivars names, Yazman local, Anokhi, Pak white, Khobani, Foladi, Dehli white, Bahawalpur 1 and Mehmoodwali were included in the experiment. The analysis of variance showed that maximum total soluble solids (10.66 %), total sugars (13.77 %) and non-reducing sugars (9.34 %) were recorded in Mehmoodwali cultivar. Maximum tritable acidity 2.23 % was recorded in khobani cultivar. However, maximum total phenolic content (258.02 µg/ml FW) and vitamin C (95.24 mg/100g) was recorded in Dehli white cultivar. In physical characters of ber fruits, maximum stone weight and stone length was observed in Foladi

cultivar whereas maximum seed length and seed width was observed in seedless cultivar.

### *Capsella bursa-pastoris:* A potential nutraceutical

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Large numbers of wild plants growing in Pakistan are used by the ethnic communities, with both medicinal and nutritional importance. Such resources found profusely growing on wasteland, free of chemical fertilizers and may introduce new palatable taste to the people. Such wild vegetables are not well-known to the common people and they feel hesitation to use them as vegetables in their food menu, *Capsella bursa-pastoris* is one of them and belongs to family Brassicaceae commonly known as shepherd's purse. In Pakistan it is traditionally used for various ailments like stimulant, astringent, anti-diarrheal and diuretic. Besides this it has high nutritional value eaten in raw or cooked form. Preliminary phytochemical analysis confirmed the presence of Alkaloids, flavonoides, cardiac glycosides, steroids, Saponins, tannins and Phenolics while the quantitative analysis showed the presence of Alkaloids (0.58mg/g), Tannins (0.46 mg/g), Flavonoids (0.4mg/g), Saponins (0.26 mg/g) and Phenolics (156µg/mgGAE). Capsella has good nutritional value as well, having crude protein (21.88%), crude fiber (21.5%), crude fat (4%), total ash (12%) and carbohydrate (50.02%). Elemental evaluation showed the presence of Cd (0.031), Fe (0.195), Mn (0.297), Zn (0.455), Cu (1.245), Cr (2.192), Na (21) and K (67.5) ppm. It is concluded that this plant is important for both medicinal and nutritional purposes and may help to develop a new drug in near future.

## Functional and medicinal attributes of guava

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Preventive aspect of fruits and vegetables are needed to be explored to have its maximum potential to cope with alarmingly increasing public health burden of developing countries. Guava is among the fruit known as “poor man’s apple” having numerous functional and therapeutic properties. Not only the whole fruit but also its leaves have found many applications in different food products. Extract from guava leaves and flesh has potential antioxidant, anti-diabetic, antidiarrheal, anti-microbial, anti-cancer, antispasmodic, anti-allergy, anti-genotoxic, anti-inflammatory, anti-cough, cardio active, cytotoxic and hepatoprotective attributes. Twenty four phenolic compounds from guava flesh and twelve from guava leaves has been characterized up till now that have the functional features. Guava polysaccharides also has anti-diabetic and anti lipidemic affects. Guava polysachharides reduces risk of lipedemia, vascular diseases and cirrhosis via P13K/AKt signaling pathway. Tea prepared from Guava leaves also has medicinal traits regarding glycemic index modulation. Guava leaves has inhibition effect on the protein glycation and formation of advanced glycation end products. Phytodrug (QG-5®) is a guava leaf extract product and has anti-spasmodic affect. Lycopene extracted from red guava has cytotoxic affect against human breast adenocarcinoma by apoptotic–like pathway. Tincture and tea prepared from guava leaves has potential ability to combat infections caused by fungus of genus candida.

# Processing Techniques and Value Addition of Horticultural Crops

## Electrolyzed water for the preservation of fresh cut fruits

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The demand for fresh-cut fruits and vegetables is growing rapidly in the recent years due to their dietary health benefits. Fresh-cut fruits and vegetables are highly perishable. Several chemical and physical techniques are being used to extend their shelf life. A variety of disinfectants (chlorine, hydrogen peroxide, organic acids, ozone, etc.) have been used to reduce the bacterial population on fresh-cut fruits and vegetables. Due to potential toxicity of disinfectants, they are being discouraged. Electrolyzed water has been regarded as a new sanitizer, cleaner and relatively novel antimicrobial agent having potential to inactivate pathogens on fresh-cut produce. Disinfecting fresh-cut fruits and vegetables with electrolyzed water has been considered as an eco-innovative sanitizing technique that could be used to replace chlorine from fresh-cut industry. EW is produced from regular water without addition of any harmful chemicals except NaCl. Device for the production of electrolyzed water consists of an electrolytic tank having horizontal membrane, anode chamber and cathode chamber. Electrolysis is performed by applying DC 20 voltage between electrodes. As a result of this, alkaline electrolyzed water is produced at cathode plate and acidic electrolyzed water is produced at anode plate. The application of EW is a sustainable and green concept with several advantages over traditional cleaning systems which include cost effectiveness, ease of application, and simplicity of production, effective disinfection and safety for human beings as well as environment.

# Physico-chemical attributes of dried Indian jujube fruits as affected by different drying methods

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Indian jujube (*Ziziphus mauritiana* Lamk.) is commonly used as fresh fruit but some other forms like dried, candied and squash are also used due to its high nutritive value. Fresh fruit is vulnerable to decay after few days of picking due to high moisture content and needs to be preserved through drying. Therefore, the current study was aimed to assess the effect of different drying methods on physico-chemical characteristics of various jujube cultivars. Fruits of eleven jujube cultivars were collected from Horticultural Research Station, Bahawalpur in 2017. Ripe fruits were dried by using two different methods i.e. Sun drying and oven drying (at 50, 60, and 70 °C). The results elaborated that physico-chemical characteristics significantly varied by drying methods and also among the cultivars. Cultivar Foladi exhibited maximum (6.17 g) fruit weight after sun drying. Fruit length was maximum (36.03 mm) in Karella when sun dried. Regarding fruit diameter, it remained maximum in cultivar Pak White when dried in oven at 50 °C. Vitamin C content was found maximum (77.14 mg/100g) in cultivar Khobani when dried in oven also at 50 °C. The maximum values of total phenolic content (305.40 mg GAE /100g), antioxidant capacity (128.05 µM trolox/g) and β-carotene (3490.7 µg/g) content were noted higher in oven dried fruits at 70 °C and decreased when drying temperature was decreased to 60 and 50 °C. However, these attributes did not differ significantly among the jujube cultivars. Organoleptic evaluation revealed that cultivar Mehmoodwali exhibited better aroma, color and shape after drying at 60 °C when compared with other cultivars and drying method. Fruit taste was significantly better in cultivar Sadqia when oven dried at 50 °C. Conclusively, Khobani cultivar gave better results regarding biochemical analysis, whereas in organoleptic analysis, cultivar Mehmoodwali performed better among all the studied cultivars.

**Development of different value added products from wild mulberry of Gilgit-Baltistan, Pakistan**

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Mulberry is an important horticultural commodity with high nutritional significance. It is among the widely available underutilized fruits of Gilgit-Baltistan having the highest pre harvest wastage. This study was carried out to develop shelf stable food products for utilization of mulberry and extend horticultural value chain. Jam, syrup and squash were prepared from white and black mulberry, treated with different combinations of chemical preservatives; $T_0$, (controlled) T1, (sodium benzoate 0.1%), $T_2$ (potassium sorbate 0.1%) and $T_3$ (potassium sorbate and sodium benzoate (0.5% each)). Jam samples were packed in 450g glass jars, syrup and squash were packed in 250 ml PET bottles and stored at ambient temperature. Impact of preservatives on quality parameters, physiochemical (pH, TSS, titratable acidity, ascorbic acid, total sugars, reducing sugars and non-reducing sugars) and phytochemical (total phenolic, total flavonoids, total carotenoids and antioxidants) for 90 days with intervals of 15 days were studied. The results revealed that among white and black mulberry products, minimum physiochemical and phytochemical changes were recorded in $T_3$ followed by $T_1$, while maximum changes were recorded in $T_0$ followed by $T_1$ after three months of storage time. Based on the sensory attributes (color, flavor, taste and overall acceptability) $T_3$ was liked most by the judges followed by $T_1$ of all tested products jam, syrup and squash. It was concluded from the current research that among different preservatives; combination of potassium sorbate and sodium benzoate followed by sodium benzoate provided best results in terms of quality and shelf life of wild mulberry products.

## Effect of chemical preservatives on shelf life and quality of olive pickle

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Olive (*Olea Europeae*) cultivation in Pakistan is increasing day by day due to its cultural and economical benefits. Its impact on human health and environment is highly beneficial and positive. Product development from olive fruit has pivotal role for post harvest management of olive fruit and sector development. Olive pickle is one of the most popular olive products. These studies were envisaged to determine most suitable chemical preservative with optimum concentration to enhance shelf life of good quality olive. Some chemical preservatives with different concentrations were used to increase shelf life of olive pickle and ensuring its quality. Prominent shelf life (55-67 days) was recorded with excellent flavor (6-12) and taste (5-91) when sodium benzoate @ 2 mg/kg was used in pickle of olive variety FS-17. Product firmness and color remained preserved.

## Comparison of apple drying methods

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Apple (*Malusdomestica* L.) is among most vastly cultivated and vital fruit crop in terms of economy all around the globe, which are rich in quercetin glycosides. Such commonly occurring natural antioxidant compounds from the family of flavonoids with cancer and cardio protecting properties. Apple processing is combined with enzymatic and non-enzymatic browning of fruit tissues. The enzymatic browning reaction in plants is based on polyphenol oxidase (PPO). The total quercetin content and quercetin glycoside composition are not affected by Microwave vacuum drying and freeze drying. Air drying results in an average quercetin glycoside loss of 44% and undesirable changes, particularly discoloration. After 12 months at 20 $^{o}$C, the total quercetin contents decreased about 21%. Sensory characteristics (color, texture, taste) can also be influenced by drying. For high-quality products, it is essential to avoid drying methods with

high temperatures and long drying times. Freeze drying (FD) is considered as a process that preserves quality characteristics of apple. Microwave vacuum drying serves as an alternative to preserve temperature sensitive products and for the economization of time and energy. Hot-air drying is a typical convective drying method that has been largely applied for the drying of a variety of fruits and vegetables and its by-products. Equilibrium material moisture contents is affected by humidity and temperature of the surrounding air, while the osmotic pretreatment shifts the isotherms to higher water activity levels. The quality properties examined are significantly affected by the drying method.

## Role of biotechnology in food processing industry

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Biotechnology has revolutionized mankind since its existence. It has played a diverse role in the application of science in different spheres of life. Gene transfer, Recombinant DNA technology, development of vaccines including DNA-vaccines, development of hybrid plants, genetic modifications, etc. are some of the areas where biotechnology has played a major role. Biotechnology also has an important role in food processing whereby it helps in improving the edibility, texture, and storage of the food; in preventing the attack of the food, mainly dairy, by the virus like bacteriophage; producing antimicrobial effect to destroy the unwanted microorganisms in food that cause toxicity; to prevent the formation of mycotoxins; and degradation of other toxins and anti-nutritional elements present naturally in food. The advance in application of biotechnology in food processing mainly concerns with the traditional approach of improving the strains of microorganisms and development of further improved micro-organic derivatives like enzymes, etc. Before application of various techniques, the characterization of the genetics of the microorganisms is very essential as it gives a clear idea about the favorable and non-favorable factors that affect the growth of the microorganisms. Improved strains of microorganisms can be produced by a variety of techniques like genetic

modification by mutagenesis by exposure to various chemicals, gene transfer mediated conjugation by using plasmid DNA, or by genetic recombination by hybridization with better yielding microorganism (E.g. Yeast). Recombinant DNA technology also plays an important role in modification of the genetics of the microorganisms favorably by accelerating the expression of favorable genes and hindering that of non-favorable ones by the introduction of plasmid vectors, which are food grade. In all the cases, genomic study of the microorganisms related to food is essential as it acts as a guide in identifying the metabolic process as well as the genetic mechanisms. From this, the genes responsible for the production of favorable enzymes and sugars for fermentation are identified and the application of proteomics for the identification of the proteins responsible and the interactions between proteins for the improved fermentation process is possible. Various amino acids, food-flavoring agents, food additives, and preservatives are all different derivatives obtained from different microorganisms. Biotechnology helps in understanding the metabolic pathways of the microorganisms thereby helping in isolating the required derivatives. The technology also helps in the identification of the pathogens, pesticides, as well as anti-nutritional factors present in the food. It helps identifying various contaminants like mycotoxins, which cause decrease in shelf life of the foods as well as cause toxicity of foods, by different tests like ELISA, microarray, etc. Although, Biotechnology plays a very important role in the food processing industry, much advance has not been made in this area mainly in developing countries due to socio-economic factors of the population. Research in this area is possible only if the government of the developing countries gives support and makes improvement in the development policies regarding the food sector.

## Novel and emerging technologies in processing of agricultural produce

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By the turn of the century, consumers have been more demanding, sophisticated and discretionary. They want much safer, high-quality and convenience foods.

there is a growing interest in non-thermal processes for food processing and preservation. Advanced technologies such as high-pressure processing, pulsed electric fields, and ultrasound are being applied to develop gentle but targeted processes to further improve the quality and safety of processed foods. These technologies also offer the potential for improving existing processes as well as for developing new process options. Furthermore, by adding new process dimensions (such as hydrostatic pressure, electric fields, ultrasonic, supercritical CO2) to the conventional process variables of temperature and time, they facilitate enlargement of the availability of unit operations. The aim of this review is to discuss the impact of the most promising novel food preservation technologies in terms of energy efficiency, water savings and reduced emissions. The emergence of non-thermal technologies allows producing high quality products with improvements in terms of heating efficiency and, consequently, in energy savings. Effective combinations of two or more hurdles may be chosen once the mode of action and cellular targets are known. Novel processing technologies are increasingly attracting the attention of food processors once they can provide food products with improved quality and a reduced environmental footprint, while reducing processing costs and improving the added-value of the products. Non-thermal methods allow the processing of foods below temperatures used during thermal pasteurisation, so flavours, essential nutrients, and vitamins undergo minimal or no changes. Novel non-thermal technologies such as pulsed electric fields (PEF), pulsed light treatment (PLT), high pressure processing (HPP) and ionizing radiation (IR) among others have the ability to inactivate microorganisms at near-ambient temperatures avoiding thermal degradation of the food components and consequently preserving the sensory and nutritional quality of the food product.

# Seed Production of Horticultural Crops

**Seed treatment of pea *(Pisum sativum)* with proline improves growth, biochemical attributes and quality of produced seed**

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Pea is and important cereal crop and to meet increasing demand due to rapid population growth, there is dire need to increase yield of peas. Different chemicals are applied to plants as seed treatment or soils drenching, which can influence different biochemical attributes within plant body, therefore improve plant growth and development. In this regard, role of proline to sustain plant growth under stress conditions has extensively been explored; however impact of proline for improving growth and quality of pea seed produced under normal growth environment has been evaluated in this research work. The experiment was conducted to optimize the concentration of proline (50, 100, 150, 200, and 250ppm) for seed treatment of two pea cultivars (Meter & PF-400) in comparison to control (untreated seeds).Experiment was conducted in field at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan (31.4336$^{o}$ N, 73.0683$^{o}$ E) during 2013-14 and 2014-15. Results implied a positive impact of proline treatment of pea seeds with improvement of vegetative and reproductive growth resulting in better quality seed production as compared to control (untreated seeds)**.** Seed treatment with 200 ppm proline showed maximum main shoot length (58.7 cm) and root length (14.5 cm) of Meteor plants, while maximum root length (14.0 cm), flowers per plant (39.7) and antioxidants (73.4%) of PF-400 plants. However, seed treatment with 250 ppm proline produced maximum flowers per plant (36.8), pods per plant (31.7), chlorophyll contents (3.31 mg $g^{-1}$FWt.), total antioxidants (70.8%) of Meteor plants, whereas utmost main shoot length (53.6 cm), pods per plant (30.7) and chlorophyll contents (3.13 mg $g^{-1}$FWt.) of PF-400 plants. Highest accumulation of carotenoid contents in pea plants (0.655 mg $g^{-1}$FWt.) was recorded in response to seed treatment with 200 ppm proline .Highest seedling fresh weight of both Meteor (4.58 g) and PF-400 (4.75 g) was recorded of seeds harvested from pea plants raised by using seeds treated with 250 ppm proline.

Maximum dry weight of pea seedlings (1.685 g) was recorded of seeds harvested from plants under this (250 ppm) proline seed treatment. Pea seeds of Meteor and PF-400 cultivar may be treated with 250 ppm proline to get maximum pods production and better quality seed.

## Foliar spray of GA3 on different plant growth stages alters the vegetative, floral and seed yield in onion

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Lack of scientific literature exists regarding the effects of Gibberellic acid ($GA_3$) application timings on various phonological and physiological aspects of seed crop of locally available onion cultivars. Therefore, current study was planned in Vegetable Research Area, University of Agriculture, Faisalabad to optimize the growth stage for Gibberellic acid application on seed production in two local onion cultivars (Phulkara and Dark Red) during 2013 and 2014. Application timings of gibberellins @ 100 mg/ L of $H_2O$ were as: $G_1$) Control (No spray), $G_2$) at 2-3 leaf stage, $G_3$) at 6-7 leaf stage and $G_4$) at the time of first flowering. Average of both years have shown that plant height (66.15 cm) and number of leaves per plant (84.57) were best in cv. Phulkara when $GA_3$ applied at the time of 2-3 leaf stage and 6-7 leaf stage of onion plant. Early flowering initiation (47.92 days) and completion (69.73 days) were noted best by spraying $GA_3$ at the time of flowering in cv. Dark Red. The highest seed yield per umbel (2.94 g) was recorded in cv. Dark Red when $GA_3$ sprayed at 6-7 leaf stage, while $GA_3$ application at the time of flowering in the same cultivar showed highest germination rate index (60.14) and highest seedling vigour index (586.80). Overall, it appears that seed yield and quality characters were promoted by the application of $GA_3$ at 6-7 leaf stage and at the time of flowering in cultivar Dark Red.

## NaCl priming: A practical way of improving seed quality attributes in vegetables

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Healthy seed germination is pre-requisite for successful crop production. Seed priming improves seed germination as well seedling quality. Several studies successfully tested various chemicals for improving seed quality; however, the availability of these chemicals to the local farming community is limited. Present study aims to use table salt 'NaCl' for seed priming of vegetables (Carrot, Radish, Tomato and Coriander). The study was conducted in Olericulture section of Horticulture Laboratory of UAF Sub campus Burewala-Vehari during spring 2018. Four different concentrations of NaCl solution (0.5%, 1%, 1.5% and 2%) were tested under completely randomized design with three replications. Duration of the priming was kept constant (2 hours) for all vegetables. Different seed quality attributes such as germination percentage (%), seedling length (cm), root shoot ratio, mean germination time (days) and germination index were recorded. Results concluded that 0.5 and 2% NaCl seed priming were effective for improving seed quality traits in tomato and carrot respectively, while, in coriander and radish seed priming of 1% NaCl showed better seed quality traits.

## Effect of sowing dates, bacterial strains and foliar application of potassium nitrate on yield and quality of fenugreek seed

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Fenugreek (*T rigonella foenum-graecum* L.) is important medicinal plant used all over the world due to its beneficial qualities. It is an important spice; its dried seeds have wide application in food and beverages as a flavoring additive as well as in medicines. Present study was conducted to evaluate the effect of sowing time, potassium nitrate (0, 0.5, l, 1.5, 2, 2.5 and 3%) and different bacterial strains

viz., Rhizobium, Pseudomonas, Azotobacter, PSJN and K554 on seed yield of fenugreek. For this purpose, three experiments were conducted. In first experiment, effect of two different sowing times (20$^{th}$ September and 20$^{th}$ October) was evaluated on vegetative growth and yield of fenugreek. In second experiment, $KNO_3$ (@ 0, 0.5, 1, 1.5, 2, 2.5 and 3%) was sprayed at the time of 50% flowering to assess its effect on seed yield and quality. Third experiment was conducted to ascertain the impact of seed treatment with different bacterial strains (Rhizobium, Pseudomonas, Azotobacter, PSHV and KS54) on vegetative growth, yield and seed quality. It can be implied from the results of three experiments that sowing on 20$^{th}$ September resulted in higher seed yield as compared to 20$^{th}$ October, seed treatment with bacterial strains enhanced the vegetative growth and yield as compared to untreated (control) and foliar application of (3% $KNO_3$) at 50% flowering stage improved the seed yield and boosted the seed production as compared to control and other treatments of potassium nitrate of fenugreek under Faisalabad conditions.

## Promotion of leaf area, early flowering and seed contributing factors with increasing onion set and bulb size

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Set and bulb size directly influence onion seed production by increasing yield and yield contributing factors. Therefore, optimization of set and bulb size is necessary to increase onion seed production. In the present study, three set sizes (1-2.5 g, 2.6-4 g, and 4.1-5.5 g) and three bulb sizes (41-70 g, 71-100 g and 101-130 g) were tested to explore the best size for higher yield and quality of two onion cultivars at University of Agriculture, Faisalabad, Pakistan during 2013 and 2014. Average data of both years have shown that cv. Phulkara showed maximum plant height (71.36 cm), number of leaves per plant (78.25) and leaf area (13305 $cm^2$) with maximum bulb size (101-130 g). Improved flowering attributes, higher number of umbels (15.52) and more number of splits per plant (12.13) were observed in cv. Dark Red from the bulb size of 101-130 g, while higher seed yield

(1543 kg/ha) was observed from bulb size of 71-100 g in the same cultivar. Therefore, larger sized bulbs of cv. Dark Red are recommended for better onion seed production under agro-climatic conditions of Faisalabad.

## Carrot invigoration through seed priming with salicylic acid at high temperature

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Carrot (*Daucus carota*) is a cool season vegetable and belongs to family Umbelliferae, and is very popular because of its high nutritional value along with many health benefits. Usually carrot is grown in October in Punjab-Pakistan but early in the season, during August-September carrot production is also practiced in Punjab due to its high profitability but facing high temperature issue that caused poor seed germination, so crop yield directly affected under such circumstances because of insufficient plant population. Thus, present study was conducted to manage this problem at Vegetable Seed Lab, Institute of Horticultural Sciences, and University of Agriculture Faisalabad. Recent studies, suggested that seed priming with salicylic acid (SA) has been proven to enhance not only seed germination but also subsequent growth and yield under a range of environmental conditions. That's why; SA was employed for carrot seed priming to achieve the benefits. Carrot seeds (cultivar T-29) were primed with various concentration of SA (0, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2mM and distilled water) for 12 h at room temperature. Seeds were dried and then placed in Petri dishes for evaluation in term of germination assay at high temperature (35±2 $^{o}$C) in the incubator. Salicylic acid seed priming enhanced the germination indices along with other attributes of carrot seeds in comparison with unprimed seeds. Maximum germination (79%) was attained with 0.1 mM Sap riming followed by 0.2mMSA and unprimed seeds showed least germination (55%) under high temperature (35±2 $^{o}$C). SA seed priming with 0.1mMpriming solution also improved germination index, germination energy, seedling, fresh and dry weight, seedling vigor index and decreased the time taken to 50% germination and mean

germination time. Electrical conductivity of seed leachates was lowered by all of the seed priming treatments (lowest in 0.1 mM SA) as compared to control.SA seed priming with lowest concentration showed considerably higher antioxidants and total phenolic contents in carrot seedlings and enhanced enzymatic activities in term of superoxide dismutase, peroxidase, catalase, and lowered the malondialdehyde contents. Such changes might be a possible reason of improvement in carrot performance under high temperature because of seed priming with SA. Therefore, it was concluded that carrot seed priming with lower concentration of SA could enhance carrot seed germination and biochemical processes under high temperature that may lead towards improved early carrot plant population which may increase yield of early carrot crop.

**Role of potassium in yield and quality seed production of carrot**

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Quality seed is the basis for better crop stand establishment and high production. Carrot (*Daucus carota*) seed quality is affected by umbel position and nutrient availability. Potassium has significant role in improving yield and crop quality but is becoming limiting element in most of the areas on the globe. It is particularly important under stress environment and plays key role in maintaining seed structures. This study was carried out at Vegetable Farm and Vegetable Seed Laboratory, Institute of Horticultural Sciences, Horticulture Lab, Seed Science and Technology Department, University of Agriculture, Faisalabad to investigate the impact of various potash levels (0, 20, 40, 60, 80,100 and 120 kg $ha^{-1}$) on yield and seed quality of carrot (*Daucus carota*) cv. T-29. Potassium significantly affected yield as well as seed quality attributes of carrot. Among different levels of potash, application of 80 to 100 kg potash $ha^{-1}$ produced highest seed yield, 1000 seed weight of primary and secondary umbels as well as seed quality traits, including final germination percentage and vigor index from seeds of primary and secondary umbels. However, yield and seed quality of tertiary umbel seeds was also enhanced by potash application. Interestingly, electrical conductivity of the

seeds due to nutrient application differed significantly in response to highest level of potash (80 to 100 kg $ha^{-1}$) as evident from decreased seed leachates from primary, secondary and tertiary umbel seeds. All seed yield and quality related traits were improved by potash application up to 80 or 100 kg $ha^{-1}$ sulphate of potash (SOP), but further increase in potash did not result in significant enhancement of various attributes. Based on the above results it is concluded that application of potash @ 80 to 100 kg $ha^{-1}$ could be used for maximum seed production and quality carrot seed for higher umbel orders (primary and secondary umbels) as well as lower umbel order (tertiary umbels) under conditions of Faisalabad.

## Correlation between true seed and tuber dormancy in a *Solanum tuberosum* group phureja × stenotomum population

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Short tuber dormancy is desirable when multiple cropping seasons occur yearly, yet most potato cultivars were developed for regions with one growing season per year and have long dormancy. Although several methods exist for breaking tuber dormancy, they can lead to uneven emergence and poor stand counts. Breeding short dormancy cultivars could alleviate this problem. A long-day adapted diploid hybrid population of *S. tuberosum* Group *phureja- S. stenotomum* (*phu-stn*) has been developed with short tuber dormancy. The purpose of this study was to determine if there was a correlation between tuber dormancy in these *phu-stn* parents and true potato seed dormancy in their offspring, which would allow rapid breeding of short-dormancy germplasm. Tuber dormancy was evaluated for 12 diploid *phu-stn* parents harvested from three different locations: Presque Isle, Maine (ME); Plymouth, North Carolina (NC) and Beltsville, Maryland (MD); and stored at 7 °C in MD. Twelve crosses were made among these parents; each parent was represented twice in the offspring. True potato seed (TPS) from these 12 families were disinfected and soaked in water for 24 hours, dried, and sown in tissue culture. TPS germination was recorded daily for 35 days and the proportion

germinated calculated. The experiment was conducted three times. Parental tuber dormancy ranged from 6-10+ weeks. TPS family proportion germination ranged from 9 to 99%. There was no correlation (r = 0.01) between parental tuber dormancy and TPS family germination proportion. These results show that the relationship between offspring TPS dormancy and their parent's tuber dormancy is unpredictable. Additional research is needed to determine if selection for early sprouting in the offspring *in vitro* is correlated with short tuber dormancy in subsequent field generations of these offspring.

**Studies on flower biology and seed production ability of *Petunia hybrida***

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Petunia is an important bedding flower as a part of our aesthetic life and its demand is increasing day by day in our societies. It has become an essential part of our interior decoration and as bedding material in home garden owing to great variation in flower colors. Further desire for novel varieties with the blend of different flower colors can be fulfilled by hybridization techniques. This trial was, therefore, designed with an aim to study the hybridization of Petunia. The plant material includes the five different varieties of Petunia i.e. WHITE, PASTEL, PINK, MAGENTA, BLUE and STAR RED. The petunia seeds were planted in pots which were crossed. In this trial, five different varieties of petunia and their six crosses were studied. Data for different morphological parameters i.e. plant height, leaf length, leaf area, days to maturity, days to flowering, blooming period, petal size, flower color, weight of flower, number of flower per plant, number of pods per plant and number of seeds per pod was recorded during cropping season and after harvest. Morphological assessment of these varieties was done and in accordance with their mean performance it was noticed that the WHITE × PASTEL PINK showed best results for plant height (14.40 cm). Whereas STAR RED × BLUE showed better results for leaf length (8.04 cm), leaf area (12.82 $cm^2$) and petal size (7.66 cm). The WHITE× MAGENTA showed striking performance for days to maturity (75.66), number of flowers per plant (49.20) and number of pods per plant (49.20). WHITE × BLUE is better in

performance for days to flowering (35.5) number of seeds per pods (187.60) and blooming period (147.9). The STAR RED × MAGENTA gave best results for weight of the flower (1657.3 mg).From the present study, it is concluded that the STAR RED × BLUE and WHITE × BLUE performed better for different traits. Thus these crosses are recommended to be used in breeding programs related to yield and quality traits for crop improvement.

# Insect and Disease Management of Horticultural Crops

## Integrated management of fruit flies *Bactrocera sp.* (diptera: *tephritidae*) infesting mango (*Mangifera indica*) in Pakistan

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In a series of experiments, food and sex lure, and neem oil was tested to devise the IPM model for fruit fly *Bactrocera sp.* (Diptera: Tephritidae) management in mango orchards. The assessment was based on percent infestation in dropped and harvested fruits. Neem oil at 50 ml and 30 ml/l of water were equally effective. Pheromone traps lured with Methyl Eugenol integrated with intermittent food bait of protein hydrolysate application reduced the fruit fly population by 86.48 and 94.18% in dropped and harvested fruits in year-1 and 87.5 and 89.2% in year-2, respectively. On the basis of experiments the IPM models were tested on a sizeable mango orchard. The model comprised of 1) installation of sex lure traps (4/acres), 2) Crop Hygiene (CH) [removal of weed flora and fruit fly resting and sheltering places], 3) twice hoeing under the trees; 4) twice intermittent food bait application during the fruiting season. Data revealed that IPM practices reduced the % infestation dropped to 0.4 and 0.8% in dropped and harvested fruits respectively in comparison with that of farmer's practice where it was 7% in dropped fruits and 10.5% in harvested fruits.

## Toxicity of selected insecticides and botanicals against citrus mealybug *Planococcus citri* in controlled laboratory conditions

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Mealy bug (Hemiptera: *Pseudococcidae*) are small soft bodied and sap sucking most damaging insect pests of major crops. Among mealy bug species citrus mealy bug, *Planococcus citri* is considered to be the key pest of horticultural crops. Toxicity of insecticides imidacloprid, bifenthrin, Methomyl, profenophos, neem and citrus peel oil was determined on the basis of median lethal concentration ($Lc_{50}$) values on 2$^{nd}$ instar citrus mealy bug under controlled

laboratory conditions with temperature of 25±2°C and 60±10% relative humidity, photoperiod of LD 8:16 hours respectively. The $Lc_{50}$ values determined for insecticides viz., imidacloprid, and bifenthrin. Methomyl, profenophos and botanical oils include neem and citrus oil was 0.22, 0.36, 0.29, 0.07, 0.09 and 4.8 ppm respectively. Profenophos was most toxic among all the tested insecticides and caused 80% mortality of 2nd instar nymphs of *P. citri* after 72 hours of exposure period followed by neem oil under laboratory conditions. Citrus peel oil was less effective than neem oil and synthetic insecticides but exhibited statistically significant mortality over control. Moreover, $Lc_{50}$ values for imidacloprid with neem oil in 1:1 proportion was most toxic (0.012) amongst all other binary combinations of selected insecticides with neem oil at 1:1 proportion.

## Evaluation of environment friendly botanical pesticides to suppress citrus mites and thrips population in order to manage kinnow mandarin fruit blemishes

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Eco friendly and less hazardous pest control technologies are need of the hour and challenging tasks to improve agricultural productivity in a sustainable manner. Keeping in view the increased awareness about pesticide abuses and food safety concerns in fresh produce, this three year study was aimed to envisage the potential of plant based oils for management of citrus mites (*Panonychus citri*) and citrus thrips (*Scirtothrips citri*) population as both of these insects are involved in causing skin blemishes in kinnow mandarin. Five different oils including neem oil, lemongrass oil, eucalyptus oil, coriander oil and *Eurica sativa* oil each at two different concentrations (0.75% and 1.5%) were evaluated along with synthetic insecticides such as bifenthrin and imidacloprid each at 2ml/L for comparison. Different Combinations of best performing treatments and increased concentrations of non performing treatments were also test in third year trial. Study demonstrated that neem oil at 1.5% was at par with synthetic insecticides in managing citrus mites and thrips population followed by lemongrass oil. Among all tested oils, neem oil at 1.5% concentration resulted in maximum number of

fruits with less than 1 and 1-5% blemished area. When neem oil and lemongrass oil were used in combination they proved their insecticidal behavior more prominently and yielded more number of fruits with less blemishes. While none of the oils control any insect pest population at lower concentration (0.75%). These investigations could be greatly exploited for blemish free kinnow mandarin production under the concept of environment friendly pest management techniques and quality enhancement.

**Environment friendly management of fruit fly in fruits and vegetables**

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Fruit flies (*Bactrocera spp*.) are recognized as the most damaging insect pests of fruits and vegetables which cause tremendous losses to fruits and vegetables at farm level, as well to traders, retailers and exporters. Male Annihilation Technique (MAT) provides an easy and environmentally safe approach of fly control; hence, the objective of the study was to improve the efficiency of MAT. To synergize the attraction of cue lure & methyl eugenol, different concentrations (5%, 10%, 15%, 20%, 25%, 30% and 50%) of lures blended in mixture of three preferred food attractants (protein hydrolysate, yeast and molasses) in equal ratio along with 5% dipterex and 10% sugar, were tested in bitter gourd & pear orchards at Peshawar. The results indicated that in bitter gourd, a very cheap formulation (20% lure) attracted significantly greater number of flies as compared to other tested formulations which can be used effectively to suppress fruit fly population in bitter gourd whereas, in pear, the standard traps (100% lure) attracted significantly greater number of flies. The findings of this study will directly benefit the end users by increasing their per capita income.

## Bio-pesticides way forward to safe agriculture

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Crop production and protection have profoundly relied on synthetic chemical pesticides over the last 50 years, but the scenario won't be the same over the coming years as crop production will have to increase significantly to meet the needs of a rising human population. This challenge has to be met without serious consequences to environment and non-target biota. Chemical pesticides are not the only solution as their usage beyond certain limits can cause serious problems. Therefore, alternative pest management tactics are needed and bio-pesticide is one promising solution. Bio-pesticides are pest management agents based on living micro-organisms or natural products and around 299 bio-pesticide active ingredients and 1401 active bio-pesticide products have been registered so far (USEPA, 2017). Bio-pesticides are less toxic and generally tend to affect only the target pest, in contrast to broad spectrum conventional pesticides. They are effective in small quantities and decompose quickly, resulting in lower exposures and avoiding the pollution problems caused by conventional pesticides. Bio-pesticide research has progressed globally during the last 35 years, with a significant number of products registered. While the synthetic pesticide market has decreased by 12% over the last 5 years, demand for bio-pesticides is expected to exceed in sales. In some countries, banning of chemicals in municipalities, development of pesticide resistance in pests, demand for new products by organic farmers and the recognition of hidden costs to human health are further fueling the need for biological alternatives. Research and regulatory work needs to be undertaken to develop, popularize and commercialize bio-pesticides as they can prove to be a boon for safe agriculture.

**Morpho-molecular characterization of *Colletotrichum capsici* isolates associated with chilli anthracnose pathogen recovered from major chilli growing areas of the Punjab, Pakistan**

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Chilli is the most important spice crop cultivated around the world including Pakistan and is attacked by many deleterious diseases like anthracnose. In the present study, a comprehensive survey was conducted to determine the mean disease incidence (%) of chilli anthracnose and collect diseased samples for morho-molecular characterization of isolates. Disease incidence (%) ranged from 25 to 71% in five major chilli growing districts of Punjab *i.e.* Vehari, Bahawal Nagar, Kasur, Okara and Rawalpindi. One hundred forty two isolates recovered from study areas were characterized for morphological variations along with molecular characterization of the highly virulent representative isolates from each district. White to Grayish colony colour was observed in all isolates with cottony and fluffy growth habit. Variations in size and shape of conidia were observed between isolates and two types of conidial shapes were observed *i.e.* falcate in 105(73.1%) isolates and fusiform in 37(27%) isolates. Nucleotide sequences of inter transcribed spacer region (ITS1, 5.8S, ITS4) from 5 highly virulent isolates were submitted in the database of NCBI under accession numbers MG799567, MG799563, MG799564, MG799565 and MG799566 respectively. Evolutionary history was computed with previously available sequences of *C. capsici* reported from different region of the world. Evolutionary tree constructed by maximum likelihood method showed 2 clad in terms of their evolutionary relationship. Amino acid sequences exhibited 99 -100% genetic homology with all the reference isolates of the pathogen taken in the study. This is the first Comprehensive study covering cultural, morphological and molecular characterization of *C. capsici* isolates associated with chilli anthracnose from the Punjab, Pakistan.

**Unlocking the potential of transcriptional gene silencing based resistance bullets against chilli leaf curl viral disease complex**

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Whitefly transmitted geminivirus are circular ssDNA viruses and known to be a major problem in the chilli and other crops in Pakistan particularly in the Punjab region. Crops infected with these viruses show a notable decrease in the yield which results in major losses for farmers in particular and for the nation's economy in general. Transcriptional gene silencing (TGS) is a novel intrinsic biochemical pathway in plant that blocks specific gene expression by promoter methylation. Transgenic cotton expressing the siRNA bullets homologous to the intergenic region of Pepper leaf curl Lahore Virus develops a wide spectrum resistance to an entire genus of whitefly transmitted geminiviruses. Here we discuss how small RNAs can be used to direct TGS in transgenic plant against virus infection.

**Nucleotide evidence of potato virus Y for CP mediated resistance in potato crop of Pakistan**

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Potato virus Y (PVY) has been reported an emerging threat in potato (*Solanum tuberosum*L.) growing areas of Pakistan. A comprehensive survey was conducted in the main potato growing areas of Pakistan and mild to severe mosaic symptoms were recorded. Double Antibody Sandwich (DAS) Enzyme Linked Immunosorbant Assay (ELISA) was used for serological confirmation and susceptible indicator host plants (*Nicotiana tabacum* cv. Samsun NN and *N. rustica*) were used for biological identification. Coat protein (CP) gene specific sense and antisense primers amplified approximately 800bp in PCR assay and final sequences of two isolates were submitted in the public database of the National Centre for Biological Information (NCBI) under the accession number

KX185670 and KX255681. Percentage genetic homology of these isolates was determined by Basic Local Alignment Standard Tool (BLAST) and these sequences were exhibiting 99% genetic homology with previously reported $PVY^{NTN}$ isolates. The serological, biological and nucleotide information of these two isolates are sufficient enough to report $PVY^{NTN}$ strain in potato crop of Pakistan. The nucleotide evidences of local isolates will play a vital role for CP mediated resistance in potato crop of Pakistan.

## Fungicidal activity of crop and wasteland weeds against *Myrothecium roridum* *charantia* L. (bitter gourd)

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A total of nine weeds (*Chenopodium album, Parthenium hysterophorus, Trianthema portulacastrum* L.*, Malvestrum coromendelianum, Amaranthus viridis, Digera arvensis, Solanum nigrum and Nicotiana plumbaginifolia*) from different plant families had been collected for their *in vitro* evaluation of antifungal potential against *Myrothecium roridum*. *Myrothecium roridum* was isolated from *Momordica charantia* L. (bitter gourd) leaves and maintained on potato dextrose agar (PDA) medium at 4˚C. Aqueous extract of weeds was prepared by taking 20 grams of fresh leaves and macerated in 20ml of distilled water. The extract was double filtered through muslin cloth and filter paper and added (@ 10%) in 2% PDA medium. Among tested aqueous extracts, *Nicotiana plumbaginifolia* extracts was found noteworthy antifungal potential and inhibits the growth up to 88%. *Malvestrum coromendelianum* was least effective which inhibits the growth up to 11% while aqueous extracts of *Digera arvensis* did not exhibit any antifungal activity against test fungus in the present study.

## Non-chemical control of collar rot of bell pepper

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Collar rot of bell pepper (*Capsicum annuum* L.) is caused by a notorious soil-borne fungal plant pathogen *Sclerotium rolfsii* Sacc. It is a serious disease that causes significant yield losses in bell pepper annually. A pot experiment was carried out for the management of this disease using dry biomass of *Datura metel* L.*,* a weed of family Solanaceae having medicinal properties. Soil was amended with 0.5, 1.0, …3.0% dry biomass of *D. metel* with and without inoculation of *S. rolfsii*. The highest disease incidence (100%) was recorded in positive control where soil was inoculated with *S. rolfsii* without any soil amendment. Disease was completely controlled by 2% soil amendment. This soil amendment treatment enhanced bell pepper yield by 30% over negative control (without any inoculation or amendment) and 136% over positive control. Activities of defence related enzymes namely polyphenol oxidase (PPO), peroxidase (PO) and phenylalanine ammonia lyase (PAL) were significantly increased in positive control which became lowered significantly due to soil amendment with *D. metel*.

## Antifungal activity of plant extracts to reduce *Rhizophus stolonifer* of plum

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Plum (*Prunus domestica* L.) is an important stone fruit, enriched with different nutritional products but Rhizopus rot cause considerable losses towards its yield worldwide. Present study was carried out to check the antifungal activity of four plant extracts such as thyme (*Thymus vulgaris*), garlic (*Allium sativum)*, orange peel (*Citrus sinensis*) and datura (*Datura stramonium*) at different concentrations against *R. stolonifer* causes of rhizopus rot of plum under lab conditions and on harvested fruits. Results showed that garlic, thyme, orange peel and datura inhabited fungal radial growth 100%, 90.34%, 84.33% and 77.24% respectively under lab conditions. Similarly, on harvested fruits garlic proved to be more

effective (100%) followed by thyme, orange peel and datura inhabited fungal growth of 89.34%, 87.55% and 74.44% respectively. The experimental findings also showed that an increase in fungal inhibition can be seen by increasing concentration of plant extracts.

**Distribution spectra of *Pythium* and *Phytophthora* spp. associated with chili and tomato in Pothwar region of Pakistan**

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Chili and tomato crops are susceptible to a wide range of fungal diseases which are the major constraints in their production. Among these diseases, damping off caused by *Pythium* spp. and late blight caused by *Phytophthora* spp. are the most important causing severe yield losses in chili and tomato. The information regarding distribution of these diseases in the Pothwar region has not been very much studied, therefore, the present study was carried out to determine incidence and severity of *Pythium* and *Phytophthora* in Pothwar region. The maximum incidence of damping off on chili was found to be 19.8% in Attock while the minimum incidence of 10% was recorded in Jhelum. On the other hand maximum disease severity of 11% was observed in Attock and minimum of 5% was recorded in Chakwal. On tomato, maximum disease incidence and severity of damping off was observed in Attock (15.69% and 8.89%) while minimum was observed in Jhelum (11.08% and 6.04%). The incidence and severity of late blight of chili was the maximum in Rawalpindi (18.44% and 6.63%) while the minimum was in Chakwal (10.23% and 3.54%). The maximum incidence of late blight on tomato (19.28%) was observed in Attock while the minimum incidence of disease was in Jhelum (11.69%). On the other hand, maximum disease severity was observed in Attock (8.24%) while minimum severity was found in Chakwal (3.29%). As these diseases have been found fairly distributed in the Pothwar region, therefore, continuous surveillance and stringent control strategies should be followed.

**Evaluation of rhizobacterial potential against bacterial canker disease in stone fruits of Khyber Pakhtunkhwa Pakistan**

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Bacterial canker has become ubiquitous disease of stone fruits in major stone fruits growing areas of Punjab and Khyber Pakhtunkhwa (KPK) which came out from a two (02) year survey (2014-16). A total of 90 orchards were surveyed in five (05) selected districts and 100% bacterial canker disease prevalence was recorded while the disease incidence was varying among orchards. On peach, maximum disease incidence was recorded in Abbottabad (68.8%) followed by Nowshera (51.2%) while minimum in Sawat (42.1%).On plum, maximum disease incidence was recorded in Abbottabad (48.35%) followed by Mansehra (35.33%) while minimum in Nowshera (14.28%).On apricot, maximum incidence was recorded in Abbottabad (60.63%) followed by Nowshera (39.05%) while minimum in Peshawar (22.82%).Thirty-four (34) *Pesudomonas syringae* isolates were retrieved from the infected leaves and fruit samples of peach, plum and apricot under lab conditions. Pathogenicity assay confirmed that 19 bacterial isolates were highly virulent. During rhizobacterial isolation, a total of 213 isolates were recovered from collected soil and root samples and most of the isolates were morphologically identified belonging to *Bacillus* and *Psuedomonas* spp.Dual culture method was adopted for the screening of highly antagonistic rhizobacteria against *P. syringae*(Ps3, Ps9 and Ps17) and out of 213 tested bacteria, nine (9) rhizobacteria were found highly effective antagonists. Highly antagonistic rhizobacterial isolates were subjected to study plant growth promoting (PGP) traits including IAA synthesis, siderophore production, Phosphate solubilization, biofilm formation, root colonization, ammonia production and HCN production and isolates with highest PGP traits were subjected to molecular studies for identification and Phylogenetic relationship analysis. Molecular identification reveled that three (03) rhizobacterial isolates showed 99-100% identity with *Bacillus tequilensis*, *B. pumilus* and *Psuedomonas aeruginosa.B.tequilensis*, *B. pumilus* and *P. aeruginosa* were tested alone and in various combinations for the disease

suppression and plant growth promotions traits under greenhouse conditions. Rhizobacteria when applied in combination resulted into maximum disease suppression and enhanced plant growth characters (Shoot height, Shoot fresh weight and Shoot dry weight).*B. tequilensis* (Rh3), *B. pumilus* (Rh13), and *P. aeruginosa* (Rh37) can also be tested against *P. syringae* infecting various other fruits trees in Pakistan. *B. tequilensis* (Rh3) and *B. pumilus* (Rh13) also possess antifungal and antiviral properties and hence could be tested against fungal and viral pathogens of peach, plum and apricot.

**Studies of some chalcid parasitoids associated with insect pests of apple crop in central Kashmir (India)**

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An attempt was taken to study the Chalcid parasitoids associated with insect pests of Apple in central Kashmir and current status of parasitism on Sanjose scale and Wooly aphid during 2014-2016.The work resulted in identifying the important parasitoids such as *Encarsia pernicious* affecting Sanjose scale and *Aphelinus mali* affecting woolly Aphid with the help of Key characters provided by Taxonomists. Extent of parasitism by the predominant natural enemies of Sanjose scale (*Quadraspidiotus perniciosus*) and Woolly Aphid (*Eri osoma lanigerum*) in the field recorded at 7 days interval revealed that proportion of mean live scales and Aphids in managed and unmanaged orchards were 25.1 per cent and 52.27 per cent ,9.02 and 44.39 at Zawoora of Srinagar and Kralpora of Budgam respectively .Emergence of Parasitoids of Sanjose scale of managed and unmanaged orchards shows a significant difference at both the locations (Budgam and Srinagar).Emergance of parasitoid *Aphelinus mali* recorded mean of 4.6 and 33.97 in managed and unmanaged orchards at location Zawoora respectively while as mean emergence of *Aphelinus mali* 4.3 and 34.27 was recorded in managed and unmanaged orchards of location Budgam.

**Contribution of biotechnology towards integrated pest management**

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Biotechnology is the technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes of specific use. Biotechnology has considerable potential to contribute towards sustainable biological elements of integrated pest management. It has enormous potential to improve pest management. (De Vault *et al*., 1996). There are three approaches of biotechnology in IPM - Development of crop varieties resistant to pests by incorporating resistance gene, improving natural enemies of pests as pest control agents and RNA interference technology. Since first transgenic plant resistant to insects was produced some 27 years ago, a number of novel resistance genes of different origin were discovered and used for plant transformation. It has a significant role in improving efficacy, cost-effectiveness and in expanding the markets for the bio insecticides. Proteinaceous insect toxins (scorpion toxin, mite toxin and trypsin inhibitor), hormones (eclosion hormone, diuretic hormone) and metabolic enzymes (juvenile hormone esterase) has been introduced into NPV genome to increase its efficacy to kill insect (Inceoglu *et al*., 2001). Genetic manipulation of Bacillus thuringiensis (Bt) genes encoding for proteins toxic to insects offers an opportunity to produce genetically modified strains with more potent and transgenic plant expressing Bt toxin (Duke,2011). However, field resistance of *Bt* crops to various insects have been noticed and to combat this problem two approaches namely refuge and pyramiding were recently introduced (Talukdar, 2013). In recent years, attentions have been focused on the idea of using digestive enzyme inhibitors that affect the growth and development of pest species (Mehrabadi et al., 2011). RNAi technology enables engineering of a new generation of pest-resistant genetically modified crops. Insect control strategies that integrate advance knowledge in biotechnology with traditional wisdom and technology will contribute to the sustainability of agriculture (Talukdar, 2013).

## Boosting the production through integrated pest management

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Even as World Health Organization (WHO) and the Food and Agricultural Organization (FAO) of the United Nations continue to press for the wider use of pesticides to help raise the level of efficiency in agriculture there are also voices of concern being heard. The World Health Organization appears in a dilemma over the issue. Should it advocate ban on use of pesticides; the chemical agents used to control pests, which include insecticides, fungicides and herbicides, there are chances of food becoming scare. And if it blinks its eyes to the hazards involved in the use of pesticides it would be viewed as not doing its duty. As with all the substances used by modern man, pesticides offer a risk-benefit ratio, which must be assessed for each application. A modern society should always advocate very specific, carefully planned usage of pesticides well integrated with other control practices. This approach has become quite popular today and is referred as Integrated Pest Management (IPM**).**

## Evaluation of AM fungi collected from apple, pear and cherry rhizosphere for growth improvement in maize under protected conditions.

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An experiment was conducted to determine the effect of arbuscular mycorrhiza fungal (AMF) isolates on various growth parameters and enzymatic activity in maize grown under protected conditions. One hundred and eight AMF isolates, collected from apple, pear and cherry rhizosphere, were chosen to assess their efficiency in improving growth of maize cv. “C6”. The plant height, root biomass, shoot biomass, root mycorrhizal colonization and root and shoot phosphatase in

AMF inoculated maize plants ranged from 16.0 to 27.9 cm, 2.75 to 4.60 g, 9.37 to 14.26 g, 17.78 to 65.15%, 3.59 to 40.66 m moles PNP/g fresh root weight and 3.20 to 30.73 m moles PNP/g soil, respectively, as compared 18.1 cm, 3.25 g, 10.74 g, 0%, 3.66 m moles PNP/g fresh weight and 3.33 m moles PNP/g soil in control. The AMF isolates collected from different hosts, revealed variable behavior with respect to plant growth improvement and enzyme activities. The AMF isolates showed almost similar pattern with a little variation. The AMF isolates of cherry, apple and pear rhizosphere showed 23.2 to 65.2, 19.8 to 53.1 and 17.8 to 61.5% root colonization, respectively. On the basis of initial screening twenty most efficient isolates were compared statistically which showed significant increase of 7.0 to 54.6, 12.6 to 41.5 and 11.7 to 32.8% in plant height, root biomass and shoot biomass, respectively, in maize.

## Association analyses for fusarium wilt resistance in castor (*Ricinus communis* l.)

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Castor is an economically important oil seed crop grown historically in India and various countries. Wilt disease caused by *Fusarium oxysporum* f.sp. *ricini* is a major problem in all castor growing areas of India leading to heavy yield loss. Being a soil-borne pathogen, chemical control is difficult and non-economical. Cultivation of wilt resistant cultivars has proved to be an effective strategy to minimize the loss. However, breeding for wilt resistance has been challenging due to complex inheritance and pathogen variability. A breeding programme for disease resistance requires simple, rapid and reliable procedure for routine screening of progenies. Conventional screening procedures for evaluating wilt resistance in castor are cumbersome and often misleading. Marker-assisted selection is a modern tool, which has been effective for selecting diverse disease resistance genes in crop breeding. A total of 75 SSR markers were used on 87 genotypes, out of which 49 were found polymorphic with a mean polymorphism information content of 0.32. The expected heterozygosity (gene diversity) ranged

from 0.021 to 0.768 with mean of 0.374 indicating a reasonable level of genetic diversity in the genotype panel. The pairwise dissimilarity index (simple matching coefficient) based on allelic data from 49 SSR markers ranged from 0.065 to 0.651 with a mean of 0.372. The genotypic and phenotypic data of 87 genotypes were used for association analysis. Out of 49 markers tested, only one marker, RCM9109 showed significant ($p = 0.0026$) association with the trait (days to wilt), which explained 19.88 per cent of total phenotypic variation. This marker may be used in the breeding programme after sufficient validation in a larger set of germplasm accessions/segregating lines.

**Seasonal activity of pear psylla, *Psylla pyricola,* in the Budgam region of Kashmir**

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Pear psylla (*Psylla pyricola*, Foerster) is an important pest of pear in Kashmir. It causes three main types of injury to the pear trees including fruit russet, psylla shock and pear decline. The pest activity was recorded from May and attained its peak in June - July. The observations recorded also revealed that overall highest mean pest incidence of 27.07 per cent was recorded for the month of June followed by 24.99, 9.89 and 8.74 per cent for the months of July, August and May respectively. While the overall highest mean pest severity of 20.66 per cent was recorded for the month of July followed by 19.96, 5.51 and 4.52 per cent for the months of June, August and May respectively. There was a significant positive correlation of the pest population with maximum and minimum temperature and relative humidity (morning and evening). However the pest population had a negative but non-significant correlation with the rainfall.

# Current status and genetic variability of *Chilli veinal mottle virus* and its management using PDR approach

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Chilli (*Capsicum annuum* L.) is among the world's most popular solanaceous vegetable after potato and tomato. Chilli crop is naturally vulnerable to a wide range of viruses which are known to cause tremendous yield losses. *Chilli veinal mottle virus* (ChiVMV) is one of the important members of genus potyvirus which caused havoc and colossal losses in chilli crop and can reduce yield more than 50% worldwide. In Pakistan, the successful production of chilli crop is also mainly hampered due to ChiVMV which resulted in quite low average yield as compared to other countries. Prior to this present study, no work has been done on molecular aspects of Pakistani isolates of ChiVMV. Development of control strategies of viral diseases in plants requires better understanding and knowledge on the molecular characterization including sequencing and genetic diversity. Pathogen derived resistance (PDR) is one of the best strategies to implement effective and sustainable control measures against major viral diseases. Therefore, the present study was planned to know the current status, molecular characterization, genetic analysis of ChiVMV based on CP gene and management using PDR approach. A total of 1230 chilli leaf samples from 17 chilli growing districts were collected in 2013-2014, of which only 477 samples were positive for potyviruses by PTA-ELISA. Of these positive samples, the ChiVMV, PVY and ChiRSV were detected in 283, 123 and 71 samples respectively. The overall incidence of Potyvirus, ChiVMV, PVY and ChiRSV was recorded as 38.78%, 23%, 10.33% and 5.77%, respectively. The co-infections of ChiVMV and PVY were detected in 31 chilli leaf samples. The sequences of five ChiVMV isolates were submitted to Genbank which shared nucleotide identities of 90-97.5% with each other and 82.4-90.5% with other ChiVMV isolates. Based on nucleotides and amino acids phyolgenetic analyses of CP gene, the Pakistani isolates clustered with Indian (JN692501 and JN624776) and Chinese (KC711055, KC711055, JX088636 and HQ218936) isolates in a separate clad. Recombination events were also detected in Pakistan isolates and one ChiVMV isolate KX236451 was suggested to be a recombinant between the Pakistani isolate (KT876050) and the Indian isolate (JN692501). An infrequent gene flow was observed between the ChiVMV isolates from Pakistan and other countries of the world. Restriction sites of *Bgl*II and *Bste*II were added and CP specific primers were designed based on ChiVMV isolate ATIPK (KJ472764, *p*01) for CP gene specific amplification. CP cDNA was inserted in *p*1301 in sense direction downstream of CaMV35S promoter and transformed into *Agrobacterium* strain LBA4404. *Nicotiana benthamiana* plants were transformed with *Agrobacterium* mediated Assay. Transgenic tobacco plants were confirmed through hygromycin resistance and PCR amplification of CP gene. Transgenic plants were assessed against ChiVMV resistance level by challenging the transformed

plants with ChiVMV inoculation. After two weeks of inoculation, infection %age was evaluated by disease rating scale. Transformed plants showed low infection %age i.e 21-30% as compare to control plant. Transgenic line T3, T4 and T7 showed the resistance behaviour while T2, T6 and T8 exhibited the moderate resistance level whereas T1 and T5 showed the moderate susceptible response. The ELISA readings confirmed the phenotypic symptoms and showed virus accumulation was in detectable amount in systemically infected leaves of these transgenics. ELISA values of the inoculated non-transgenic plants indicated high ChiVMV titer as compare to transformed plants.

## Diversity and visitation of insect pollinators of loquat flowers at PMAS Arid Agriculture University Rawalpindi

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Loquat is considered as self-compatible fruit species which attracts pollinators due to its highly attractive flower fragrance. Considering it as important source of pollen and nectar for insect pollinators, insect pollinator species diversity and visitation at different time intervals was observed during 2017-18. Observations were recorded during flowering season at weekly interval. Insect pollinators belonged to insect orders Hymenoptera, Diptera and Lepidoptera with *Apis cerana* being the most common flower visitor. Five weeks survey showed Increase in pollinator activity with increase in temperature. Their numbers decreased with decrease in flowers on plants. This preliminary study suggests the use of loquat as fruit as well as ornamental plant for conservation of pollinating insects.

## Behavioral responses of *Coccinella septempunctata* and *Diaeretiella rapae* toward semiochemicals and plant extract

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The chemical ecology of natural enemies can play a pivotal role in any Integrated Pest Management (IPM) program. Different chemical cues help to correspond in diversity of associations between prey and host plant species. Recent studies

exhibited that the use of natural enemy is an ecofriendly measure to control pests. *Coccinella septempunctata* and *Diaeretiella rapae* have the abilities to explore several chemical cues released by plants under herbivore attack that may enhance their efficiency of foraging. In this study, the behavioural responses of *Coccinella septempunctata* and *Diaeretiella rapae* were examined under the application of two semiochemicals and a plant extract and their combinations using four arm olfectometer. The bioassay was consists of a pairwise treatment comparison. Data pertaining to preference of *C. septempunctata* and *D. rapae* after treatment application were recorded and analysed statistically. The mean number of entries and time spent of *Coccinella septempunctata* and *D. rapae* were greater in arms treated with E-*β*-Farnesene. However, the efficacy of E-*β*-Farnesene was enhanced when combined with *β*-pinene. Thus, the mean number of entries and time spent of *C. septempunctata* and *D. rapae* were highest in arms treated with the combination of E-*β*-Farnesene x *β*-pinene as compared with other treatments. The current work has demonstrated that the insect derived semiochemicals may enhance the efficacy of natural enemies when applied in combination.

## The influence of abiotic factors for the variation of jassid (*Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae), numbers on brinjal (*Solanum melongena* L) crop

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Jassid is the sucking pest of brinjal, it has been reported threatening pests of many crops of economic importance. This experiment was conducted about the study of jassid population and its interaction with the weather factors, the experiment was conducted in the Institute of Agricultural Sciences, University of the Punjab Lahore. The experiment laid out in Randomized Complete Block Design (RCBD) with the three replications. The coefficient of determination values were observed to find the role of weather effects on population fluctuation *Amrasca biguttula biguttula* (Ishida) on brinjal. The data were recorded at different dates at weakly bases and were correlated with the weather factors so

that to find out the effects of rainfall, relative humidity maximum temperature, , average temperature, and minimum temperature. The result showed that maximum temperature played the important role for the fluctuation of jassid population which is 42.4% and the minimum temperature, average temperature and rain fall showed 22%, 7.6% and 5% respectively. While humidity showed the less effect for population increasing and decreasing. The recorded data were transformed to square root transformation and processed for the Simple Correlation and Multiple Linear Regression analysis for study to check the role of weather factors in the fluctuation of pest population.

**Modified pest & disease management practices for economic growth of horticulture market**

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The Horticulture market has become a key driver for economic growth in many countries. Where quantity and yield are important to sustainable vegetable and fruit production, pests and diseases can melodramatically decrease crop growth, subsequent returns and quality. People spend natural resources and huge amount of money into growing vegetables and fruits. This investment can be saved from preventable losses by good pest and disease management practices. By every passing day the demand of healthy, safe and chemicals free food has been surprisingly increased. The major concern is of the adverse effects of plant protection chemicals on flora, fauna, environment and human health. To minimize the pest, damage this article uses several cultural practices that can reduce the pest attack. Making such modifications is often the best economic and consistent long-term protection solution. Selection of cultivars and field, preparation of land, methods of plantation, its time, application of fertilizers, cropping rotation, time and number of irrigation are all the factors which have an impact on pest problems. Selection of cultivar is most important in the whole scenario, where the growth of high quality product must be selected keeping in view local environmental conditions. It is most important that cultivar has the adaptation capacity to native growing conditions because healthy and vigorous plants have

better resistance against insects and pathogens attack. Cultivar must also be heat tolerant and has ability to germinate under harsh conditions. Also, up to date knowledge about disease and pest tolerance in existing cultivars must be known.

## Bacterial leaf spot of tomato and its management

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The tomato (*Solanum lycopersicum*) is one of the very popular vegetables in Pakistan. A bacterial leaf spot disease was recorded on tomato plants which were grown in the tunnel of Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. Small, yellow-green and water soaked lesions (0.26 to 0.52 cm) were recorded on young leaves which turned into brownish-red at later stage of infection. Nutritional artificial media was used for the isolation of bacterial pathogen and KOH, catalase activity, pectolytic tests, anaerobic and SIM tests were used for the reliable identification of bacterial pathogens. *Xanthomons* sp. was confirmed as the causal agent of bacterial leaf spots and its management through plant extracts will be accomplished.

## Application of *Burkholderia phytofirmans* 'PsJN' affect growth and yield of cut antirrhinum and matthiola

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A study was conducted at Commercial Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2016-17, to evaluate *Burkholderia phytofirmans* 'PsJN' application on growth and yield responseof cut *Antirrhinum* and *Matthiola*. Seeds of 'Chantilly Yellow'*Antirrhinum* and 'Canneto White'*Matthiola* were obtained from Takii, USA and sown on either 15$^{th}$ Oct.or 15$^{th}$ Nov., 2016, in 128-cell plastic plug trays containing silt, coco coir and press mud, (1:1:0.1; v/v/v) as substrate and kept in

greenhouse maintained at 20-25°C temperature with 60-70% relative humidity.After three days of seed germination, *Burkholderia phytofirmans* 'PsJN' solution (10 mL) was applied to each seedling. Seedlings were transplanted in well prepared soil beds at 3-4 leaf stage laid out in a randomized complete block design (RCBD) with factorial arrangments having three replications and 30 plants per replication. At transplanting, seeding roots were dipped in PsJN solution (100 cfu $mL^{-1}$) and 1/3 split of NPK (20:20:20) @100 kg per acre was applied. Seedling treatment with PsJN produced early flowering in *Matthiola* by 12.0 d for 15th Oct. sowing and 5.3 d in 15thNov. sowing without compromising flower quality (8.8), while *Antirrhinum* treated with PsJN solution delayed flowering by 21.1 d for15th Oct. sowingand 23.7 d for 15th Nov. sowing than plants treated with water only (control). Sowing on 15th Oct. resulted in taller plants with greater leaf area for tested species, 68.9 cm and 12.8 $cm^2$for *Antirrhinum* and 56.9 cm and 35.3 $cm^2$ for *Matthiola,* when treated with PsJN. Both species had greater number of florets with longer raceme length in 15thOct. Sowing than 15th Nov. sowing, while PsJN application further increased number of florets and raceme length. Similar results were recorded for stem diameter, fresh weight of a stem, while floret diameter and dry weight of a stem were relatively less affected by sowing time and PGPR application. Flower quality was better for early sowing in October than November sowing. Sowing time or PGPR application had no effect on vase life. Overall, sowing on October 15 performed better than November sowing, while PsJN application improved growth and yield characteristics of both tested species.

## Antibiotic treatment of citrus budwood for the management of huanglongbing disease in Pakistan

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Control of huanglongbing disease is necessary around the world to avoid complete destruction of citrus. Tetracycline and penicillin antibiotics were used in this study to eliminate *Candidatus Liberibacter* species from sweet orange

budwood. Tetracycline doses used were 250 ppm, 500 ppm, 750 ppm, 1000 ppm and 1250 ppm. Penicillin doses were 25 ppm, 50 ppm, 75 ppm, 100 ppm and 125 ppm. Kinnow mandarin (*Citrus reticulata* Blanco) nurtured in screen house were used as indicator plant. These plants were confirmed huanglongbing (HLB) negative before grafting. Budwood was obtained from HLB positive plants confirmed by conventional PCR using 16S rDNA primers OI1/OI2C and rplKAJL-rpoBC operon primers A2/J5. Budsticks treated with the above mentioned doses of antibiotics were grafted on the indicator plants. Tetracycline at 1000ppm and penicillin at 75ppm proved most effective to eliminate the *Candidatus Liberibacter asiaticus* from infected budwood as shown with real time PCR.

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In Pakistan, strawberry (*Fragaria* × *ananassa*) in an emerging fruit crop with good economic return to growers. Comprehensive survey was conducted across eight districts of Punjab during 2014-15 and 2015-16 to assess percentage disease incidence and prevalence of *Alternaria* leaf spot, which ranged from 28.00% to 51.81% and 75-100% respectively, in Rawalpindi, Sargodha, Gujranwala, Sialkot, Narowal, Sheikhupura, Lahore and Multan. Samples were subjected to isolation and purification procedures and pathogenicity test was performed on strawberry leaves to confirm Koch's postulates. Sixty one isolates were characterized for cultural, morphological and pathogenic variations. Light to dark brown and olivaceous black colonies with cottony subaerial to powdery texture having whitish to grayish regular and irregular margins with presence and absence of concentric ring was recorded. Conidia size ranged from 6.9 to 60.6 µm. Transverse and longitudinal sepatation varied from 1-6 and 0-3 respectively. Total genomic DNA was extracted from isolates and subjected to amplification with inter transcribed spacer region (ITS1, 5.8S, ITS2) primers. Amplified PCR

products were run on gel to confirm amplification and purified. Nucleotide sequences of ITS gene region of 8representative and highly virulent isolates from each district were submitted in the GenBank database of NCBI under accession numbersMF966136, MF966137, MF966140, MF966141, MF966141, MF966143, MF966144, MF966145, MF966146 and MF683080 respectively. Evolutionary history was constructed with previously reported sequences of *A. alternate* from the world. Evolutionary tree showed variation among submitted isolates and showed that all isolates belongs to *A. alternata*. Cultural and morpho-molecular characterization of A. *alternata* associated with leaf spot of strawberry was recorded first time in Pakistan.

## Inhibition of crown-gall tumor by selective phytoextracts for disease management

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Aim: Plants may provide potential alternatives to currently used diseases management because they constitute a rich source of bioactive chemicals. Much effort has, therefore, been focused on plant-derived materials for potentially useful products as commercial disease-control agents.
Methodology: *In vitro* inhibition of crown-gall tumorigenesis through crude extract of selected species assessed through bioassays protocols against *Agrobacterium tumefaciens* (At 10 strain).
Results: Responses varied plant material, concentration of crude extracts and exposure time. Overall, the most biologically dynamic plant extract which exhibited significant toxicity effect were seeds of *P. harmala*, *P. harmala* (roots), *M. alba* (leaves) and *M. azedarach* (fruits). Over 87% mortality at 1000ug/ml was achieved using extracts of *M. azedarach* fruits while extract of *P. harmala* seeds gave 94% mortality after treatment at same concentration.
Conclusion: Since these extracts are active against and potentially suitable for use in disease control, they could lead to the development of new classes of safer disease-control agents. So, these extracts have prospective to be chemically

standardized or developed into the commercial agents for integrated disease management.

## Morphological characterization of fungal post harvest pathogens of peach (*Prunus persica* L) and their management through essential oil

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The present study is to investigate the fungal post harvest pathogens of peach from Rawalpindi fruit markets in 2016-2017. Twenty samples of peach fruit were collected from each site randomly. Further Isolation techniques were proceeding in fungal plant pathology laboratory Pir Mehr Ali Shah Arid Agriculture University Rawalpindi. Among 31 fungal isolates, twelve isolates were of *Rhizopus spp.*ten isolates of *Mucor periformis*, three isolates were of *Botrytis cineria* and six isolates were of *Aspergillus niger* were morphological characterized. The highly prevalent post harvest pathogen was tested by using different essential oils (EOs), these are volatile oily liquids obtained from different plant parts and seeds.The antifungal activity of essential oils(Brassica seeds oil, Taramira oil, and Ginger oil with0.05%,0.5%, and 5% concentration were assayed by poison food Technique against *Rhizopus spp.in vitro* condition. Results of this study showed that taramira oil (5%) had good inhibitory effect on growth of phytopathogenic fungi and may be used as a new tool for preservation and extension of shelf-life of peach fruits.

## Seasonal fluctuation of nematode associated with citrus in pothwar region of Pakistan

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Citrus nematodes, *Tylenchulus semipenetrans* causes immense damage to the citrus plantation. The population of the nematode greatly depends upon the

ecological factors. Of these, soil depth is the most important. Seasonal fluctuation of *T. semipenetrans* was studied from January 2013 to December 2013 at the soil depths of 30 and 45 cm respectively from UAAR and farmer field at Khanpur. The effect of soil depths was studied on the population of citrus nematode. Two high and two low population levels were recorded. High levels occurred in May-June in UAAR that was 1910-1960 nematode population (NP) at 30cm soil depth while 1204 - 1208 NP at 45 cm soil depth and in September-October it was upto 1942 NP at 30cm while 1224 NP at 45 cm soil depth and low levels in December-January and July-August. Similarly, in case of Khanpur population density of nematodes were high in May-June and Aug-Sept that was upto 1916 NP and 1942 NP respectively at 30 cm soil depth. Although *T. semipenetrans* was found throughout the year in the soil but in roots population increased from April to June and decreased in July significantly and became zero in July-August. The population again increased from September to November and was the highest in September-October and minimum in December-January. Nematodes were recorded from the soil throughout the year but in roots were found one month before and after the peak periods.

## Role of morphological traits and chlorophyll and phenolic contents in imparting resistance against cucumber mosaic virus and zucchini yellow mosaic virus in cucumber genotypes

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Cucumber is a popular vegetable of Cucurbitaceae family, it is cultivated on large scale all over the world including Pakistan. In the present study the role of morphological traits and biochemical factors of six cucumber genotypes viz (Shaheen, Beit alpha, Songroo, Best Pick, All Season and Alpha prime) were investigated in imparting resistance and susceptibility against Cucumber mosaic virus (CMV) and Zucchini yellow mosaic virus (ZYMV). Different vegetative parameters showed different trends among the diseased and healthy plants for resistant and susceptible varieties. Total number of leaves, flowers and shoots per

plant, Leaf area (cm2), plant height (cm), stem diameter (mm), total chlorophyll contents and total soluble phenols were reduced in inoculated plants of both susceptible and resistant genotypes. But in resistant varieties this decrease was less as compared to decrease in the inoculated plants of the susceptible varieties. The result of this study suggest that the breeders should prefer the use of resistant variety (beit alpha) in development of new resistant cucumber varieties so that they can perform better against CMV and ZYMV infections.

# Miscellaneous

# Impact of trainings provided to citrus growers by agricultural extension staff in district Sargodha

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Citrus is one of the major export fruit of Pakistan. Pakistani citrus is very famous across the globe especially Kinnow cultivars because of its aroma and taste. From last few years the department of agricultural extension has started the trainings of the citrus growers. Mainly in the hub of citrus growing area i.e. Sargodha, Punjab Pakistan. This research was conducted in district Sargodha. The interview schedule was designed for the purpose of data collection. The data was collected from 120 farmers randomly selected from 15 Farmers Field Schools. All the respondents were in collaboration with Fruit and Vegetable development Project. The main aim of the study is to evaluate the knowledge and skills gained by the farmers from the trainings provided. The data was analysed through statistical package for social sciences (SPSS). The respondents were asked about the skill and knowledge they learnt and the responses are displayed in About 40% of the farmers learnt about citrus varieties, 32% of respondents learnt about management of young plants/orchards, 28% of the respondents get the knowledge about cultivation of fruits & 20% of respondents get the knowledge & skills about layout & management of citrus orchards. About 35% of the respondents learned about time duration between two irrigations, (24-19%) of the respondents learned about tensio-meter installation and the way to check tensio-meter readings in citrus orchards, drip irrigation technique & saline water treatment. More than fifty (52%) of the respondents learnt about identification control and management of citrus canker, 23% about fruit drop disease and citrus scab, 18% learnt about citrus melanose & (2-1%) of the respondents learnt about gummosis, damping off and wither tip. Nearly forty five percent (44-43%) of the respondents learned about waxing and packaging, 21% about grading and only 2% about the picking of citrus fruit. On the basis of conclusions, following suggestions were made

i.e. Government should continue projects on the training of citrus growers in future to provide more benefits to the farmers of the area even after the abolishment of project in District. Farmers from this area of Pakistan are passive leaners so Government Agricultural Extension staff must keep supporting them to increase per acre yield of citrus and to produce export quality citrus.

## Backyard gardens in urban areas and their associated wildlife

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Backyard gardens can add beauty to landscape and a habitat for a variety of wildlife species. The present study was designed to gather baseline data on association of wildlife species with backyard gardens in Islamabad Capital Territory. We carried out field surveys in the selected gardens, ranging from 20-50 $m^2$, using standard methods from March, 2017 to June, 2017. We made observations on the flora of gardens and visiting wildlife species. We observed that majority of gardens had plant species such as Sago palm (*Cycas revoluta*), Chir pine (*Pinus roxburghii),* Common sunflower (*Helianthus annuus),* Rose flower (*Rosa indica*) and Dog Flower (*Antirrhinum majus*). The most common wildlife species associated with the gardens included Crow (*Corvus splendens*), Common myna (*Acridotheres tristis*), Sparrow (*Passer domesticus*), Collared dove (*Streptopelia decaocto*), Pigeons (*Columba livia*), Green parakeet (*Psittacara holochlorus*), Hoopoe *(Upupa epops*) and Black drongo (*Dicrurus macrocercus*).We found that natural tree holes were used for nesting and roosting for a variety of species. Besides wildlife species, the owners also kept some various pet species which included African grey parrot (*Psittacus errithacus*), Diamond doves (*Geopelia cuneata*), Jawa finch (*Lonchura oryzivora*), and Mallard duck (*Anas platyrhynchos*) in small ponds. The gardens were infested with exotic vegetation species such as Carrot grass (*Parthenium hysterophorus*), Marijuana (*Cannabis sativa*)*,* Butterfly weed (*Lantana camara),* Common cocklebur (*Xanthium strumarium*)*,* Khaki weed (*Alternanthera pungens*)*,* Water lettuce (*Pistia stratiotes*) and Common reed (*Phragmites australis*). It is suggested that maintain natural habitat at backyard gardens can attract variety of

wildlife species which not only contribute towards beautification of the landscape but for conservation of wildlife in urban areas as well.

## Quantitative ethnobotanical study of plants of tehsil Razar, district Swabi, Pakistan

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The present study is aimed to explore the quantitative ethnobotanical profile of plants of Tehsil Razar, District Swabi, by means of Relative frequency citation (RFC) and Use value (UV) of plant resources. Pearson correlation coefficient (PCC) was calculated to find any significance between RFC and UV. A total of 60 plants from 37 families had ethnobotanical importance in the investigated area. It included 1 pteridophyte, 13 monocots and 46 dicots. There were 34 herb species, 18 tree and 7 shrub species. Family Poaceae had 10 species with ethnobotanical uses. It was followed by Family Amaranthaceae (4 spp.), Family Mimosaceae, Euphorbaceae and Asteraceae (each with 3 species). Most of the plants had multipurpose uses. Thirty five (58.33%) species were medicinally used, Fodder (25 spp.) and fuel wood (16 spp.). Thirteen species were used for construction and as a building material. Twelve species were used for furniture making. Twelve species were edible. Fourteen species were used in making of hedges, mates, ropes, Miswak and dyes. Quantitative results showed that 24 species with the highest RFC value of 1 were important in the area in terms of their uses. *Acacia modesta*, *Acacia nilotica sub sp. Nilotica* and *Ailanthus altissima* were popular and common medicinal plants in the study area with highest use value of 6.07, 5.60 and 3.40 respectively. The Pearson correlation coefficient (PCC) between RFC and UV was 0.01 with P value well below than 1% which demonstrate a highly significant correlation between RFC and UV.

## Optimization of culture conditions for the biomass production of *Scenedesmus dimorphus* (Turpin) Kutzing

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The green alga *Scenedesmus dimorphus* is used as food, for biofuel production and removal of heavy metals from polluted water. Keeping in view the importance of alga the present study was under taken to collect and identify the *S.dimorphus* from Rawalpindi and Islamabad ponds and streams. The algal samples were collected in the plastic bottles and brought in the laboratory preserved in the ice box. The isolation of algal sample was done by pour plate and streak plate method. The isolated samples were cultured in laboratory in BG11 medium at varying conditions of pH, temperature, photoperiod, light intensity and culturing time. The maximum biomass was observed at 8 pH,25$^{o}$C temperature, 16 hours light duration, 3000 lux light intensity after 20 days of culturing in the laboratory. This information can be useful for food industry, phycoremediation of wastewater and biofuel production using *S.dimorphus* in future studies.

## Floristic list, ecological features and biological spectrum of district Nowshera, Khyber Pakhtunkhwa, Pakistan

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A survey was carried out to evaluate the phytosociological and ethnobotanical features of district Nowshera, Khyber Pakhtunkhwa, Pakistan. The study was performed in different seasons of 2013-2015. The plant diversity comprised of 222 species belonging to 72 families. Among the total reported plant species, Poaceae (28 spp.) was the dominant family, followed by Brassicaceae (15 spp.) and Papilionaceae (13 spp.) while other families had less than 09 species each. Hydrophytes had 44 species (19.8%); xerophytes had the share of 157 species

(70.72%), while 21 species (9.45%) were amphibious in nature. Plant species possessing simple leaves were 170 (76.57%) species having compound leaves were 23 (10.36%). There were 24 species (10.81%) with dissected leaves and 05 species (2.25%) were aphyllous. Seasonal variation of species diversity indicated 173 species (77.92%) in spring, followed by summer with 120 species (54.5%), winter with 90 species (40.54%) and autumn with 84 species (37.83%). Biological spectrum showed that therophytes were dominant life form and were represented by 110 species (50.1%), followed by microphanerophytes with 24 species (10.58%). Nanophylls were the leading leaf size spectra with 94 species (42.23%), followed by microphylls with 75 species (33.78%), while leptophylls had 32 species (14.41%), mesophylls had 16 species (7.20%) and aphyllous were 05 species (2.25%).

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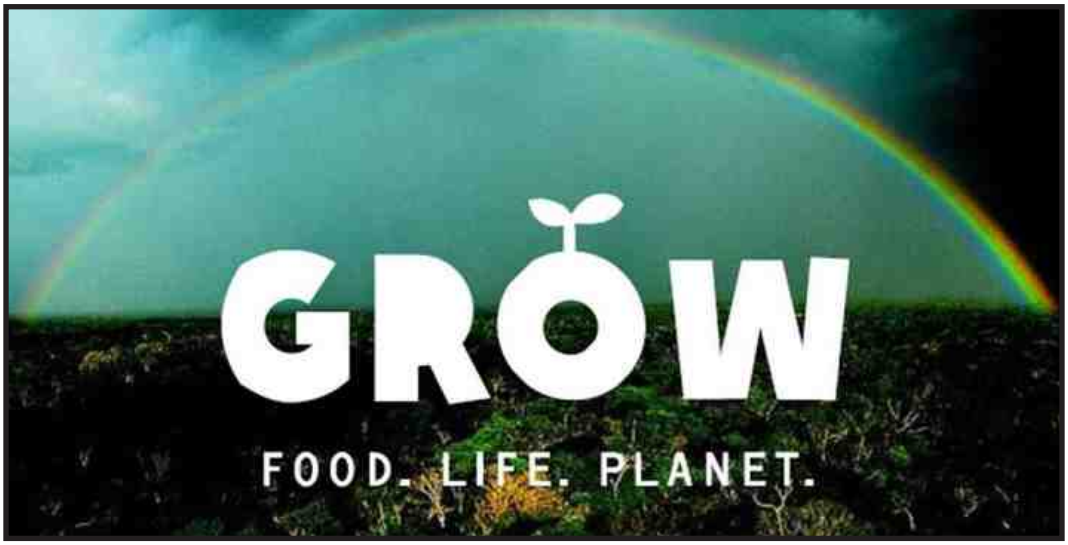


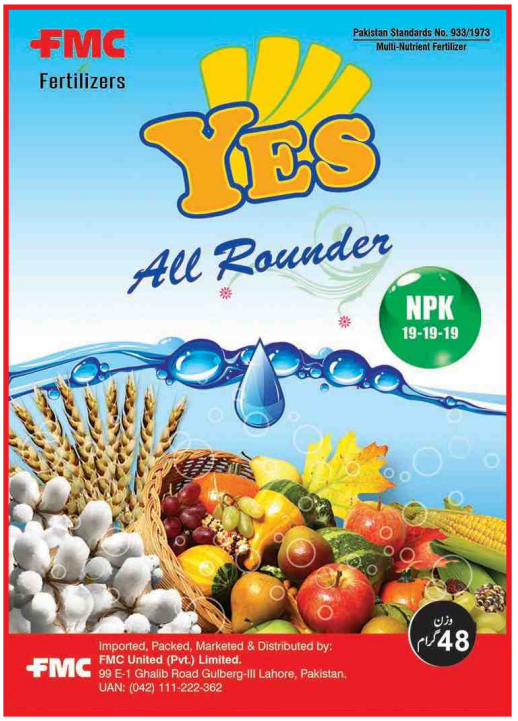
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