Innovation Catalogue

2nd Edition

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Contents

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Foreword

The agriculture sector is facing unprecedented challenges that affect the sustainability of food and agriculture systems, putting food and nutrition security at significant risk. In addition to visible hunger, there is 'hidden hunger' that results from the lack of micronutrients available to people. The region is also experiencing alarming levels of natural resources deterioration and the impacts of climate change.

These challenges along with population growth, are a cause of growing instability associated with land, water and energy shortages. The critical role of innovation to make agriculture more competitive and sustainable is obvious. We see the challenges as opportunities.

Businesses and governments see the university and its members ideally suited to "connect the dots" because they are driven by curiosity. To connect the dots effectively, UAF has been highly responsive, adaptable, strategically directed, and densely interlinked with its regional partners as well as through international networks.

We at UAF, collaborate with farmers, government and environmental groups on researching and developing sustainable solutions. The Innovations Catalogue aims to showcase solutions to challenges faced by small farmers. The second edition of our Innovation Catalogue will help in unlocking the potential of innovation to drive socioeconomic growth, ensure food and nutrition security, alleviate poverty and improve resilience to climate change, thereby helping to achieve the Sustainable Development Goals.

We hope that the innovations presented in this catalogue will arouse interest among the potential investors and eventually promote culture of innovation and entrepreneurship among students and faculty members. Finally, I would like to thank all contributors and co-editors for putting together this catalogue. To ensure wider access by different categories of stakeholders, a soft version of the catalogue is available online (www.uaf.edu.pk)

Prof. Dr. Iqrar Ahmad Khan (S.I)
Vice Chancellor

Cottonized Hemp Fiber for Application in Denim Garments

Dr. Assad Farooq, Associate Professor
Ms. Farida Irshad, Lecturer
Department of Fibre and Textile Technology
University of Agriculture, Faisalabad.

Challenges/issues

- The production of cotton in Pakistan is declining and a decrease of approximately 4 million bales was observed in year 2020. The production of raw material for feeding the huge textile industry of the country is very vital.
- Hemp is a highly valuable natural fibrous crop, known to mankind for decades. Hemp fibers possess remarkable characteristics: strength and durability better than cotton along with some functional properties like antimicrobial and UV resistance. The fabrics developed from hemp are very strong, breathable, and flexible. There is a growing demand in the Denim industry of the country for cotton : hemp blended yarns especially for denim jeans.
- Wild hemp is present in the arid areas of the country. However, cultivation of non-toxic hemp crop and development of efficient and eco-friendly methods for extraction and Cottonization of the hemp fibre is required .

Intervention/Technology Brief

- The department of Fibre and Textile Technology has developed the efficient and economical method for the extraction of hemp fibres.
- Mechanical, and chemical procedures for cottonization i.e. softening of fibres for blending with cotton and other fibers has been developed.
- Yarns from hemp & cotton blend fibers have been manufactured and then converted to Denim Jeans with support from US Group, which has signed an MOU with the University of Agriculture, Faisalabad for research activities on natural fibres.

Outcomes

- The development will address the serious issue of shortage of natural fibre raw material in the country.
- The traditional non-environment friendly method of fibre extraction will be substituted with more eco-friendly and efficient methods.
- The sustainable denim products from the hemp fibres will enhance the potential of the export industries of the country.

Way Forward/Future Strategy

- Better chemical cottonization of hemp fibres to produce improved quality textile products.
- Spinning of hemp fibres on long staple spinning systems.

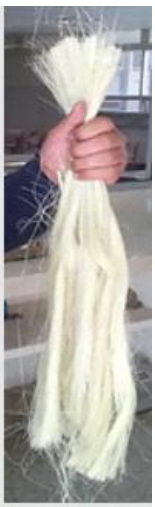
Sisal Decorticator

Dr. Assad Farooq
Department of Fibre and Textile Technology,
University of Agriculture, Faisalabad

Challenges/issues

- Sisal fiber is extracted from the leaves of *Agave sisalana* that is Mexican plant and is now mainly cultivated in Tanzania, Brazil, Indonesia and India.
- Sisal plant is present in Pakistan and can be grown in the country due to its xerophytic nature. Due to its strength and durability, it is placed in the category of "hard fibers". Sisal fibers have the ability to be utilized into simpler end uses like twines, ropes and other packing materials, sisal fabrics, buffs, matts, carpets, filters and handicrafts. Moreover, specialized high value end uses include geo-textiles and fiber reinforced composites. However, in the presence of the Sisal fibers in the country and also having the potential of being grown at vast areas, the country is lacking in the sisal processing machinery.

Sisal Decorticating Machine



Sisal Fibres

Intervention/Technology Brief

- Sisal fiber decorticator has been designed and developed in the Department of Fibre and textile technology.
- The developed decorticator machine is smarter than the other internationally available machines.
- The decortication machine has been developed on the basis of respaidor design.
- The sisal leaves are subjected to the action of blunt knives attached to a fast moving cylinder and feed plates.
- This action eliminates the green matter from the leaves and the fiber are decorticated.

Outcomes

- The Decortications action is more effective due to the special design of decorticating cylinder and knife. Hence, fibers come out clean and are almost free of green matter.

Way Forward/Future Strategy

- Utilization of sisal fibres as reinforcement in the fibre, reinforced plastic for light weight performance composites.

Fibers from the Waste of Banana Plant

Dr. Assad Farooq, Associate Professor
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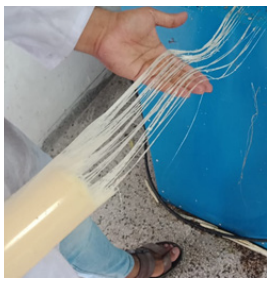
Department of Fibre and Textile Technology
University of Agriculture, Faisalabad

Challenges/issues

- Banana is a fruit crop of Pakistan, and it is cultivated on 34,800 hectares of land annually. Its total production is 154,800 tons per annum. However, banana pseudo-stem lives for 4-6 years but its gives fruit once. After picking the fruit, banana stem is treated as waste and burnt or left for decomposition, which has the serious consequences for the environment like smog, toxic smoke, and ashes etc.
- Declining trends in cotton production of Pakistan is a serious issue that must be addressed immediately in order to make sustainable progress of the textile industry in the country. Moreover, increasing awareness about the sustainability in textile has shifted the focus of the textile market worldwide from conventional unsustainable fibres to new sustainable raw materials.



- The presented development corresponds to the development of indigenous methods for the fibre extraction and cottonization of the banana fibre for making the fibres useable for the textile and packaging industry through different chemical and mechanical treatments.

Intervention/Technology Brief

- Extraction of fibres from the pseudo stem Banana Fibre through respaidor based decortication machine has been optimized for the said purpose.
- Application of chemical treatments for swelling of fibres, mercerization, delignification, degumming using alkaline and bleaching agents and softening through oil emulsions and non-ionic softeners.
- Spinning of Banana fibres : Cotton blend into yarns for utilization in different textile fabric and apparel applications.
- Substitution of traditional jute fibres packaging with the extracted banana fibres.

Outcomes

- The intelligent use of the waste to extract the banana fibers and blend it with cotton will not only lift the stress from the cotton production of the country but will also contribute to the development of the country.
- As the textile industry is looking towards natural and sustainable substitutes of the cotton, this technology will pave the way for the future developments in the conventional textile industry and the opening of new textile markets worldwide for the country products.

Way Forward/Future Strategy

- Spinning of banana fibers on jute spinning system to compensate the shortage of packing fibers in the country
- Development of highly absorbent and comfortable banana cotton socks.

Multi-tasking Machine for Precision Sowing of Row Crops

Dr. Muhammad Zaman, Assistant Professor
Department of Irrigation and Drainage
Dr. Abdul Ghafoor, Assistant Professor
Department of Farm Machinery and Power
University of Agriculture, Faisalabad

Challenges/issues

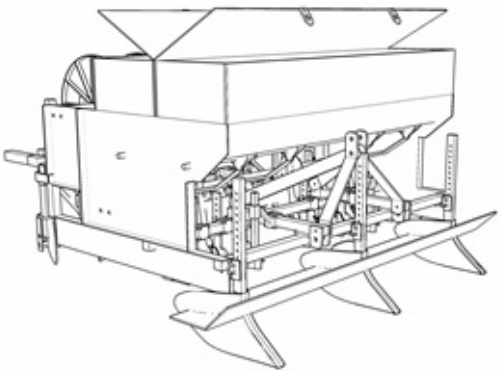
- Abundant population growth and resource scarcity demands precision and adoption of new agronomic techniques in agricultural practices.
- Mechanical operations performed during different crop stages require expensive inputs and are labor extensive tasks which increase operational cost if not performed efficiently.
- Change in climate, water availability situations and latest agricultural techniques are forcing the farmers to use drip irrigation and plastic mulching to enhance the crop productivity.

Intervention/Technology Brief

- The multitasking machine involves performing multiple operation in one go for their different agronomic benefits.

The machine can perform following operations

- Prepare beds of desired width with channel of adjustable depth and width.
- Lay drip tape at desired depth.
- Place two types of fertilizer in rows at adjustable height and distance from seed placing area.
- Install plastic mulch.
- Plant seed of multiple types.



Outcomes

- A multi-tasking machine to efficiently perform 6 functions in one go of the tractor i.e., bed formations, drip laying, gypsum application / fertigation, plastic mulch installation and seed sowing of multiple crops (cotton, maize, corn, wheat etc) can save up to 60% input costs at sowing stage.
- An affordable machine for small farmers whose different functions can be avoidable if not required in the field and can be used by others as per requirement.

Way Forward/Future Strategy

- The developed machine is beneficial to perform multiple operation in one go of tractor to save input cost.
- Commercialization of developed machine on large scale is way forward.
- The small farmers will also be approached with the help of field wing and extension department of agriculture to spread the technology.
- Incorporation of pneumatic planting assembly for precise sowing of the seeds.

Fodder Chopping Machine

Dr. Abdul Ghafoor, Associate Professor
Prof. Dr. Muhammad Azam Khan
Department of Farm Machinery and Power
Dr. Muhammad Usman Farid
Department of Structures and Environmental Engineering
University of Agriculture, Faisalabad

Challenges/issues

- Substandard and unsafe design resulting in severe injuries
- Lack of safety provisions
- Higher maintenance and replacement cost

Intervention/Technology Brief

- Safety provisions and friendly operation
- Lower initial cost
- Suitable for small scale farmers
- Can be operated using electric motor or engine
- Possibility of controlling the size of fodder pieces
- No. of rollers: 2
- No. of blades: 4
- Output: 150-200 kg/hr
- Weight: 80 kg

Outcomes

- Replacement of existing conventional toka machine
- User-friendly operation reducing severe injuries
- Lower maintenance cost
- Suitable for chopping of fodder crops like barseem, sorghum, corn stalk, hay and sugarcane stalks

Way Forward/Future Strategy

- The technology will be promoted and commercialized in collaboration with industrial partner.

Zone Disk Tiller

Prof. (R) Dr. Muhammad Iqbal
Department of Farm Machinery and Power
University of Agriculture, Faisalabad

Challenges/issues

- For successful adoption of till plant technology in rice-wheat rotation system and to avoid the delay in wheat sowing, a technically and economically acceptable tractor drawn Power Take Off (PTO) driven "Zone Disk Tiller Drill"(ZDTD) has been designed, developed, fabricated, and tested for sowing wheat in standing paddy crop residue fields directly after harvesting paddy crop.

Intervention/Technology Brief

- The extensive experiments were conducted in the untilled paddy fields of Sheikhupura (Mananwala) and Faisalabad (Jaranwala, University of Agri. FSD.) during the wheat growing seasons of 1998 to 2012.
- The crop was planted successfully in 9"rows by seven wavy coulters revolving at 172 RPM mounted on a common shaft ahead of the furrow openers.

Outcomes

- The machine is one of its own kind in the world. The savings in diesel energy, labor, and irrigation water were found 75%, 50% & 30%, respectively, as compared with conventional method of wheat planting in Pakistan. Moreover, 14-15% yield was increased in this new system of crop planting.

Way Forward/Future Strategy

- This machine can be used for planting maize, barley, and grams. Moreover, an extra shaft can be developed to use this machine as a rotavator if needed.

Sensor Based Unmanned Aerial Agro-Chemical Spraying (UAAS) System

Dr. Ahsan Latif, Assistant Professor
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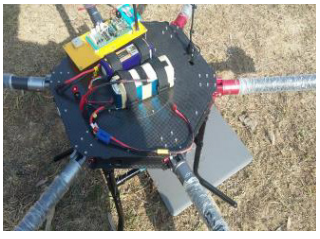
University of Agriculture, Faisalabad
Dr. M. Jehanzeb Masud Cheema,
PMAS-Arid University of Agriculture, Rawalpindi

Challenges/issues

- The agro-chemicals are being applied on crops and orchards by conventional spraying systems homogeneously without considering substantial variation in plant population and canopies. Excessive application for the regions without vegetation results in over-use of the expensive agro-chemicals as well as environmental hazard.
- The conventional land- spraying machines are inconvenient for spraying in crops like sugar cane and rice. Furthermore, the continuously increasing cost of the agro-chemicals and an un-precedented dependence on these chemicals for the increased production leads to an economic threat while below-par application would restrict the crop yield.
- Globally, unmanned aerial vehicles (UAV) are also used in various precision agricultural projects for monitoring and management (spraying insecticides/pesticides) of crops and orchards. However, they are of high cost and semi-autonomous thus requiring visual control to differentiate between cropped and non-cropped area for spraying.
- The demand of the system has been increased due to non availability of the labor as well as growing of high value crops where available machinery cannot spray properly e.g. sugarcane, rice etc.

Intervention/ Technology Brief

- Indigenization and assemble of unmanned aerial system (UAS) for application of pesticides/weedicides.
- The prototype was imported from international market and its various processes were indigenized (including software and hardware) for making it spot application system, were developed and deployed in collaboration with SATUMA pvt limited, Islamabad.
- By integrating the system with inputs from multispectral sensors and control through “Spot Spraying Controller (SSCon)” was deployed on UAS. SSCon connected with ultra high volume sprayer allowed route planning software to direct the UAS for spot application at infected cropped area or orchard trees avoiding excessive overlap or gaps in the spray patterns.
- The SSCon device on board UAS has made it a “Sensor Based Unmanned Aerial Agro-Chemical Spraying (UAAS) System”. The UAAS system reduces the use of costly chemicals as well as environmental hazards.



Outcomes

- The main output was the development of an Unmanned Aerial Agro-Chemical Spraying (UAAS) System that should be able to spray measured and controlled volumes on those spotted areas that are affected with disease without wastage on areas that do not require spraying by recognition of cropped and non cropped areas through vegetation sensor on board UAV.
- The overall output objective has been attained through indigenized assembly of unmanned aerial system (UAS) for application of pesticides/weedicides.
- The prototype was assembled and its various processes were indigenized (including software and hardware) for making it variable rate spot spray application system for crops and orchards.
- It was done by integrating the system with inputs from multispectral sensor and control through “Spot Spraying Controller (SSCon)” deployed on UAS. SSCon connected with ultra high volume sprayer allowed route planning software to direct the UAS for spot application at infected cropped area or orchard trees avoiding excessive overlap or gaps in the spray patterns.
- The SSCon device on board UAS has made it a “Sensor Based Unmanned Aerial Agro-Chemical Spraying (UAAS) System”, a variable rate spraying system thus reducing cost of chemicals as well as environmental hazards.
- One provisional patent has also been filed

Way Forward/Future Strategy

- Large number of farmers are willing to use these systems (buy/service).
- The technology is available but there are some hindrances in import of some parts especially high performance batteries.
- Approvals from higher authorities regarding flying of such systems is also a hindrance in its commercialization.
- Business model for providing services and training to its users is also under consideration before starting mass scale production by the partner industry.

Fruit & Vegetable Sterilizer

Prof. Dr. Aman Ullah Malik
Dr. Raheel Anwar, Assistant Professor
Institute of Horticultural Sciences
Dr. Anjum Munir, Associate Professor
Department Energy System Engineering
Dr. Muhammad Inam-ur-Raheem, Assistant Professor
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

- Food safety is a major challenge in production and supply chain of fresh fruits and vegetables.
- Poor production practices, improper harvesting and unhygienic handling contaminate fruits and vegetables with various pathogenic microbes (bacteria, viruses, amoeba etc) and pesticide residues. Fresh consumption of such food poses a serious threat to public health.
- Complex and non-traceable production and marketing system makes it relatively impossible to decontaminate fruits and vegetables at any stage except when produce reaches end-consumer.
- Heat treatments (thermal) are not feasible since fresh fruits and vegetables cannot tolerate high temperature required to kill microbial pathogens.

Intervention/ Technology Brief

- Among various non-thermal treatments available for perishable fruits and vegetable, combined use of ozone and ultrasonic waves has been proven effective in controlling microbial proliferation and chemical decontamination.
- This hybrid technology (ultrasonic + ozone) has been incorporated in small-volume equipment to sterilize and clean fruits and vegetables making them safe for consumption.

Sterilization Treatment Effects

Outcomes

- Indigenization of the equipment (imported from China) in Pakistan to help reduce day to day food safety risk to public.
- Product development was carried out by industry partner [Koldware Industries (Pvt.) Ltd, Karachi.] in collaboration with our Lab, while performance tests were conducted at Postharvest Research and Training Centre, Institute of Horticultural Sciences and NIFSAT, University of Agriculture and pesticide residue analysis was conducted at Nuclear Institute of Agriculture and Biology, Faisalabad.
- Performance tests were made on microbiological evaluation, residual analysis of targeted pesticides and any possible change in quality attributes (taste, odour, acidity, TSS etc.) of fruits and vegetables postharvest.
- The results revealed that ozone and ultrasound technology have remarkabl reduction in microbial plate counts (Graph) and pesticide residues (Table) in tested fruits (grapes, peach, guava etc) and vegetables (chillies, tomato, cucumber and cauliflower etc).
- The locally developed unit is of equally good performance comparable to imported unit in terms of reducing microbial and chemical concentration.

Way Forward/Future Strategy

- Koldware Industries Pvt. Ltd., Karachi has established business over 3 decades, and this "Fruits & Vegetable Hybrid Sterilizer" is very relevant to their business and they would like to invest and promote the product on long term basis.

Graph: Efficacy of Ozone and Ultrasound Treatment on Peach fruit

Table: Pesticide residues in strawberry samples, control vs treated (6 min combined O_3 and Ultrasound)

Commodity	Pesticides	Control (µg/g)	Treated (µg/g)
Strawberry	Thimathoxyamil	33.75	0
	Imidacloprid	0.63	0.014
	Acetamiprid	0.01	0.005
	Carbendazim	0.15	0.061

Android Soil Moisture Meter

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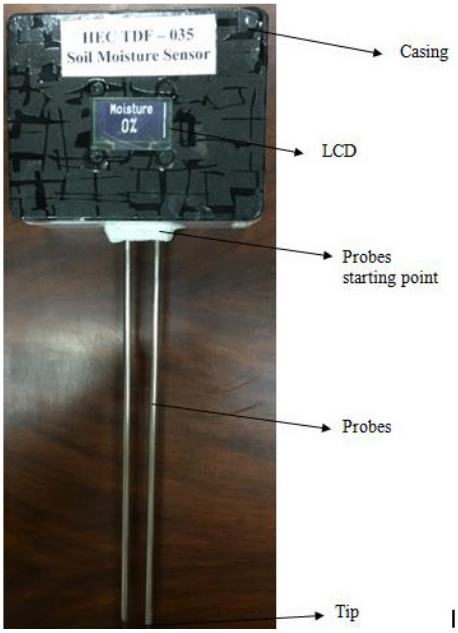
University of Agriculture, Faisalabad

Challenges/issues

- Prevailing water shortages in the country have compelled all the stakeholders to devise innovative ways for efficiently utilizing the available meager water supplies.
- Pakistan is facing both water scarcity and low water productivity issues and challenges to address these issues are to enhance water availability, as well as conserve water by reducing conveyance water losses and efficiently utilizing the applied irrigation water to the fields.
- An important challenge in this regard is to apply only the required amount of water through precise irrigation scheduling, which can be performed using soil moisture sensors for monitoring real time status of water availability in the root zone.



Intervention/ Technology Brief

- This invention / disclosure is related to Android application based indigenized two probe soil moisture meter for measuring real time soil moisture conditions in the root zone, which can be a viable option to improve water productivity through precise irrigation applications.
- The electric current (mA) measured in proportion to the soil moisture status in the root zone is converted into digital form using microcontroller (Arduino Nano / ATMEGA328) and volumetric soil moisture content (%) is displayed on LCD within ten seconds after the probes are pushed into the soil.
- At the same time, the reading is also displayed on Android equipped mobile phone. This Android based soil moisture meter has been designed and fabricated locally using steel material for probes and is about ten times cheaper than the imported ones.
- The meter has been tested in the soil pots using gravimetric method and showed results within acceptable range of accuracy of 2%. The said sensor can be a viable tool to monitor real time soil moisture at 150 mm depth in the root zone for promoting precision irrigations to improve water productivity.

Outcomes/ Input

- Initially in phase-I, soil moisture sensors from brass, copper and steel were manufactured, calibrated and validated using gravimetric method.
- Later on, these sensors were further refined in phase-II, and two probe steel soil moisture meter was developed, which was able to display soil moisture status in the root zone at the contact depth.
- This soil moisture meter was also calibrated, and validated. In third phase, soil moisture meter was coupled with Android App to further make its operation easy and quick. The latest version is equipped with two steel probes of 203 mm length, and LCD (33 x 33 mm) for displaying soil moisture data and linked with Android App on mobile phone for easy data collection

Way Forward/Future Strategy

- The development of Android soil moisture meter is a need based technology, and is a kind of pre-requisite for applying precision irrigations scheduling.
- The Directorate of On Farm Water Management (OFWM) has imported soil moisture meter, which are seven times expansive than the locally developed Android soil moisture meter.
- Therefore, there is promising potential for commercialization of the product.
- There is a plan to work with all the institutions dealing with water management such as Directorate of OFWM (Punjab), Lahore, PCRWR, NARC, IWASRI, IWMI, research institutions and universities for creating awareness as well as adaptation of the technology, which will have significant impact on the water usage in the agriculture sector for growing crops as sensor based precision irrigation scheduling can save water by 30 to 40%.

Portable Water Monitoring System

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University of Agriculture, Faisalabad.

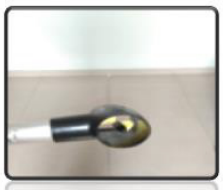
Challenges/issues

- The continuous flow measurement is important for flood forecasting and equitable water distribution.
- The methods for the measurement of discharge in an open channel are: (1) Structural Instruments; and (2) Analytical method. The former involves the usage of different types of flumes and weirs; which define discharge as a function of flow depth. Nevertheless, these instruments suffer from submergence and maintenance issue __ which limit their use. Moreover, the complicated formula for the execution of discharge can make discharge measurement an impossible task for a layman. On the other hand, analytical method, which is generally considered to be more convenient, of two methods, in application, requires the knowledge of channel area and mean flow velocity.

- The velocity parameter which is mandatory for the measurement of discharge requires the use of expensive scientific instruments (e.g., current meter or flow probe) placed at the precise flow depth for the measurement of mean velocity. However, experience suggests that the placement of instrument at the required depth can be complicated for very deep channels. Moreover, the calibrated propulsion system for the measurement of flow velocity sticks as a result of continuous usage in silt carrying water.

Intervention/ Technology Brief

- **Input:** A more convenient and perhaps the most commonly used option to measure the discharge at any desired section of the channel is velocity-area method. The method relates discharge in an open channel as a product function of channel area and velocity.



US made velocity probe fan

Our Thrust measuring device of digital Velocity meter.

Outcomes

- A discharge measurement mechanism, which converts water thrust into velocity; to find the channel dimensions; to execute the flow rate; to record the time series flow data; and to transmit the recorded data to an online source.

Way Forward/Future Strategy

- Laser-scaling on pipes for depth measurement;
- Leveller installation to allow erect insertion in water; and
- Installation of full-scale model of digital velocity meter in Canals to validate its performance.

VegeBot – Kitchen Gardening Robot

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Dr. M. Ahsan Latif, Assistant Professor
Department of Computer Science
Dr. Khurram Ziaf, Assistant Professor
Institute of Horticulture Sciences
University of Agriculture, Faisalabad

Challenges/issues

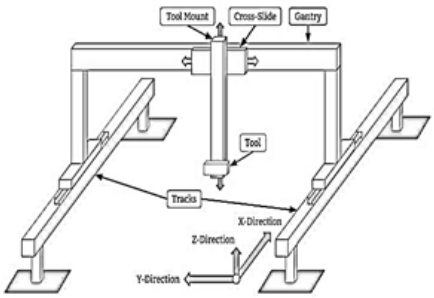
The country's vegetable yield is in decline since the last few years due to huge increase in the number of housing schemes on agriculture land in peri-urban areas, which is a great source of cheap and fresh vegetables for the urban population. The official data showed the crop wise area reduction in Lahore district from 245,926 acres to around 230,000 acres for Rabi season and 219,920 to 190,000 acres for Kharif crops from year 2010 to 2020. Abundance in population growth caused the vegetable prices to skyrocket rapidly in Pakistan and causes a threat to food security. This situation critically demands increase in vegetable productivity per unit area with fresh, organic, and good quality vegetables particularly in urban aeras. One of the prominent solutions to the above said challenge is to encourage household or kitchen gardening practices in the country as it has a vast potential for addressing the food security issues in urban areas of Pakistan. However, for the urban community, it is quite challenging and time consuming to maintain a kitchen garden in a busy schedule of the daily life. They do not have enough knowledge and training regarding vegetable selection, land preparation, seed selection, seed sowing, irrigation, crop growth, spraying, fertilizing, and harvesting.

Intervention/Technology Brief

VegeBot is a fully automated, scalable, and customizable precision farming kitchen gardening robot designed such that the urban community can grow their own vegetables without any knowledge of agricultural practices using a mobile/web app.

The main functions of the Vegebot are:

- To provide the ability to plant in a more efficient manner.
- Hardware employs linear guides in the X, Y, and Z directions that allow for tooling such as plows, seed injectors, watering nozzles, and sensors, to be precisely positioned and used on the plants.
- To provide complete environment monitoring with the help of sensors like water level sensor, temperature sensor, humidity sensor.
- To optimize the typical farming objectives such as seeding and watering, each plant can be programmed for specific water needs.
- To ensure perfect seed spacing and most efficient planting layouts.
- To provide surveillance 24 hours a day, 7 days a week.
- To provide a completely scalable setup, which allows use it for use it for backyard gardening, or large scale farming.
- To deliver a virtual accessibility for anyone, anywhere in the world.
- To equip farmers/gardeners to keep track of exact locations of seed plantings, watering, etc.
- To provide an advanced weed removal without damaging plants with precise selective tilling.



Outcomes

- A fully automated, scalable, and customizable precision farming kitchen gardening robot that enables urban community to grow their own vegetables efficiently.
- VegeBot, a totally advanced indigenous technology based on IoT, Robotics, and Artificial Intelligence with an objective to provide food security in the country.
- It helps to overcome the shortage of vegetables/food by providing pesticide free, healthy vegetables/food.
- It also mitigates the limited space and resources problems of urban areas.
- Providing a cost-effective solution for the advance food production with today's technologies.

Way Forward/Future Strategy

VegeBot is beneficial to provide fresh, pesticides free, and high on nutrients vegetables.
For the successful commercialization of the product, a startup is responsible for the following tasks.

- Technology dissemination and awareness campaign of the product through social media and other platforms.
- Managing startup/product website, online store, and inventory of the product.
- Hands on Training on the operation of VegeBot.
- Time-to-time updates and customization of the VegeBot software stack and mobile/web APP.
- Customer Support through filed/online trainings.
- Managing supply chain for after sales service of the product.
- Analyzing customer feedback for future improvement of the product.

Artificial Intelligence Based Prediction System for Textile Processing Industry

Dr. Assad Farooq, Associate Professor
Ms. Farida Irshad Lecturer
Department of Fibre & Textile Technology
University of Agriculture, Faisalabad

Challenges/issues

- Finish application on dyed fabric can result in plenty of changes in fabric characteristics including mechanical properties and color change. The most crucial of these problems is the shade change of the final fabric after the application of functional chemicals.
- This problem eventually results in lots of reprocessing to rematch the shade in dyeing and even often in rejection.
- This problem has been pestering the dyers from several years and the only possible solution is the adjustment of actual dyeing recipe on the judgment of final shade after finishing application based on their experience over the years as there is no other method to fix the shade after finishing, which has reached the point of no return.

Intervention/Technology Brief

- Artificial neural networks (ANN) are computing systems that are inspired by, but not necessarily identical to, the biological neural networks that constitute animal brains . Such systems "learn" to perform tasks by considering examples, generally without being programmed with any task specific rules.
- The core of the presented technology is to predict the shade change after application of finish by using artificial neural networks which includes the development of an intelligent predictive system to foresee the behavior of shade change after finishing application.
- This Artificial Neural Network model will help textile colorist to predict shade changes in the fabric even before first dyeing.
- The Intelligent shade change predictive system will be very beneficial for the local industry

Outcomes

- The shade predicting software is a new technological advancement developed for the use of textile wet processing industry.
- The developed software will be disseminated in the form of android application.
- The predictive system can foresee the behavior of shade after the application of certain functional finishes

Way Forward/Future Strategy

- This software will help to reduce the reprocess and rejection rate due to change in shade, hence will save the massive cost and time. Furthermore, this system is being disseminated to working staff of the industry through android application.
- This will help them taking timely decision of the dyeing recipe adjustment according to final finishing recipe.

Multi Nutrient Liquid Fertilizer (NeeRoGAH)

Dr. Junaid Nawaz Ch, Research Officer
Water Management Research Center
University of Agriculture, Faisalabad

Challenges/issues

- Unavailability of cheap fertilizer machines in local market for manufacturing of fertilizer products.
- Limited use of fertigation under drip irrigation system, causing low crop productivity, due to improper fertilizer materials and expensive water soluble fertilizers.
- Unavailability of low cost indigenous fertilizers for use in drip irrigation.

Intervention/Technology Brief

- Making of liquid fertilizer using improper machinery and without standard safety measures is very dangerous and can cause serious accidents. The proper fertilizer machines of imported brands are expensive because these machines are not available in local market. To promote the use of liquid fertilizer, there is need to manufacture these fertilizers on large scale by local investors by using cheap fertilizer machines. To address this problem, a low cost indigenous liquid fertilizer machine has been developed to reduce the cost of fertilizer unit for encouragement of local investors to purchase fertilizer machinery for production of liquid fertilizer.
- This fertilizer machine is simple in structure and saves energy and labor. The solid raw material is fed directly from funnel of the reactor. The precise and calculated amount of acid and liquid raw material is fed through Acid transfer pump. The chemical reactions are performed during mixing of raw material inside the reactor under controlled temperature and pressure. The temperature can continuously be monitored at control panel and cooling mechanism is used to maintain standard temperature inside the reactor. The agitator speed can also be changed as per chemical used in fertilizer recipe. The fertilizer is collected from drain valve for packing into cans for sale in market.
- The multi-nutrient liquid fertilizer relates to fertilizer compositions in which macro and micro nutrients are incorporated in fully mixed form. Fertilizer compositions applied to the soil to assist plant growth are often wasted to a considerable and costly extent due to fixing in soil and later on its leaching by rain or surface water directly through the soil without being able to be absorbed by the plant roots. This problem is especially prevalent with un-soluble fertilizer compounds used particularly in agricultural fields. It is an object of this invention to provide readily available fertilizer materials that contain all essential nutrients for plant growth.
- This invention “Multi-nutrient liquid fertilizer” contains sufficient amount of Nitrogen (N), Phosphorus pentoxide (P_2O_5), Potassium oxide (K_2O), Calcium oxide (CaO), Magnesium oxide (MgO), Sulphate (SO_4), Zinc (Zn), Copper (Cu), Ferrous (Fe), Manganese (Mn), Boron (B), Chloride (Cl-) and Molybdenum (Mo) in proper composition/fraction for efficient plant growth.

Fertilizer making machine installed at WMRC, UAF

Outcomes

- Development of Indigenous low cost fertilizer making machine.
- Development of multi-nutrient liquid fertilizer for use in drip irrigation system and hydroponic farming.
- Development of management schemes for production of high value crops.
- Commercialization of developed technologies in collaboration with partner industry through farmer meetings, exhibitions, farmer days etc.
- Development of dissemination material including documentaries, brochures etc.

Multi-nutrient liquid fertilizer

Acid storage tanks

Way forward/Future Strategy

- Commercialization of developed technologies on large scale
- Work on efficient and precise applications of fertilizers in field for reduction in production cost.

Acid storage tanks

Acid metering pump of fertilizer machine

Solar Continuous Roaster (SCR)

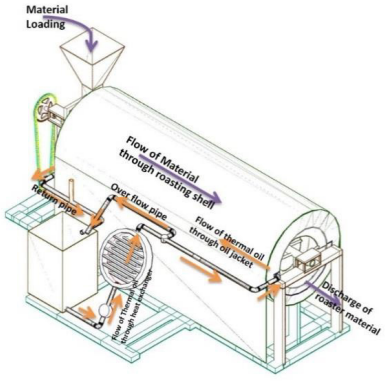
Prof. Dr. Anjum Munir,
Department of Energy Systems Engineering
University of Agriculture, Faisalabad

Challenges/issues

- It is difficult to maintain controlled roasting conditions
- Possess contamination by dirt, garbage and environmental pollution
- Un-hygienic process conditions occur during conventional roasting
- Transportation losses due to unavailability of on-farm processing facility
- Value losses due to delay in processing after harvesting

Intervention/Technology Brief

- The system includes a Scheffler fixed focus concentrator (10 m^2 surface area), a dehydration system which comprises of a feeding hopper, discharge chute and a separator for separating the roasted material and heating medium.
- The receiver is faced towards the primary heating system and thermal oil conveying mechanism (a gear pump powered by ¼ hp motor) is equipped with heat exchanger (diameter 350 mm and wall thickness of 16 mm) with casted ribs in zigzag manner.
- Then the feeding into the roasting drum (2000 mm length, 450 mm inner diameter and 6 mm wall thickness) is done with a triangular shape hopper.



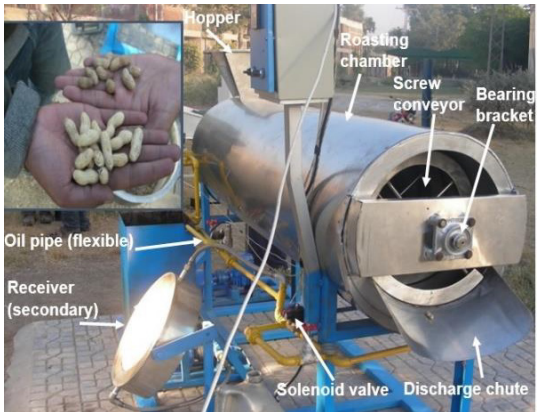
- The roasting drum is made of food grade stainless steel material. A ribbon type screw conveyor is designed inside the chamber to convey the material from feeding side to discharge side.

Outcomes

- Various agricultural commodities can be processed timely at farm level like roasting of ground nuts, peanuts, coffee and drying of seeds/grains to preserve them from spoilage.
- This technology can facilitate farming community by on-farm processing for the value addition of agricultural products.
- It is a sustainable technology with a payback period of 10500 working hours (4 years and 7 months) beyond which the roasting process will be much less than the conventional roasting system.

Way forward/Future Strategy

- Value addition is the way forward.
- This newly developed solar based processing unit is the way forward if we want to save our surplus.
- An advertisement plan would be the best way forward for technology dissemination.



Solar Dehydrator

Prof. Dr. Anjum Munir
Dr. Waseem Amjad, Assistant Professor
Department of Energy Systems Engineering,
Dr. Abdul Ghafoor, Assistant Professor,
Department of Farm Machinery & Power
University of Agriculture, Faisalabad

Challenges/issues

- Drying is a complex and energy intensive process used for the preservation of food material.
- Due to the increasing cost of electricity and fossil fuels, application of solar energy for drying of various agricultural products has become need of the time.
- It is not only economical but also ceases the gas emissions. By solar drying, huge amount of national revenue can be saved by avoiding the spoilage of agricultural products due to non-availability of conventional processing facilities

Intervention/Technology Brief

- Keeping in view the energy crises and small farming community a new solar tunnel dryer (STD) has been designed and developed at University of Agriculture Faisalabad to meet the drying needs of small farmers and small co-operatives.
- Instead of forcing air through the depth of product, it is just directed over the product spread in a thin layer.
- The distinct feature of this dryer is the use of glass windows instead of plastic material (polythene dryer) which become fade due to dust and temperature creating hurdle for the transmitting of sun rays into the collector and drying chamber. The glass can easily be washed in case of dust problems.

Outcomes

- Uniform drying of perishable fruits & vegetables with hot air.

Way forward/Future Strategy

- This technology will be disseminated among farmers for the value addition of perishable fruits & vegetables in remote areas and for generation of income.

Solar Distillation System

Prof. Dr. Anjum Munir
Department of Energy Systems Engineering
University of Agriculture Faisalabad

Challenges/issues

- The promotion of small scale agro-based industry by using innovative solar collectors can open new opportunities in rural development.
- Essential oil extraction from medicinal and aromatic plants is one of the medium temperature agro-based industries.
- These oil are used for medicinal and pharmaceutical purposes, food and food ingredients, herbal tea, cosmetics, perfumery, aromatherapy, pest, and disease control, dying in textiles, gelling agents, plant growth regulators and paper making. Essential oils are extracted from various parts of the plant like leaves, roots, wood, bark, seeds/fruits, buds, branches, twigs, etc.

Intervention/Technology Brief

- Out of all extraction methods, the distillation methods have advantages of extracting pure and refined essential oils by evaporating the volatile essence of the plant material.
- At present, there are large and centralized distillation units mostly located in city areas.
- Due to their high operating costs, these are, sometimes, unmanageable by farmers or even groups of farmers in most of the developing countries. Further, some essential oils come from extremely delicate leaves that must be processed soon after harvesting.

Outcomes

- The solar distillation system was designed as a fixed installation of Scheffler reflector (10m^2 surface area) and all parts of the reflector stand were fabricated and assembled at the University of Agriculture, Faisalabad, Pakistan.
- The Scheffler concentrator is a lateral part of a paraboloid and does not require any manual tracking during the whole day once it is set. Further, it provides a fixed focus for all the days of the year which can be best utilized during different distillation experiments.
- The solar distillation system comprises of a primary reflector, secondary reflector, photovoltaic tracking system, distillation still, condenser, Florentine vessels.

Way Forward/Future Strategy

- The on-farm solar distillation is a decentralized approach to reduce the post-harvest losses and to prevent spoilage of essential oil components by processing the fresh medicinal plants

Solar Drying Cabinet

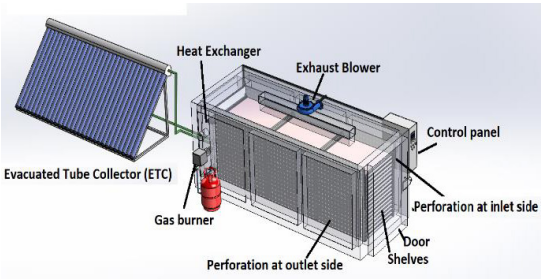
Dr. Waseem Amjad, Assistant Professor
Prof. Dr. Anjum Munir
Department of Energy Systems Engineering
University of Agriculture, Faisalabad

Challenges/issues

Mechanized and Hygienic Drying Process, Drying Heterogeneity, High heating (energy) cost, Food Security, Processing Capacity

Intervention/Technology Brief

- Capacity: 200-250 kg/batch
- Drying area: 280 ft^2 (45 W×51H×137L in inches)
- Heating source: Hybrid (Solar and gas)
- Mode of operation: Auto controlled (single or dual mode of heating)
- VFD based inlet and exhaust blowers
- No. of trolleys and trays: 03 and 45 (15 trays per trolley)
- Multi-crop handling (processing)
- Drying time increased on solar mode of heating= 20-25% compared to gas based mode of operation



Outcomes

- Heating cost can be reduced up to 30-40% (under day time solar based and night time gas based mode of operations.
- 27-30 electric unit consumed in 20 hrs drying cycle which can be saved using PV system

Way forward/Future Strategy

- This newly developed solar drawing cabinet will facilitate farmers from remote areas for value addition of their produce.

Solar Milk Chiller

Prof. Dr. Anjum Munir
Department of Energy Systems Engineering
Dr. Abdul Ghafoor
Department of Farm Machinery & Power
University of Agriculture, Faisalabad

Challenges/issues

- Pakistan is the 4th largest milk producing country in the world (34 million tons annually) while the larger proportion of producers are small scale farmers (>80%). Unfortunately, only 5% of this milk is processed while other is handled by Milkman which is mostly unhygienic at high health risks especially for the infants.
- Moreover, the farming community do not get proper price for milk due to non-availability of processing facilities at farm level. The pasteurized milk can be preserved for longer shelf life thus increasing its shelf life and marketability

Intervention/Technology Brief

- The promotion of small-scale agro-based industries for value addition and income generation using innovative solar technologies can become a multiplier in rural development.
- An energy efficient solar milk chiller has been developed as a part of research and demand of the livestock department of the Government of Punjab as well as the farming community who wish to process and store milk in the chilled form.

Outcomes

- The milk processing is a rapid growing business but high energy running cost is a serious problem.
- With solar based technology milk is chilled with cheapest source of energy which is solar energy available in Pakistan for more than 300 sunny days in a year.

Way Forward/Future Strategy

- Solar energy is the medium of energy production for this technology and the milk is cooled down to 4°C in the chiller within two hours (standard time by WHO).

Solar Based Desalination System Through Reverse Osmosis (Pv-Ro)

Dr. Abdul Ghafoor, Assistant Professor
Department of Farm Machinery and Power
Prof. Dr. Anjum Munir
Department of Energy Systems Engineering
Dr. Muhammad Usman Farid, Assistant Professor
Department of Structures and Environmental Engineering
University of Agriculture, Faisalabad

Challenges/issues

- Water scarcity problems are increasing day by day in Pakistan.
- About 1.1 billion population in the world have inadequate access to quality freshwater for drinking purpose
- The increasing world population, urbanization and industrial expansion have increased the fresh water demand throughout the world
- The water demand has increased from 2,961 to 3,420 cubic meter per capita
- In today's world, desalination of brackish water is an innovative idea to meet the demand of fresh water productivity.

Intervention/Technology Brief

- PV-RO System comprises of PV Panels, hybrid inverter, Pre-treatment unit, AC/DC pumps, RO membranes and Water Storage Tanks.
- The pumps of Reverse Osmosis (RO) driven with PV panels are the initiation of the reverse osmosis (RO) process to separate permeates from brackish water.
- To operate 500 liter per hour RO plant, an optimal sized 2 kWp solar system was coupled with an RO plant through 5 kVA hybrid inverter to keep the capital cost at the lower side.

Outcomes

- 18% of higher PV energy was obtained throughout the day using tracking of the PV system.
- 10% higher PV energy was obtained due to the cooling of PV panels as compared to no cooling.
- The cost per liter of permeate is calculated to be PKR 0.72 with payback period of 1.83 years.
- The desalination of saline water through RO coupled with PV System is very efficient in terms of money and energy consumption.
- The research is not only beneficial for Pakistan's region but also to the other island and coastal areas of the world.

Way Forward/Future Strategy

- The technology will be promoted and commercialized in collaboration with industrial partner.

Variable Height Self-Propelled Multicrop Sprayer

Dr. Abdul Ghafoor, Assistant Professor
Prof. Dr. Muhammad Azam Khan
Department of Farm Machinery and Power
Dr. Anjum Munir
Department of Energy Systems Engineering
University of Agriculture, Faisalabad

Challenges/issues

- Use of inefficient knapsack or tractor driven sprayers
- Power mismatch between sprayer and tractor
- Non-uniform and excessive spray application
- Poor spraying efficiency
- Higher fuel cost for tractor driven sprayers
- Carbon emission into environment due to diesel operated tractors

Intervention/Technology Brief

- Novel efficient variable height pesticide applicator for multicrops
- Automatic gear transmission mechanism for ease of operators
- Innovative nozzle replacement mechanism for quick replacement of various types of nozzles for better spray coverage
- Battery driven hydraulic system for easier adjustment of smart spray lance during on-the-go field operation
- One click button for quick height control of smart spray lance to ensure enhanced spray deposit density
- Provision of petrol engine instead of diesel engine to decrease fuel consumption and lower hazardous pollutants

Outcomes

- 25-30% saving of agrochemicals due to enhanced spraying efficiency
- Timely control of insect, pest etc. due to highly effective field capacity
- Opportunities for establishment of machinery centers/machinery pools
- Opportunities of entrepreneurship for young entrepreneurs/employment generation through mass production of sprayers.

Way Forward/Future Strategy

- The technology will be promoted and commercialized in collaboration with industry.

Dip & Grow

Prof. Dr. Hafiz Naeem Asghar
Prof. Dr. Zahir Ahamd Zahir
Soil Microbiology & Biochemistry
Institute of Soil and Environmental Sciences
University of Agriculture Faisalabad

Challenges/issues

- Biological approaches, along with chemical fertilizers, are plausible option to get yield up to the maximum potential. Plant Growth Promoting Rhizobacteria (PGPR) are well known to promote the plant growth in different crops, but due to submerged ecology of rice crop, there are some bottlenecks to harvest maximum benefits of PGPR. To overcome this challenge a formulation of organic chemicals and essential nutrients has been developed to supplement the plant nutritional and hormonal mechanism and to drive the indigenous microbial ecology to produce plant growth regulators and enzymes to increase the yield and nutritional status of paddy.

Intervention/Technology Brief

- Dip & Grow is a formulation of organic compounds such as plant growth regulating chemicals and certain essential nutrients. Before transplanting, nursery is dipped in this formulation and these chemicals are taken up by the plants through roots.
- These chemicals are very effective even at low concentrations. This formulation was developed after a series of laboratory, pot and field experiments.
- Consistent trials revealed that the contents of this formulation not only play a vital role in crop growth but also improve indigenous plant growth-promoting bacteria and overall soil ecology and microbial efficiency to support the plants.

Outcomes

- After undergoing research trials, this product was extensively tested on farmers' fields, and it maintained its quality by exhibiting ten to twelve percent increase in paddy yield.
- It has a high benefit-cost ratio, therefore, there will be no additional burden on the farmer and his profit will be increased as compared to his production cost.

Way Forward/Future Strategy

- This formulation has initially been developed for rice but it has potential to fill up the yield gaps of all plants/crops sown by nursery method, especially vegetable. Further crop specific features may also be added.

Uni-Grow Soil Conditioner: A Low pH Organic Product

Dr. Muhammad Naveed, Associate Professor
Institute of Soil and Environmental Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Burgeoningly increasing population is demanding amplified agricultural production that is directly associated with soil P availability which is receiving more and more attention with time. It is an essential macronutrient for plants and environmental dormancy of P is a matter of great concern as its poor availability and mobility in soil is the prime restriction in crop yield.
- In Pakistan, high pH and calcareous nature of soils ride to decrease P availability that leads towards low fertilizer use efficiency (FUE) i.e., 10-25%. An elevated price of phosphate fertilizers is making the scenario even worse. Various strategies are documented to stimulate the phosphorus bioavailability in calcareous soils such as acidified fertilizers, phosphorus solubilizing bacteria (PSB), organic matter, coated fertilizers, elemental sulfur (S°), sulfur oxidizing bacteria (SOB) etc.
- Bio-augmentation of S° and manure with SOB is an apt remedy for calcareous soils and seemly solution to enhance nutrient uptake especially phosphorus. The SOB oxidizes S° to SO4-2 and generate sulfuric acid, having ability to solubilize and convert the insoluble P compounds to plant available P. Due to rapid oxidation by SOB, more sulfuric acid is produced which solubilizes minerals and manure in addition corrects the problems of calcareous soils and improves soil properties.

Intervention/Technology Brief

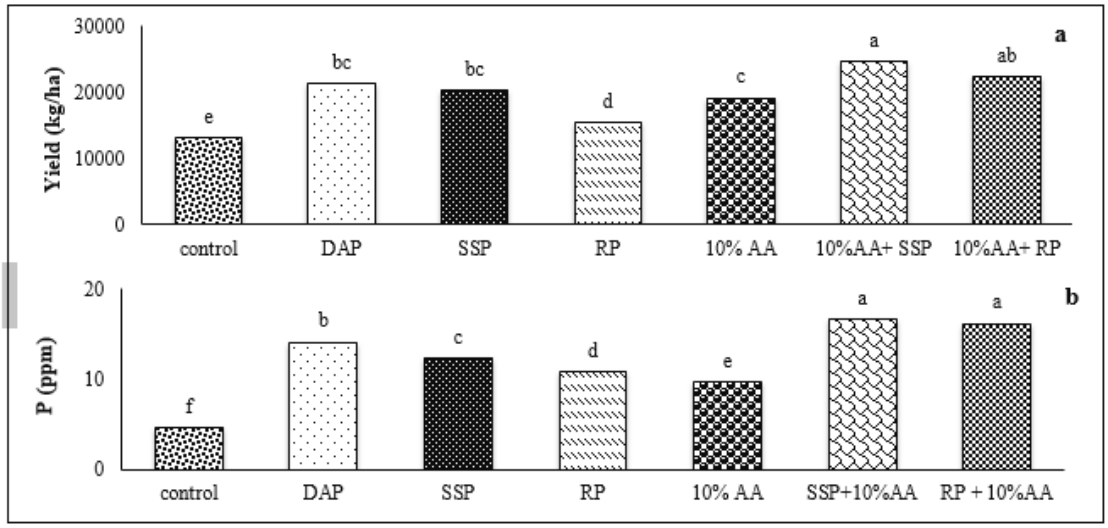
- Uni-Grow soil conditioner is an innovative biologically augmented organic product, developed for enhancing nutrient uptake (particularly P) and crop yields in calcareous soil.
- SOB were isolated and characterized on the basis of pH reduction, SO4-2 production, P-solubilization, and other growth promoting traits.
- The S° and animal manure were bioaugmented with SOB for lowering pH. This biodynamic preparation temporary provides the pH shock to calcareous soils which enhances the P-mineral solubilization in soil as well as enhances its availability to plants.

Outcomes

- Promising SOB strains have been isolated and tested for bioaugmentation of S° and animal manure to lower the pH.
- The acidulated Uni-grow soil conditioner has been tested at multi-site field trials on farmer fields and enhanced production of wheat and maize by 15-18% compared to untreated control has been recorded besides high uptake of nutrients especially phosphorus.

Way Forward/Future Strategy

This product could be used in industry for preparation of bio-organo phosphate (BOP) and single super phosphate (SSP) fertilizer, as the acid produced from oxidation of elemental sulfur could be used with rock phosphate to enhance its solubilization and availability of P in calcareous soils of Pakistan.



Plant-based Superabsorbent Polymers

Dr. Saddam Hussain
Department of Agronomy
Ms. Farida Irshad
Department of Fibre and Textile Technology
University of Agriculture, Faisalabad.

Challenges/issues

The use of biodegradable and superabsorbent polymers (BSPs) might be an efficient, sustainable and environment friendly approach to ensure the profitable cultivation of crops in marginal and stress prone areas. Application of BSPs may increase the water and nutrient holding capacity, reduce irrigation requirement, ensure uniform water consumption, facilitate rapid root growth, minimize nutrient losses, and enhance soil physical properties. Nevertheless, most of the superabsorbent polymers particularly from synthetic sources are too costly and are difficult to apply on field-scale by resource poor farmers. Moreover, synthetic polymers are not easily degraded in soil after their application, which may increase the environmental pollution. It is, therefore, inevitable to focus on the production of BSPs with enzymes, microbes and plants, which are environmentally and economically acceptable for the farming community.

Intervention/ Technology Brief

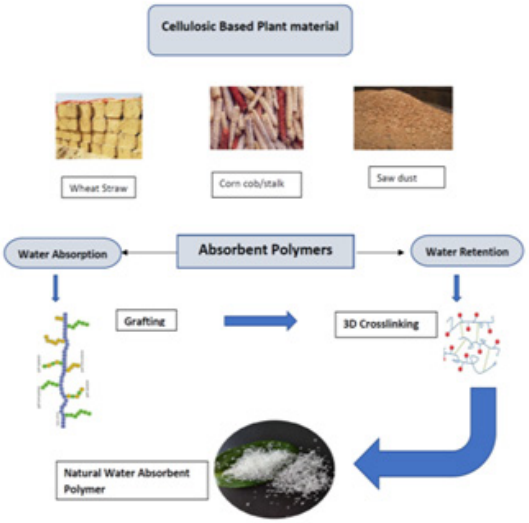
Here, for the first time, we have developed the BSPs from plant waste and tested their efficacy under drought and salinity stresses. These BSPs have been synthesized after separation of cellulosic material/monomer from corn cob, wheat straw, or saw dust, and surface polymerization in the presence of an initiator. Later, the surface crosslinking of polymerized cellulose was done in the presence of crosslinking agent to enhance its water retention.

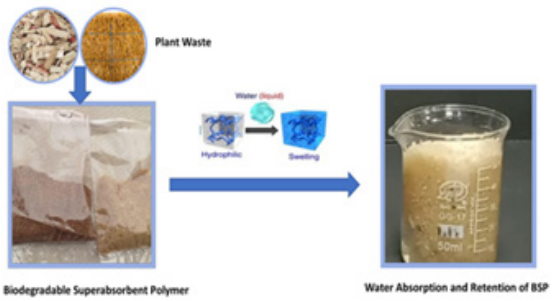
Outcomes

The developed BSPs absorbed water by 50-180 times of their weight in less than 30 seconds. In sand, water retention varied between 57-84% of absorbed water even after a period of one week. The results of pot-based trials revealed that application of the BSPs at 2g/kg soil increased the emergence and seedling growth of maize by >45% under drought stress (50% field capacity). Likewise, the seed coating (5g/kg seed) with corncob-polymers significantly increased the emergence and growth performance of wheat under salinity stress (10 dS m^{-1}). Field trials conducted under rainfed conditions also indicated better emergence and stand establishment of wheat and groundnut after seed coating with BSPs.

Way Forward/ Future Strategy

Application of novel BSPs can be used as a pragmatic approach to improve crop yield and sustain country's food security through improving productivity in marginal and stress prone areas. Moreover, exploitation of BSPs for agricultural improvement in marginal lands will significantly increase stress tolerance and reduce the use of chemical and synthetic fertilizers, thereby promoting the bio-healthy agriculture.





Effect of plant based superabsorbent polymers on maize growth after three weeks of sowing under drought stress

Burrakh-A Bacterial Bioherbicide

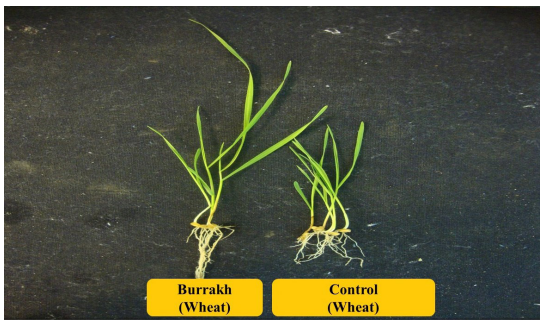
Prof. Dr. Zahir Ahmad Zahir
Dr. Muhammad Naveed, Associate Professor
Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad

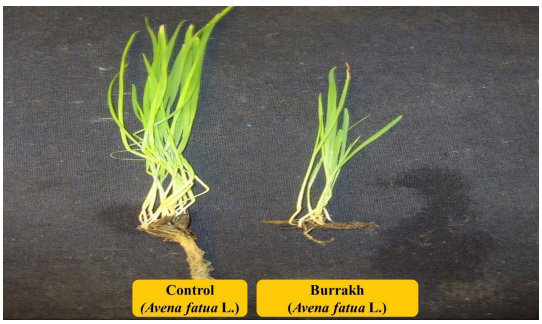
Challenges/issues

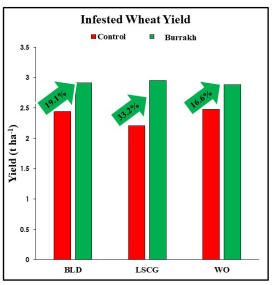
- In Pakistan wheat production decreases 24% annually by weeds which costs the national economy almost Rs. 37.9 billion. To control weeds in Pakistan farmers mostly follow physical and chemical practices.
- Physical control is expensive, labour intensive, and causes soil compaction while overuse of chemical herbicides is polluting our environment and creating herbicide resistance.
- It is now dire need to adopt cost effective and ecosystem friendly approaches for better crop production. This would be helpful for the economy of Pakistan by reducing the import bill and will ultimately secure the farmers capital by minimizing economic loss due to weeds.

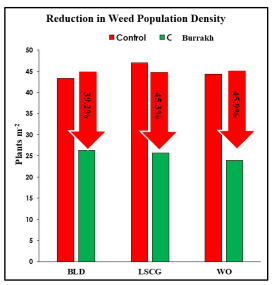
Inventions/Technology Brief

- Presently, all over the world, researchers are putting up great emphasis on the utilization of biological agents.
- Allelopathic bacteria (AB) provide an opportunity to be developed as a bioherbicide. Allelopathic bacteria suppress the growth of their host weed through multiple mechanisms.
- AB perform dual function in the rhizosphere of plants; they not only suppress the germination and growth of weeds but also promote the growth of crop plants through different plant growth promoting mechanisms. Such technology offers a novel opportunity for the development of a bioherbicide.







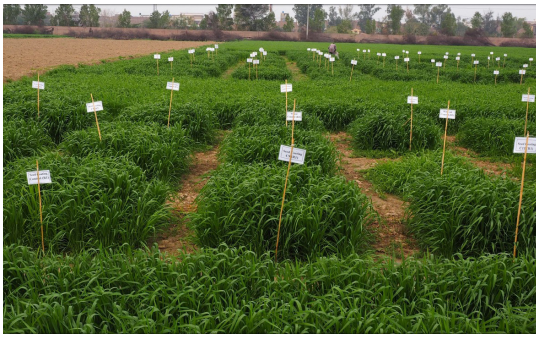


Outcomes:

- Promising strains of allelopathic bacteria were tested for reduction in weed growth and promoting plant growth in wheat to develop a microbial consortium for use as bioherbicide in wheat.
- The consortium was applied alone and in integration with reduced doses of chemical herbicides. By adopting different application methods, a series of experiments were performed under axenic and natural field conditions which have given very promising results.
- So, the allelopathic bacteria have the potential to suppress weeds of wheat and can help the farmer by reducing the doses of chemical herbicides.
- The product has been tested extensively in field and found effective for suppressing growth of wild oat, little seed canary grass and broad leaved dock.

Way Forward/Future Strategy:

- A consortium has been developed and named as "**Burrakh**" which is a carrier based product for coating on wheat seeds before sowing.
- M/S Jaffer agro services (Private) Limited has committed to commercialize this bioherbicide in a TDF project of HEC.
- A patient has already been applied.



Rhizogold Plus: A Biofertilizer for Wheat and Maize Production from Salt Affected Soils

Prof. Dr. Zahir Ahmad Zahir
Prof. Dr. Hafiz Naeem Asghar
Institute of Soil & Environmental Sciences
Dr. Sajid M. Nadeem, Associate Professor
UAF Sub Campus, Burewala
University of Agriculture, Faisalabad

Challenges/issues

- Salinity is one of the most crucial constraints limiting agricultural production around the world, including Pakistan. Pakistan has 22 million ha arable land out of which 6.67 million ha is affected by salinity.
- Pakistan is losing about 40,000 ha land annually due to salinity.
- However, utilization of such salt-affected soils is also crucial to feed the ever-increasing population of the country. Under the circumstances, it is becoming necessary to utilize sustainable techniques for inducing salt tolerance in plants.

Intervention/Technology Brief

- It has already been observed that higher ethylene concentration under salinity is harmful for plant growth. Rhizobacteria containing ACC-deaminase can decrease ethylene concentration in plants and also reduce the degree of root inhibition.

Control Rhizogold Plus

- These strains protect the wheat and maize by alleviating salinity stress and improve plant health through several traits like reduction of salinity-induced ethylene by ACC-deaminase activity, increasing K+/Na+ ratio, improving water relations of plants and production of exopolysaccharides which chelate with Na+ and thus reduce its uptake from salt affected soils.

Outcomes:

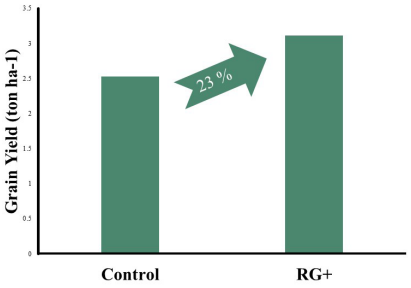
- The competency of these strains to promote growth and yield of wheat and maize has been established by conducting series of pot and field trials under salt affected conditions.
- These strains have been used to develop biofertilizer containing a bacterial consortium for sustainable production of wheat and maize from salt affected soils.

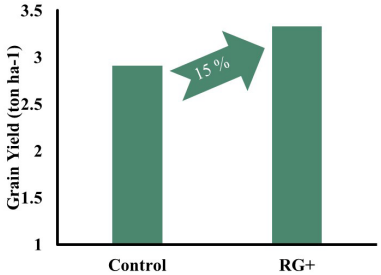
Way Forward/Future Strategy:

- The biofertilzer has been extensively evaluated on farmers' fields in different projects.


Rhizogold^Plus
Control


Rhizogold^Plus
Control


Grain Yield (ton ha-1)
23 %
Control
RG+


Grain Yield (ton ha-1)
3.5
3
2.5
2
1.5
1
15 %
Control
RG+


Rhizoçold
A multi-strain biofertilizer
for production of cereals from salt affected soils
JAFFER
Plus

Rhizogold: A Bio-fertilizer for Legume

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Challenges/issues

- Legumes are economically important and third largest plant family. Pulses have a crucial role in human diet due to its vegetable protein Protein is an essential component of human diet.
- Pulses are called “meat for poor”. The reasons behind the low production of pluses in Pakistan are cultivation of pluses in marginal and rain fed areas, low yield potential of varieties, absence of sound seed program, stresses of rain fed conditions, inadequate plant stand, poor agronomic practices, damage from diseases, insects and pests, socio-economic conditions, poor nodulation and growth which ultimately leads towards low yield

Inventions/Technology Brief

- Rhizogold is a multi-strain biofertilizer developed from different bacteria containing ACC-deaminase. This is perhaps the only biofertilizer in Pakistan which has been developed by the use of multi-strains of bacteria containing ACC-deaminase alongwith rhizobium

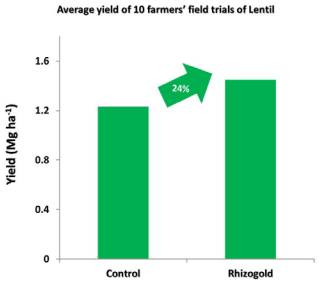
- These strains have been isolated from specific legumes, characterized and identified in the Soil Microbiology and Biochemistry Lab, Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad

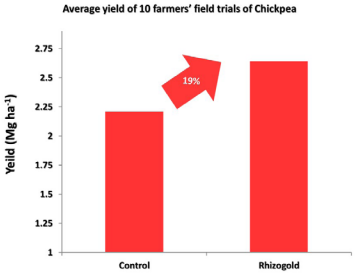
Outcomes:

- The competency of the Rhizogold has been established by conducting field trials at various locations in the Punjab.
- Rhizogold improves the growth, nodulation and yield of legumes through several traits like reduction of ethylene by ACC-deaminase activity, phosphate solubilization, root colonization, hormone production, pathogen suppression and nitrogen fixation

Way Forward/Future Strategy:

- Rhizogold increases the yield of its respective legume up to 20-25% even on marginal lands.
- Currently this product is available for chickpea, lentil and mungbean
- This may also reduce the use of chemical fertilizers and this may significantly save the farmer's input expenses.





Biostimulant Based Liquid Fertilizer

Prof. Dr. Muhammad Yaseen
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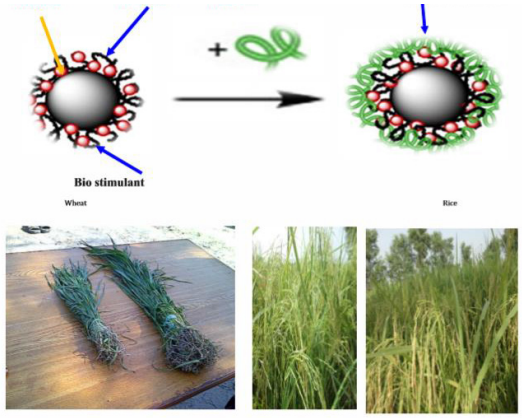
Challenges/issues

- Nutrient deficiencies and nutrient imbalances occur due to low organic matter and alkaline calcareous nature of Pakistani soils.
- These factors reduce availability of nutrients in soil, which results in low use efficiency of applied fertilizers and reduction in crop yields. The situation demands to develop innovative fertilizer product decorated with some nutrient activators to keep nutrient available



Intervention/Technology Brief

- A phenolic and activator based liquid fertilizer containing 8-8-15% NPK has been developed.
- It works as a fertilizer supplement and improves efficiency of soil applied fertilizers.
- When this product is supplemented with soil applied fertilizers, it not only keeps nutrients in available form for longer periods but also makes easy access of plant roots for absorption.
- Three liters of liquid fertilizer are applied with one irrigation and two applications are done one month after the first application.

Outcomes

- Two applications are sufficient for wheat, rice, maize and vegetable crops while for sugarcane and orchards, three applications are recommended.
- Activator Application of this fertilizer with recommended rates of fertilizers boosts up the crop yield up to 30% by improving tillering, seed setting and providing protection against most of the biotic (some soil borne diseases & insect attacks) and a-biotic stresses.

Way Forward/Future Strategy

- The product is getting attention of the farmers from the Punjab, Sindh and KPK. The product has been commercialized by industry.

Uni-Micropower

Prof. Dr. Muhammad Yaseen
Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Micronutrients play an active role in the plant metabolic processes. Decrease in availability of micronutrients in soils and their limited uptake by plants due to alkaline and calcareous nature of soil has widened the gap between potential yield and farmer's average yield of a crop.

Intervention/Technology Brief

- To narrow down the yield gap, foliar feeding of micronutrients has emerged as an innovative technology as it can be 10 to 20 times more efficient than soil application. However, this efficiency is not always achieved in actual practice due to unfavorable weather and improper formulation and application techniques.
- Therefore, judging what foliar material to apply, when to apply and how to apply are important principles to make best use of this technique. The addition of bio-stimulant to micronutrient formulation is effective to maximize feeding efficiency of foliar spray.
- Demonstration trials were conducted on farmer's fields of nine villages at Toba Tek Singh. Foliar feeding was supplemented with farmer's soil applied fertilizers which was taken as control. Multinutrients foliar feeding spray contained 4.7% Zn, 2% Fe, 1% B, 2% Mn and 0.3% Cu amended with one bio-stimulant and surfactant

Outcomes

- This spray was applied at rate of 500, 1000 and 1500 mL per acre in splits on wheat and cotton crops without disturbing farmer's followed agronomic practices.
- Comparative results on growth parameters of wheat and cotton between sprayed and unsprayed plots were shown to mass gatherings of farmers and surrounding areas by holding farmer's field days.
- The product was registered as Uni-Micropower.

Way forward/Future Strategy

- This product will be commercialized at large scale to reduce the use of imported liquid fertilizers.

New Premium Quality Mango Genotypes for Extended Harvest Season

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Institute of Horticultural Sciences
University of Agriculture, Faisalabad
Prof. Dr. Ishtiaq Rajwana
MNS-University of Agriculture Multan

Challenges/issues

- Mango is an important tropical to sub-tropical fruit. It is admired globally for its delightful taste, flavor, aroma and diuretic properties. It has a unique position in Pakistan's fruit industry. It has been cultivated in subcontinent from centuries.
- At present, mango industry in Pakistan revolves around few commercial cultivars. These cultivars offer low yields, narrow harvesting window, alternate bearing and certain other physiological disorders.
- Most of the commercial varieties of mango grown in Pakistan are mid season maturing i.e. from mid-July to mid-August, which asks for the introduction of new early and late season maturing varieties that will boost mango export from Pakistan.
- Mango industry is also affected by various insect-pests and diseases such as mango leaf hopper, mealy bug, midge, fruit fly, anthracnose, powdery mildew, malformation and decline.
- Occurrence of Mango Quick Wilt Disease (MQWD) (Ceratocystis manginecans) in various commercial mango producing areas of the country is also a serious threat.

Intervention/ Technology Brief

- Pakistan is naturally blessed with a wide range of unexplored indigenous mango germplasm. There was a need to evaluate and exploit the potential of this existing unexplored mango germplasm in the country.
- Therefore, a comprehensive study (Funded by PARB-150 Mango Project) was carried out to characterize and evaluate over five hundred mango germplasms/accessions on the basis of physical and bio-chemical fruit quality characteristics available in the districts of Azad Jammu & Kashmir (AJK) and Northern and Southern Punjab.
- Data revealed that some of the selected indigenous mango accessions such as MLT-239, MLT-240, MLT-248, MLT-369, MLT-658, KHW-250, KHW-251, RYK-265, RYK-426 and RYK-644 exhibited excellent physical and bio-chemical fruit quality characteristics.

Outcomes

- These selected accessions have shown potential as future commercial mango cultivars of Pakistan. We have released ten new mango accessions that can be future commercial cultivars of the country.

Way forward/Future Strategy

- This will help to diversify the mango industry that currently relies upon limited commercial mango cultivars. It will also help to widen the market window in the domestic and international markets.

Herbicide-tolerant (CABB-HTS) and Insect-resistant (CABB-IRS) Sugarcane

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Prof. Dr. Iqrar Ahmad Khan
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Dr. Ghulam Mustafa, Associate Professor
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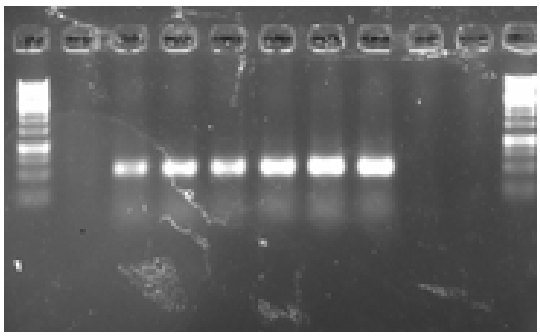
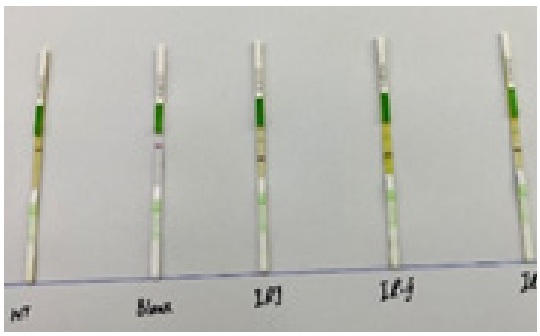
Challenges/issues

- Weeds and insect pests particularly borers are major yield limiting agents in sugarcane.
- Weeds cause up to 25% whereas insect pests cause up to 40% reduction in the cane yield.
- Excessive use of herbicides and insecticides, not only increases input cost but is also contaminating our environment including soil and water.
- Despite all inputs, yield losses due to weeds and borers are high.

Intervention/Technology Brief

- Developed transgenic plants against non-selective herbicides and borers as more than 80% of the commercialized transgenic crops are either herbicide tolerant or insect resistant.
- Glufosinate is the most effective non-selective herbicide that can be used to kill all types of weeds.
- *Bacillus thuringiensis* is a valuable insecticidal bacterium and more than 23 million hectares cry engineered crops are growing in the field for insect pest resistance.





Confirmation of transgene integration and expression of recombinant protein

Outcomes

- CABB-HTS sugarcane plants have tolerance against field dose of non-selective herbicide 'Basta' so can be effectively used to kill weeds without any damage to the crop.
- CABB-IRS sugarcane has resistance to lepidopteran insect pests.

Way Forward/Future Strategy

- Herbicide-tolerant (CABB-HTS) and Insect resistant (CABB-IRS) sugarcane have full potential to boost sugarcane yield with reduced use of chemical pesticides.
- Primary and secondary sugarcane seed will be prepared using Smart GreencaneTM Technology.

Basta sprayed CABB-HTS & Wild-type plants

CABB-IRS & Wild-type plants

Anti-fungal Transgenic Sugarcane

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Challenges/issues

- *Colletotrichum falcatum* is the most noxious fungal pathogen of sugarcane that may reduce cane-weight by 29% and sugar recovery by 30%.
- Conventional disease control methods are not effective so development of transgenic plants for resistance against fungal pathogens has great potential to culminate these pathogens.
- Abiotic stresses are also posing serious threats to crop production particularly under rapidly changing climatic conditions.

Intervention/Technology Brief

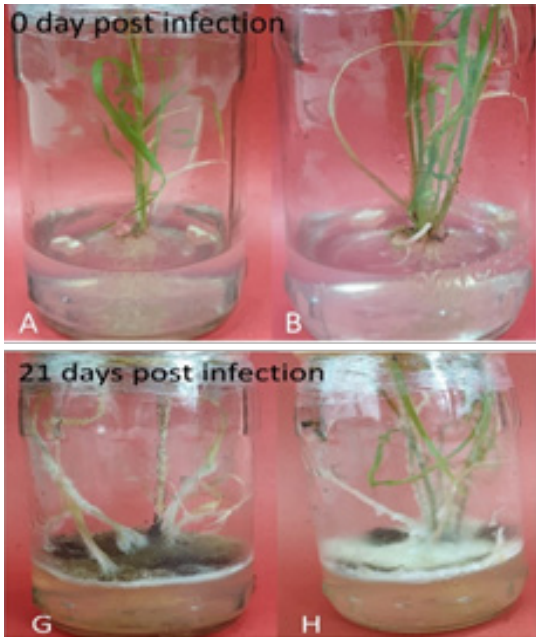
- Transgenic technology has proved its worth and area under biotech crops has reached to 191.7 million hectares
- SUGARWIN Proteins have chitinase, chitosanase and ribonuclease activity and are very effective against *Colletotrichum falactum*.
- Over expression of these proteins in plants can improve their ability to tolerate pathogen infection.
- Scdr1 plays key role in scavenging ROS (reactive oxygen species), enabling plants to tolerate drought, salinity and oxidative stresses.

Outcomes

- Recombinant SUGARWIN gene containing transgenic sugarcane plants are developed that are resistant to fungal pathogens.

Way Forward/Future Strategy

- After further screening and analysis, disease resistant sugarcane will be available for field plantation.
- Transgenic sugarcane expressing recombinant scdr1 has also been developed. These plants have potential to perform better under abiotic stresses.



Fungal bioassay of the transgenic sugarcane lines in order to assess their anti-pathogenic activity

Insect-resistant Chloroplast Transgenic Potatoes

Dr. Faiz Ahmad Joyia, Associate Professor
Prof. Dr. Muhammad Sarwar Khan
Centre of Agricultural Biochemistry and Biotechnology (CABB)
University of Agriculture, Faisalabad

Challenges/issues

- The *Bacillus transgenesis (Bt)* toxins are employed to control insects, but low levels of expression and pollen-mediated transgene dispersal have developed resistance in insects.
- High transgene expression levels, simultaneous expression of multiple proteins from polycistronic mRNAs, stable transgene expression due to the absence of epigenetics interference, and, most importantly, transgene containment due to the maternal inheritance of the chloroplast genome are all advantages of transplastomic technology (engineered plastids).
- As a result, in order to generate environmentally acceptable insect-resistant potato lines, a transplastomic method was developed and used in this research study.

Intervention/Technology Brief

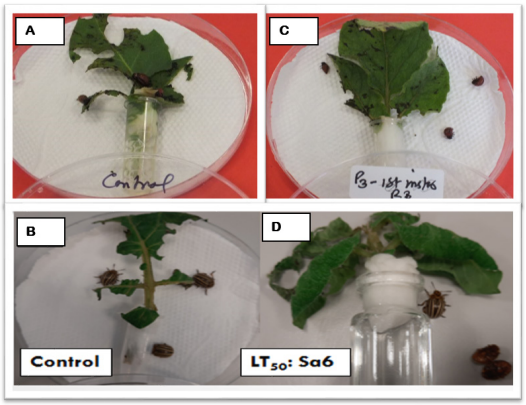
- Taking sequences of receptor binding sites from Bt-resistant insects as targets, novel Bt genes were designed using bioinformatics tools and synthesized commercially.
- The synthetic genes were used to develop insect-resistant potatoes. The resultant potatoes were analyzed using molecular tools and challenged through insect bioassays.

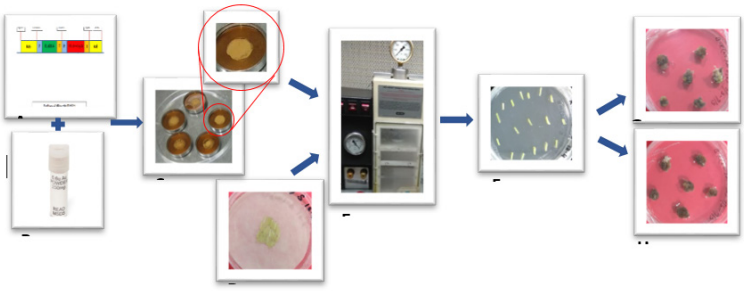
Outcomes

- Transgenic potatoes are resistant to Colorado Potato Beetle (CPB). Higher mortality rates were observed in 1st instar larvae than in the 2nd instar and adult insects, confirming the strategy as a superior insect control approach.

Way Forward/Future Strategy

- An environmentally-friendly approach to controlling insects that could be extended to other crops. Furthermore, the established protocols are being used to address the Early and Late Blight of potatoes.





Subunit and Biopeptide Vaccines against Livestock and Poultry Diseases

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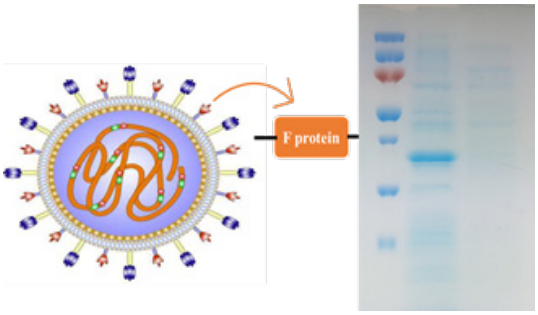
University of Agriculture, Faisalabad

Challenges/issues

- Livestock and poultry industry are among the major contributors to food security and the economy of developing countries. Several viral infections curtail their productivity. Foot and Mouth Disease (FMD) in livestock and New Castle (ND) virus in poultry results in high morbidity and mortality in the infected herd and flocks, respectively.
- Several live and inactivated vaccines are available commercially that can reduce mortality but are unable to prevent infection, virus shedding, and transmission. Recombinant subunit vaccines could prevent virus infections and significantly improve vaccine safety.



Intervention/Technology Brief

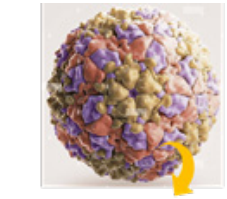
- A biopeptide vaccine is developed against the ND virus and is being evaluated/tested for dose-dependent immunogenic response in chicks.

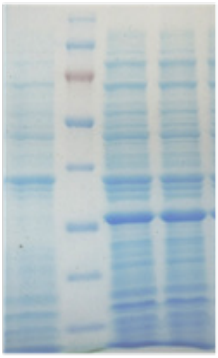
Outcomes

- The plant-based vaccine using empty capsid against major serotypes (O and Asia-1) circulating in Pakistan is developed. Furthermore, a Biopeptide-based vaccine is developed against FMD.

Way Forward/Future Strategy

- Animal testing will be carried out after the NBC approval as far as plant-based vaccines are concerned.





Overexpressed Vp1 protein in *E.coli*

UAF-Gro: A Low Cost Indigenous Soilless Organic Substrate

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Challenges/issues

- Use of agricultural by-products in horticulture is increasing day-by-day and nursery growers are trying to find a good soilless substrate for high quality containerized plants.
- However, so far, majority of nurserymen in Pakistan are using garden soil or silt for containerized plant production.
- Garden soil, on account of soil borne diseases and weed seeds, poor aeration, nutrient availability and water holding capacity, pose quarantine issues and is not suitable for quality containerized plant production.
- Moreover, import of natural soil associated with seedlings and plants is prohibited in all countries.
- Most of the nurserymen in Pakistan either use soil/silt for soil based plant production or use peat moss for soilless containerized plant production, which is expansive, unsustainable and is not readily available throughout the year.
- Therefore, export of containerized plants is negligible due to non-availability of cheaper substrate(s) in Pakistan.

Intervention/Technology Brief

- Soilless containerized plant production is globally recognized for its ability to support efficient and intensive horticultural crop production.
- Recently, an understandable focus is on renewable agricultural, industrial and municipal wastes based on their cost and easy availability for extended periods.
- Soilless substrate is the key element for producing superior quality containerized plants, which should have good water holding capacity, aeration and nutrient availability, should be free from soil borne diseases and weed seeds and should provide good anchorage.
- Pakistan being an agricultural economy produces millions of tons of agricultural wastes annually across the country, but unfortunately, a major part of these agricultural wastes is burnt or left unattended, leading to environmental pollution.
- Majority of the nurserymen use soil or silt for containerized plant production, which poses several problems due to poor water holding capacity, porosity and abundance of weed seeds and soil borne pathogens.
- On the other hand, imported materials are expansive, unsustainable and not readily available in bulk quantities.
- Therefore, a local low cost soilless organic substrate has been developed for high quality containerized plant production.
- To develop this novel indigenous organic local soilless substrate, different locally available agricultural wastes were tested, which were cost effective and easily available.
- Product development and evaluation was carried out at Institute of Horticultural Sciences and commercial nurseries, Pattoki, Kasur.
- Locally available agricultural wastes were collected, cleaned from debris, shredded to uniform particle sizes, composted at UAF designed composter at a set temperature & pressure for specific duration, value added and pasteurized to kill detrimental microbes.
- Different components were mixed in specific ratios in a mixer, evaluated for physico-chemical characteristics and packed for marketing.
- Newly developed substrate was tested and compared with other available substrates and have been found equally efficient for containerized plant production.

Outcomes

- Availability of a low cost indigenous soilless organic substrate for containerized plant production, which is comparable to other imported and locally available substrates.
- Recycling of agricultural wastes to reduce pollution and development of eco-friendly organic soilless substrate for high quality containerized plant production.
- Enhancement of export of local containerized plants to nearby global markets.

Way Forward/Future Strategy

- UAF-Gro, being economical and indigenous soilless substrate, has proved equally effective as other imported substrates. It is being commercialized with the industry in order to fulfill demand by the local nurserymen and horticultural crop growers.
- Product formulation will be further modified to make it crop specific for different horticultural crops.
- Publicity and marketing of the product at national level will be done through extension events and advertisement.
- Being almost five times cheaper than imported materials, it will lower cost of production and will enhance profitability of nurserymen and also increase country's horticultural plant exports.

New Specialty Cut Flowers for Diversification

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Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Pakistan cut flower industry is characterized by small scattered landholdings, use of old cultivars with out-dated techniques to grow flowers, and very limited commercial cut flower choices.
- Among cut flowers, local markets are dominated with only roses, gladioli, tuberoses and marigolds, which has resulted in stagnant growth of cut flower industry and subsistence agriculture for making livelihood of the flower growing families.
- Currently, there are limited cut flower crops with few flower colors available in the country.
- Cut flower imports have risen many times since the last decade which needs to be replaced with good quality local production.
- Local cut flower production need to be promoted to support local growers and to fulfill aesthetic needs of consumers.
- There are no cut flower exports currently from the country, which need to be enhanced to fetch reasonable share from global flower trade.

Intervention/Technology Brief

- With change in lifestyles and trend of saying with flowers, demand for diverse types of cut flowers has increased several folds in the country within last decade, which has necessitated to add more cut flowers in existing pattern.
- Several value chain management opportunities have also developed in the region in context of one road one belt, to benefit our economy and to fulfill aesthetic needs of the people.
- Several new cut flower crops, viz. stock, sunflower, China aster, delphinium, lisianthus, celosia etc. were evaluated for their suitability to be produced locally.
- Production and postharvest protocols of these selected annual cut flower crops has been optimized and are being produced commercially in Punjab region.
- Local growers who do not have knowledge and access to advanced harvest and handling techniques and are not aware of standards for export of flowers to international markets, have been trained for their local production.
- Production of these comparatively cheaper and easy to grow flowers would not only save foreign exchange but also increase our flower exports to global markets thereby improving economic livelihood and capacity building of the stakeholders.

Outcomes

- Among tested specialty cuts, stock, delphinium, sunflower, Chinese aster and celosia proved promising species, which are now commercially grown in Punjab.
- Among others, lisianthus, dahlia, campanula, ornamental kale and snapdragon have potential to be included in our production line for diversification of our cut flower industry.
- Cultivar selection and good quality seed procurement are most important components for these new crops production.
- Increase in area under high value cut flower crops and improve profit margin per unit area for the growers and stakeholders.
- Lower import bill currently used on import of cut flowers in the country to fulfill local demand.
- Improve business of allied stakeholders, like seed/bulb importers, packaging industry, pesticide and fertilizer industry, substrate industry and transportation industry.
- Comprehensive training program for the growers and stakeholders for popularizing these new flower crops, which are much cheaper than many bulbous cut flowers grown in the country and have similar quality and vase life.
- Tested exotic cultivars/species are well suited for diversification of cut flower industry in Punjab, Pakistan
- Annual specialty cuts are cheaper with shorter crop period.

Way Forward/Future Strategy

- More crops and varieties will be added to further diversify and evaluate their adaptability in various agro-climatic conditions.
- Publicity and marketing at national level will be done through extension events and advertisement.

Rosa centifolia UAF: A High Yielding Rose Strain for Value Addition

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Prof. (R) Dr. Muhammad Aslam Khan
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Low returns, poor productivity and marketing problems in subsistence agriculture have created social crests and financial problems for the small growers with limited resources.
- Historically, in the sub-continent, flowers were praised among people traditionally but with passage of time, transition is seen from passion oriented floriculture to business oriented.
- Among leading flowers, roses are one of the nature's most beautiful gifts to mankind, which are traditionally used for expressing or exhibiting the innermost feelings to the beloved ones or complimenting any one or versifying any conceivable emotion.
- Roses are commonly grown for ornamental purposes; however, there are some Rosa species, which have fragrance in their petals, produce best quality essential oil and are highly valuable in cosmetics and pharmaceutical industries.
- However, Pakistan floriculture lacks value addition and indigenous Rose species flower either only once or twice in a year and have low yield with poor quality oil contents.
- Our indigenous roses either have low flower productivity with shorter blooming period (*Rosa damascena*) or have average quality essential oil contents (*Rosa bourboniana* and *Rosa grussanteplitz*).

Intervention/Technology Brief

- Floriculture is an ancient farm activity with immense potential for generating remunerative self-employment among small and marginal farmers.
- A new strain of *Rosa centifolia* has been developed at Institute of Horticultural Sciences, University of Agriculture, Faisalabad, which produces profuse flowering throughout year particularly during hot months at high temperature of around 40°C.
- Its production and essential oil extraction technology has been optimized and is recommended to growers for mass production and value addition, because it:
    - Profusely flowers throughout year.
    - Produces bunches of pink, fragrant flowers and continues flowering at temperatures higher than 40°C.
    - Produces heavy flushes from March to November bearing 500-600 flowers/plant/annum.
    - Has productive life upto 12-15 years.
    - Yields best quality essential oil comparable with that of *Rosa damascena* (indigenous rose species).
    - Yields best rose water which maintains taste/freshness for longer periods than commercially available products in the market.
    - Produces better rose jam than of *Rosa chinensis* (Surkha) commercially used in the country which is best suited for value addition and product development/processing.
- Thus, cultivation of this new rose for the production of essential oil and value added products seems to be a viable option to increase farmer's income and export earnings of the country.

Outcomes

- Availability of a new strain of *Rosa centifolia*, which profusely flowers for most time of the year and has higher flower yield than all locally available roses.
- Availability of a commercial rose species, which is best suited for commercialization and value addition.
- Conservation of perishability of rose petals through value added by-product development like rose water, rose oil, rose jam etc. for later use and export.
- Availability of value added dried rose buds and petals for export to global markets.

Way Forward/Future Strategy

- *Rosa centifolia* UAF, being high yielding strain, is being commercialized in order to fulfill demand by the local rose value addition industries.
- Optimization of quality standards for value added products developed from *Rosa centifolia* for export.
- Publicity and marketing of the value added rose by-products at national level will be done through extension events and advertisement.

‘Golden Princess’ & ‘Golden Beauty’ Calendula: UAF registered Varieties

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Dr. Khurram Ziaf, Assistant Professor
Institute of Horticultural Sciences,
University of Agriculture, Faisalabad

Challenges/issues

- Pakistan floriculture industry is characterized by small scattered landholdings, use of exotic or old cultivars with out-dated techniques to grow flowers, and very limited local flower seed production.
- Among potential flowers for value addition, calendula is a potential, quite easy to grow and long lasting flower crop, which can be successfully grown in Pakistan.
- There are no local flower varieties yet registered for commercial production and multiplication, which can be grown for getting higher flower yields to be used for value addition.

Intervention/Technology Brief

- Due to its profuse flowering, hardiness and allied uses for value addition, calendula strain selection was started at UAF during 2012-13, and six strains were identified from a mixed ‘Local’ variety.
- These strains were selfed for six years and in each generation roguing (removal of off-type plants) was performed at flowering stage and plants showing small sized flowers, different flower shapes or petal whorls were discarded every year.
- Two best strains, viz. ‘Golden Princess’ and ‘Golden Beauty’, which are medium duration strains, were selected on the basis of their flower yield and other characteristics.
- ‘Golden Princess’ bears elegant double orange flowers with multiple whorls of ray florets and black central disc and has hardy stem (suitable to be used as cut flower as well) having large size bloom comparable to available hybrids in market.
- ‘Golden Beauty’ has graceful semi-double yellow flowers with black center and hardy stem (suitable to be used as cut flower as well) with medium size bloom having bright color and can be grown as alternative of ornamental sunflower & marigold.
- Both strains can be used as specialty cut flower as well as for value addition to be used in cosmetic industry.
- Indigenous seed production of these comparatively cheaper and easy to grow calendulas would not only save foreign exchange but also decrease their cost of production and availability of raw material for cosmetic industry thereby improving economic livelihood of the flower growers.

Outcomes

- Among tested strains, ‘Golden Princess’ and ‘Golden Beauty’ have been registered by FSC&RD and their seeds are being multiplied for commercial cultivation in Pakistan.
- These varieties will add up to a new specialty cut flower crop for diversification of local cut flower industry and provide raw material for cosmetic industry.
- Indigenous seed will be available at lower prices to grow more flowers in urban and peri-urban areas.
- Lower import bill currently used on import of flower seeds in the country to fulfill local demand.
- Improve business of allied stakeholders, like seed importers, substrate industry and transportation industry.
- Newly developed registered varieties of calendula are insect/pest and disease resistant and are well suited for cultivation in Pakistan.

Way Forward/Future Strategy

- More varieties will be developed to further diversify and evaluate their adaptability in various agro-climatic conditions.
- Publicity and marketing at national level will be done through extension events and advertisement.

Golden Princess

Golden Beauty

Controlled Atmosphere Technology for Storage of Fresh Fruits & Vegetables

Prof. (R) Dr. Aman Ullah Malik
Dr. Muhammad Amin
Dr. Omer Hafeez Malik
Prof. Dr. Ahmad Sattar Khan
Dr. Abdul Rehaman
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Horticultural produces are highly perishable. Maintaining quality and shelf life extension is always challenging. Due to this reason, fruits and vegetables have a limited market window, and their prices actuate from low to very high depending upon their season and supply.
- Worldwide apples are predominantly stored using controlled atmosphere technology and are available almost round the year with good quality. We have excellent quality apples, but under ordinary cold storage, they quickly lose crunchiness due to heavy loss of moisture (weight loss) and also start developing rots, within couple of months.

Intervention/ Technology Brief

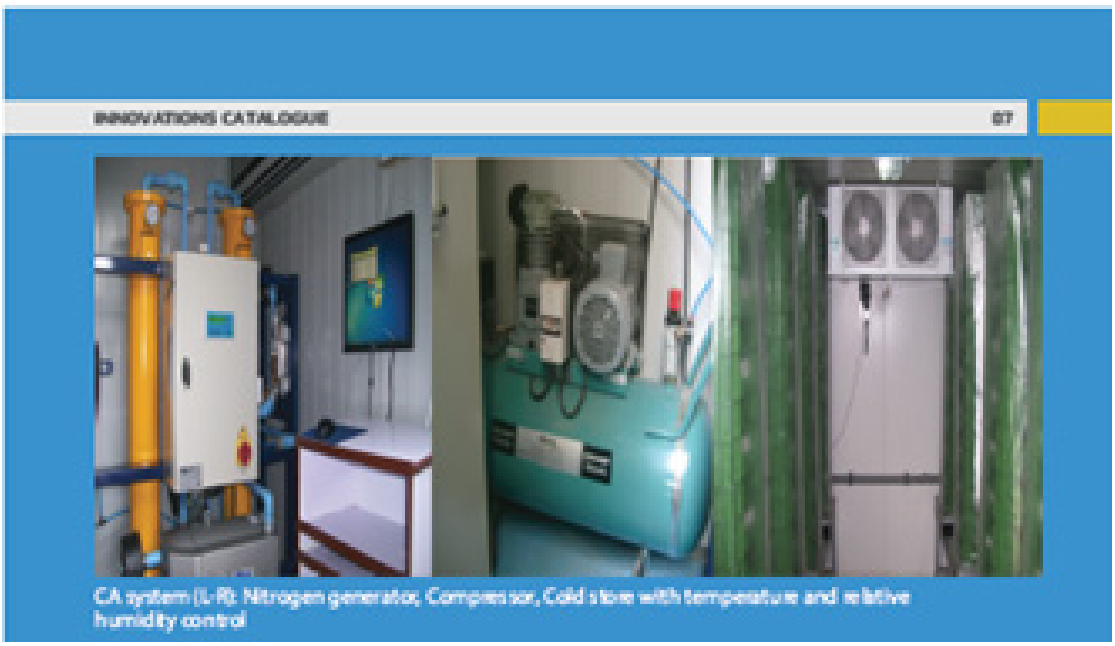
- Recent advancements in storage technology have provided option of the controlled atmosphere (CA) storage system which extends the useful marketing period of the fresh commodities during storage, transport and distribution with maintained quality and nutritive or market value.
- CA storage involves precise control of gaseous composition (oxygen and carbon dioxide, ethylene), besides low temperature and high humidity control around the fresh produce to reduce rate of respiration and ethylene production
- CA experiments have been conducted to suggest optimum conditions for different CVs of Apple, Mango and Chilies.

Outcomes

- Good handling practices along with the use of CA storage certainly help to extend shelf life. However, it is important to understand that the quality of fruits and vegetables at the time of storage is extremely important since CA-storage can only maintain quality and reduce the deterioration.
- So, good quality fruits and vegetables should be selected which are free from injuries, and insect pest or disease attack etc. and processed, packed as per standard procedures. Institute of Horticultural Sciences introduced the modern controlled atmosphere technology in collaboration with a Dutch company (Van Amerongen CA Company) and conducted necessary R&D under Punjab Agricultural Research Board (PARB) Project
- Postharvest disease especially, stem end rot needs to be managed with pre & postharvest management for its successful shipment to markets requiring more than three weeks of overall postharvest life (harvest to retail).

Way forward/Future Strategy

- CA storage is being commercially used worldwide to store a number of other crops including pomegranate, cabbage, garlic, pear, etc.



Changing Cultivars in Existing Citrus Orchards through Top Working

Prof. Dr. Muhammad Jafar Jaskani
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- The world citrus industry is diversified and has a wide market window of 6-8 months.
- Pakistan's citrus production is Kinnow based, a late maturing and seeded cultivar with a market window of 3-4 months. However, low seeded Kinnow strains are now available which have high demand in local and international market.
- Hence varietal diversification and changing citrus trees to a different variety are necessary to meet market demands and for sustainable citrus industry in Pakistan.
- Establishing new low seeded Kinnow orchards is long term planning and needs millions of nursery plants, which are not available.
- There is high demand of seedless nursery plants but it is hard to meet the growers demand. Similarly new exotic citrus varieties have been made available in UAF through ACIAR Citrus Project to extend citrus market window.
- These cultivars also need to be evaluated in different localities prior to recommend as new commercial citrus cultivars.
- Orchard establishment is a long- term investment. It is difficult to convince growers for replacing orchards (low quality fruit with less production) with new plantation (seedless
- Uprooting productive plants is direct economic loss to the growers. Therefore, a rapid system is required to establish trees which take minimum time to start fruit bearing. Top working is a successful tested technology to change varieties with market demand. Keeping this problem in view, the Institute of Horticultural Sciences has developed and standardized the Top Working technology to replace existing orchards with low seeded Kinnow or new exotic citrus cultivars

Intervention/ Technology Brief

- Top Working is the best solution to change varieties in existing orchards which become productive earlier than new plantings.
- The other advantages of top working include the replacement of old, unproductive, diseased and inferior cultivars in short time period
- The strong, well established root system of the existing tree helps to produce rapid re-growth of the new scion
- A quick return to full production with good crops is achievable in 3 to 5 years.

Outcomes

- Budwood is maintained and available at UAF
- Provision of services to citrus growers for replacing their existing low productive and poor quality mother plants with seedless Kinnow or new citrus cultivars
- Training of budders, growers and researchers on the technology
- Availability of a self-explanatory practical manual for budders, growers and researchers

Way Forward/ Future Strategy

- We hope that the adoption of the technology will create a large number of jobs for skilled and semi- skilled workers in top-working operations.
- It will enhance good quality and high production of citrus fruit on sustainable basis and thus leading to greater availability of fruits for local production and a larger export surplus.

Preparation of mother trees for top working

Cutting and loosing bark of mother plant for insertion of budwood

Modified Sun-drying Techniques for Dates

Prof. Dr. Saeed Ahmad
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- In Pakistan, monsoon rains coincide with the ripening period of dates which causes the rottening of ripened fruits.
- Hillawi is a prominent cultivar and commercially grown in Punjab. Its ripening period starts in mid-July to August which is a peak monsoon period.
- The fruit of Hillawi is completely harvested and consumed at Khalal stage with less economic value.
- There is no trend to process or cure the fruit due to occurrence of monsoon rains.

Intervention/ Technology Brief

- If the fruit is harvested at Rutab stage and properly processed/cured by using proper sun drying techniques, can be saved for future consumption with good economic value.
- The income of farmers can be increased 3-4-fold as compared to those that are sold on "Doka" stages.
- The fruits are collected at rutab/dug stage from the tree and these fruits can be dried/ processed within 6 to 8 days depending upon daily weather conditions. After the harvest, fruits are spread on mat to remain under sun and covered at night.

Outcomes

- These fruits can be packed in plastic boxes of different weights according to the requirement of consumers.

Way Forward/ Future Strategy

- Create awareness among farmers for curing the fruit to avoid economic loss.

Harvesting of Hillawi dates at Rutab stage

Removal during evening in basket

Dates covered with newspaper

Soft semi-dried dates packed in small trays and boxes

Strawberry Packaging in Plastic Punnets

Dr. Raheel Anwar, Associate Professor
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Malnutrition and food insufficiency are two of the major issues in Pakistan
- Since, strawberry is a natural and scrumptious source of phytonutrients including minerals and antioxidants, its demand is increasing in local markets and Pakistan's area under strawberry production is growing rapidly.
- Previously, it had been cultivated mainly in Swat areas of Pakistan but for the last few years, its cultivation is also being practiced across the river belt areas of Punjab and Sindh. With an annual growth in its production volume, it is now important to secure its availability and fruit quality by improving its supply chain.
- Secondly, compared to air tight mulberry/ plastic baskets, perforations in plastic punnets (4-8 holes per pack) allow sufficient exchange of air for aerobic respiration and reduce accumulation of moisture that invites fungal infection
- This practice is one of the major factors responsible for around 40% loss of strawberry fruit just during farm to wholesale market. Moreover, such packaging material also occupies larger space and need racks to avoid compression damage during bulk transport

Intervention/ Technology Brief

- Development of economical and effective packaging is imperative to ensure delivery of fresh and safe strawberries in local supply chain.
- Postharvest Research and Training Center at Institute of Horticultural Sciences, UAF has recently initiated set of studies to optimize strawberry fruit packaging. Initial studies have indicated significant reduction in postharvest losses in strawberries packed in ≤ 1 kg plastic punnets compared to those densely packed in 10-12 kg mulberry/ plastic baskets.
- The reduction in loss is due to the fact that small volume of fruit packed in plastic punnets remains safe from compression and impact damage as observed in mulberry/plastic baskets.

Outcomes

- Field packing of strawberry fruit directly in plastic punnets immediately after harvest reduces chances of physical contacts and thus maintains fruit quality and quantity. Since, consumers prefer economy packs (around 1 kg), small size plastic punnets are ready-to-sell and reduce repacking hassle by retailers.
- Visible strawberries inside clear plastic punnets further reduce physical inspection by consumers for selecting damage- and infection-free packs.
- Plastic punnets are cheaper (Rs. ≥6/punnet) and widely available in variety of shape, size and strength. Even though, optimization studies are still underway at Institute of Horticultural Sciences, UAF to standardize aforementioned strawberry packaging protocol into a viable commercial technology but initial findings are encouraging and support the positive outcomes of this technology alongwith cold chain management of strawberry fruit.

Way Forward/ Future Strategy

- Reduction in postharvest losses and improvement of fruit quality may further help to increase profitability and reduce malnutrition-related issues in the country.

Sanitized Citrus Nursery

Prof. Dr. Muhammad Jafar Jaskani
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Citrus is adversely affected by a number of virus diseases, many of which can be transmitted during budding/grafting and as a result the citrus growers have low productivity and longevity. In Pakistan the current nursery methods of citrus fruits are primitive and less efficient
- A bad nursery plant could have inherent genetic defects or be a carrier of diseases and genetic defects occur due to excessive load of somatic mutations and diseases (infected budwood or soil borne).
- Among all of the fruit crops, citrus stands alone in the number of graft transmissible diseases, which are propagated by infected budwood. As a result, most orchards are short lived and produce only a fraction of potential yields.
- Soil born diseases are the other cause of citrus orchards decline.
- In Pakistan current practice of citrus propagation is being carried out by traditional ways which are vulnerable to various diseases, causing monetary losses to the growers. It also hurt the export of citrus fruit.

Intervention/ Technology Brief

- UAF has developed a very efficient mechanism of developing a citrus disease free budwood and container grown citrus plants. This is a program to establish citrus nursery on scientific standards and focus to develop citrus budwood (required to grow a complete citrus plant) free from diseases. This is the first nursery of its kind with current capacity of 50,000 plants annually whereas demand for new citrus plants in our country is around 4 million.
- Major objectives of this program are 1) to establish a foundation block of disease-free trees of commercial varieties of citrus, 2) to maintain a rigorous program of testing and retesting of foundation trees to assure continued freedom from disease, 3) to evaluate the horticultural characteristics of foundation trees to assure trueness-to-type, 4) to develop and maintain container grown citrus rootstock seedlings and propagate disease free citrus nursery plants for sale.

Outcomes

- If all citrus plantations have been carried out through these nurseries then there will be revolution of healthy citrus.
- The citrus budwood from scientifically established nurseries can yield following benefits:
  - Disease free citrus budwood and plants
  - Longer life span of groves
  - Higher productivity and quality fruits
  - Nursery production and management business

Way Forward/ Future Strategy

- A certification program ensures supply of healthy and true-to-type nursery plants to the growers. Under such nursery production systems the orchards have long productive life, high yields and quality fruits.

Sanitized Guava Nursery Production Technology

Dr. Muhammad Usman, Associate Professor
Institute of Horticultural Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Pakistan is merely producing 7-8 tons/ha guava compared with 21-28 tons/ha in Taiwan and Brazil. India having similar agro-climatic conditions is also producing 3 tons/ha more.
- Area under new plantations is increasing and old or productive orchards have been massively removed due to decline in guava. Poor health status of guava orchards leads to early termination of productive life and a declining fruit industry.
- Faulty conventional nurseries play key role in spreading diseases to the orchards even in areas with little or no disease. Biotic factors including soil borne fungal infestations play major role in causing guava decline

Intervention/ Technology Brief

- This is a dire need for the development of containerized guava nursery in sterilized nutritious potting media and to establish a model for nursery growers and other stake holders. Hence, sanitized guava nursery production system has been established and technology has been presented to guava stake holders.
- Superior fruit of elite guava cultivars were selected from different areas of Punjab for quality analysis. Seeds were extracted and treated with acid for enhanced germination.
- Different types of potting media were used to standardize growing conditions for enhanced growth of guava plants.
- Media were sterilized in the model steam sterilization unit and conditions were optimized for sterilization.
- Guava seedlings of selected cultivars were raised in containers filled with sterilized media and plant growth patterns were noted.

Outcomes

- Winter crop was better for most of the fruit physical and chemical traits compared with summer crop under Faisalabad conditions. In summer season, higher ratio of flesh weight: seed cavity weight indicated more flesh growth relative to seed development. Sugar: acid ratio was higher in cv. Gola depicting sweet fruit development during summer season compared with winter. Fruit quality in guava cultivars was strongly related to orchard localities.
- Steam sterilization of potting media did not affect nutrition and chemical composition of media.
- Sterilized sand gave higher seed germination. Scarification using HCl doubled the seed germination and modified silt media markedly enhanced plant growth and development. Potting mix comprising silt with organic matter (sand + silt + FYM + compost + coir) and silt as media alone enhanced shoot growth and no of leaves compared with other media components

Way Forward/ Future Strategy

- Development of sanitized containerized nursery technology in guava is potentially important to minimize disease spread from nursery

Anaaji Drum-Hermatic Commodity Storage Container

Dr Irfan Afzal, Associate Professor
Department of Agronomy
University of Agriculture, Faisalabad

Challenges/issues

- Food supplies are limited in developing countries by both yield gaps and postharvest losses. Reducing wastage can improve food quality, safety and security, as up to one-third of food produced is lost after harvest.
- The primary cause of such losses is poor storage conditions, especially high moisture contents (MC) that promote mold and insect damage. In autumn season, open-air drying is unable to reduce commodity MC to safe levels that prevents fungal growth.
- Even when harvest occurs in dry seasons and the commodities can be dried to low MC, they are predominantly stored in porous (e.g., jute or woven) bags, allowing increases in MC during monsoon seasons and enabling product spoilage.

Hermetic Technology

Anaaji bag (50kg)

Anaaji Drum (160L)

Intervention/Technology Brief

- Dry Chain Technology is the drying of seeds and grains at appropriate moisture contents whether through natural or artificial means after harvest followed by hermetic packaging to make the product dry and keep it dry until used in the value chain.
- This relatively simple procedure would largely prevent or mitigate postharvest losses of dry commodities. In dry areas and seasons, seeds can be dried in the field and packaged in hermetic bags to prevent moisture absorption during high humidity periods particularly in monsoon season.
- This pesticide-free organic storage monitors seed moisture contents and does not require any equipment or energy input and preserves the quality and germination capacity of stored grains, oilseeds and pulses.
- The use of modern hermetic storage technologies is limited in Pakistan. These storage methods preserve grain in a flexible system.

Outcomes

- Cost effective hermetic Anaaji bags and drums are developed locally which are very effective for cereals, oilseeds and pulses storage without compromising seed and grain qualities.
- “Anaaji Drum” is hermetically sealed plastic drum having 160 L capacity that can prevent both moisture and oxygen penetration into seeds and thus reduce the storage losses.
- Hygrometer is attached with this drum, which monitors moisture contents of seeds indirectly by measuring equilibrium relative humidity inside the drum.
- “Anaaji bag” is an improved multilayer hermetic grain storage technology, which requires no fumigation or chemical application that preserves quality and germination capacity of stored seeds.
- A humidicator strip has been developed to monitor relative humidity of product. The color of strip turns blue in dry seed and red in wet seed. It can store grains and pulses for over a year without gain or loss in moisture, insect pest infestation and fungal growth.
- A license agreement with a private company has been signed and this technology is being promoted in South Punjab and Sindh with the collaboration of leading NGOs in Pakistan

Way Forward/Future Strategy

- As seeds and cereal grains are stored similarly by smallholders, expanded use of these technologies will improve dry product quality in Pakistan for both domestic consumption and export.
- Access, cost and affordability of technology is the only solution for sustainable development of product. These technologies are being promoted to smallholder farmers, national seed companies and research institutions.

Options for Measuring RH

Utilization of Rice Industrial Waste for Oil Extraction and Value Added Products

Prof. Dr. Masood Sadiq Butt
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

- Rice bran holds significant nutritional value containing about 18-20% oil and 14-18% protein. In Pakistan, millions of children, less than five years old, are malnourished and about 38% are underweight.
- To curtail these challenges there is an urge to explore unconventional nutritional sources like rice bran, bran oil, protein and allied supplemented products.
- Rice bran oil contains both essential and non-essential fatty acids like oleic acid (38.4%), linoleic acid (34.4%),and linolenic acid (2.2%) unsaturated essential fatty acids while palmitic (21.5%) and stearic (2.9%) acids are non-essential saturated fatty acids. It is extensively used in Japan, Korea, China, Taiwan and Thailand and called as" Premium Edible Oil" whilst in Japan famous as "Heart Friendly Oil". Now, the trend of utilization of rice bran oil is increasing in Asian countries like India and Sri Lanka.
- Rice bran protein is easily digestible and hypoallergenic food ingredient. For this reason, supplementation of wheat flour with defatted rice bran holds potential to uplift the nutritional status of cookies with special reference to lysine and dietary fiber thus used to address protein energy malnutrition.

Intervention/Technology Brief

- The oil was extracted from the bran that was further employed for the development of baked items with special reference to cakes and cookies.
- The oil was extracted from the bran using soxhlet technique then the crude oil was refined to obtain the high quality edible oil through several refining steps like dewaxing, degumming, neutralization and bleaching. After the refining process, 14-16% refined oil was obtained from the bran.
- The refined oil samples were analyzed for different quality parameters i.e. specific gravity, smoke point, fire point, free fatty acids, iodine value, saponification value and rancidity test.
- The RBO contains high levels of naturally occurring components such as *phytosterols, gamma-oryzanol, tocotrienols* and *tocopherols* that impart resistance to thermal oxidation and deterioration of the oil. The high oxidative stability of RBO makes it preferred oil for baking and frying applications.

Outcomes

- The results revealed that there is a possibility of up to 25% and 50% replacement of RBO with normal shortening in the production of cookies and cakes, respectively.
- It is worth mentioning that chicken nuggets fried in RBO absorbed about 33% less oil than that of fried in commercial oil.
- The results indicated that there is possibility of 6% replacement of defatted bran with white flour for the preparation of enriched bread without substantially affecting the quality.

Way Forward/Future Strategy

- Research on defatted rice bran being a rich source of protein with tendency to supplement cereal based products like cookies.
- Massive awareness program to alleviate protein energy malnutrition in the public.

Modified Bran Flours

Prof. Dr. Imran Pasha
Prof. (R) Dr. Tahir Zahoor
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

- Cereals are cultivated for their edible grains and are consumed as staple diet worldwide, providing plentiful calories and nutrients together with useful functional components for value addition.
- The most important botanical parts of grain include endosperm, bran and germ. Approximately, 14 - 19% part of the kernel is bran.
- Cereal brans grasp a significant position in food applications in the current atmosphere of increasing consumer consciousness about health foods.
- By using appropriate processing techniques, the biological value of bran could be improved, and at the same time the technological drawbacks, such as unappealing taste and loss of volume in bread could be overcome.
- The foremost objective to formulate composite flour was to acquire a product better than its individual ingredients, with improved performances and better economies.
- Replacement of a portion of wheat flour not only brings economic benefits but also leads towards ensuring food security.
- As according to FAO, 320 million dollars could be saved annually if wheat flour substituted at the rate of 20% with non-wheat flour and at 30% substitution savings may be 480 million dollars annually.
- Nutrient-dense substitutes like cereal brans can be used to fabricate flour blends with good sensory and physical attributes and importantly superior nutritional composition

Intervention/Technology Brief

- Despite of many health benefits, the bran is utilized in food products in inadequate proportion because of the technical problems and quality defects as for example in breads, increased crumb firmness, darkened crumb, reduced loaf volume, reduced tolerance to fermentation, and most prominently loss of palatability due to gritty structure of bran. Bran can therefore be modified to curb all the quality defects.
- The modifications might include particle size reduction, heat treatment, soaking, fermentation and altering the constituent polymers solubility i.e. dietary fiber. Enzymes could be greatly helpful to modify and dissolve lofty polysaccharides releasing the bound constituents and altering dietary fiber solubility.

Outcomes

- To overcome this problem, we need to bring in low-cost, diversified and better-quality nutritious foods to common people diets. Replacement of wheat flour even at the rate of 20% with different cereal brans would be an important step leading towards ensuring food security and managing malnutrition in Pakistan.
- The industry will market the composite flours in different packaging sizes i.e. 2Kg, 5Kg and 10Kg.
- This is an effort to manage the malnutrition in Pakistan and food security for ever increasing population. Local raw material like sorghum and millet, mostly under-utilized crops for food uses would be brought into human consumption.

Way Forward/ Future Strategy

- This technology will be transferred to millers primarily to ensure provision of nutritious flour to public.

Post-Mortem Aging Technology: A Way to Improve Nutritional and Sensorial Quality of Meat

Dr. Muhammad Issa Khan, Associate Professor
Dr. Aysha Sameen, Associate Professor
Dr. Amna Sahar, Associate Professor
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

- In Pakistan, meat markets have been established by municipal and local authorities.
- However, the marketing of meat is characterized by several factors including hold of private sector, absence of reliable data on main marketing channels, inadequacy of slaughtering and marketing infrastructure and improper storage and transportation facilities.
- Locally, the meat is usually subjected to marketing for consumption immediately after slaughtering. Practically, aging is not performed for local consumption of meat. However, the desired consistency of meat tenderness could be achieved by incorporation of freezing and additional aging period.
- These methods can be incorporated for the normal commercial products to improve the meat tenderness.
- Additionally, by providing proper aging, international marketing of meat can also be explored in a much effective way.

Intervention/ Technology Brief

- The improvement in meat quality during the refrigerated storage has been known since the turn of the century.
- However, the mechanistic approach involved behind the changes in meat composition occurred during postmortem storage have remained elusive and controversial.
- The main objective of postmortem storage of meat is the improvement in meat tenderness as it is the major parameter considered by the consumers while purchasing meat. Additionally, protein degradation is another important phenomenon seen during the storage of meat.
- The variations in the pH have significant influence on the rate of protein denaturation.
- The elevated pH values are the resultant of depleted muscular glycogen reserves prior to slaughter and affect the meat quality in a considerable manner.
- The major contributors responsible for depleted glycogen level include manner and length of animal transportation, feeding restrictions, lairage time and conditions; pathological status and genetic makeup of animal.
- The mechanisms of proteolysis and meat tenderization are quite complex and are influenced by various factors including animal age, gender, rate of glycolysis, solubility of collagen, sarcomere length, extent of protein degradation, ultimate pH (pHu) and ageing conditions.
- Among these, pHu and ageing time and temperature are considered the most important parameters that have great influence on meat quality during the postmortem storage.

Outcomes

- Post-mortem aging is aimed toward achieving flavorsome and tender meat.
- The potential to increase the value of end cuts on a beef carcass is evident in the high overall like, tenderness, juiciness, and flavor responses of the value cut.
- It enhances flavor and juiciness of meat and meat products. Using an education platform like our study would allow beef consumers to learn while sampling and thus establishing a higher order learning process that could lead to action.
- In this case, requesting value cuts from their local butcher which would ultimately drive more value up the meat market chain. To enhance the trends, we should improve the impacts of private sector, reliable data on main marketing channels, inadequacy of slaughtering and marketing infrastructure and improper storage and transportation facilities and betterment in infrastructure of meat industries. These channels create job opportunities and employment. The meat processing manufacturers optimize the effects of aging for specific muscles, the palatability, color, and the shelf life of the aged meat products could be significantly enhanced.

Way Forward/Future Strategy

- To standardize post-mortem aging parameters for meat of different meat species
- To assess impact of post-mortem aging on nutritional quality and sensory attributes of meat
- To determine factors affecting quality and safety of aged meat
- Aging cause an improvement in the overall quality of meat so when quality improves living standards also improves.
- The standardization of meat and meat products different parameters of quality and safety are focused.

Enhancing Value Addition of Milk by Developing Specialized Cheese and Cheese Spread

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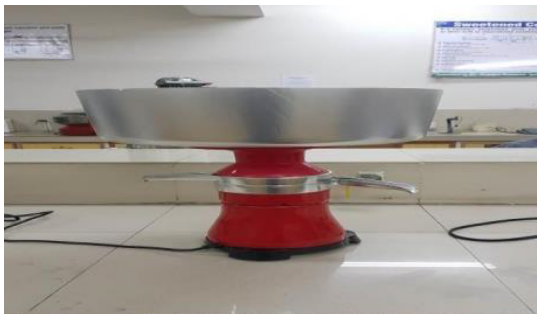
Dr. Amna Sahar Associate Professor
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

- Pakistan is the 5th largest country in milk production but only 4% of milk is being used for product development.
- The gap between supply and demand of cheese is getting wider day by day.
- Indigenous production of cheese does not meet the requirement of local consumers.
- There is an increased trend in the import of cheese for last 5 to 6 years due to greater consumption.
- The supply-demand gap of 10-15% offers attractive opportunities for investments in dairy sector. Almost all of the cream cheese available locally is of imported brands (Krafts, Almarai, Emborg). Cheese production and processing can be a very profitable business venture for new and existing investors.



Intervention/ Technology Brief

- Development of cheese spread on lab scale and finalization of cheese spread formulation for industrial scale and transfer of technology to dairy industry.
- Commercialization and marketing of the cheese spread by working with dairy industries (Fauji Foods)

Outcomes

- The most important outcome is the development of cheese spread using local resources and reduction in the import of cheese thereby, decreasing the strain on our economy.
- Production of cheese spread will result in the decrease in the prices as well as wide availability to the consumers.
- It can also contribute in the alleviation of malnutrition from our country, as it is rich source of micro and macronutrients.

Way Forward/Future Strategy

- Development of various types of cheese spread using indigenous resources according to requirements of local consumers.
- Provide awareness about the health benefits of the cheese spread and increase its demand using different marketing strategies.
- Promote production of cheese spread by transfer of technology to the dairy industry of the country.

Protocols for Commercially Processed Products of Mango, Kinnow, Potato and Tomato

Dr. Inam-ur-Raheem, Assistant professor
National Institute of Food Science and Technology
University of Agriculture, Faisalabad

Challenges/issues

Two major challenges to Pakistan economy are Human health and safe food That's why we have to introduce most suitable processing/packaging techniques used to:

- Process food in safer environment free from contaminants and smoothening process in sequence
- Store food product for longer storage time Without danger of their spoilage and food safety risk factors
- Help in reducing the final cost of production with increased profit margin

Technology Brief

- Survey and sampling of processing areas, equipment used in industry, packaging and raw material of food additives along with fresh fruits and vegetables
- Evaluating the samples through different physico-chemical tests in laboratories of NIFSAT, UAF and Post Harvest Research Centre, AARI and identify critical control points in existing processing line
- Processing of different products in Shezan Industry through standardized techniques
- Evaluating processed products through sensory and physico-chemical tests in laboratory of industry along with NIFSAT, UAF and Postharvest Research Centre, AARI

Outcomes

- Standardize ingredient recipe, processing sequence and packaging technique of selected food products
- Extension in storage life through reduction in microbial contamination. Capacity building of local industry in developed processing techniques through trainings and e-media

Way Forward/Future Strategy

- Developed technology will be shared with food processing industries in Pakistan.

Extreme Rainfall and Flood Monitoring System

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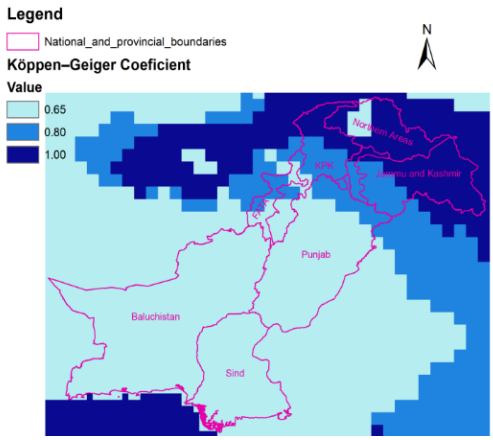
Prof. Dr. Muhammad Arshad
Department of Irrigation & Drainage
University of Agriculture, Faisalabad

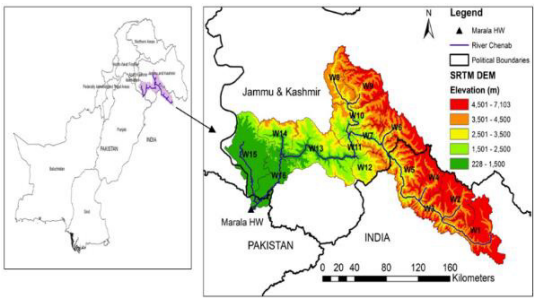
Challenges/issues

- Pakistan is highly vulnerable to climate change, which is resulting in increased frequency and intensity of extreme rainfall and flood events.
- To effectively cope with the challenges of flood management, the climate monitoring and detection of any extreme event is really important.
- On-ground climatic stations and rain gauges provide accurate data, but the existing low density rain gauge network in the country is not enough to effectively predict and monitor any flood situation.



Intervention/ Technology Brief

- Use of satellite rainfall data and forecast may be very beneficial to monitor and predict any extreme rainfall and flood situation.
- The proposed Extreme Rainfall and Flood Monitoring System has been developed in following two phases:
  - Initially a satellite rainfall data based web-tool has been developed for Pakistan to provide extreme rainfall alerts in real time.
  - In the next phase, this extreme rainfall and flood monitoring system will be refined by developing hydrologic models for individual river catchments and integrating them with the system.



Outcomes

- Basic input in the development of this product is the satellite rainfall data downloaded and integrated with other geographic information using modern GIS and modeling tools.
- Availability of a real time extreme rainfall detection web-tool.
- Real time rainfall information along with other informative GIS layers to assess the vulnerability and sensitivity of an extreme event.
- Near real time prediction of flows for specific river catchments based on hydrologic modeling.
- The developed system may help emergency management departments in timely evacuation of masses from flood prone areas and better planning of relief activities.

Way Forward/Future Strategy

- Developing an extreme rainfall and flood monitoring system for Pakistan, which will be beneficial for the farmers having their homes and agricultural crops and commodities in flood prone areas
- Integration with mobile SMS service to provide alerts to premium users through SMS. For this purpose, services of telecommunication companies will be employed.
- There is a big community of large land holders in the flood prone areas, who will be convinced to be the premium members; and thus, will be provided with regular alerts about any forthcoming flood situation, as well as about the extreme rainfall events to plan their agricultural operations in a befitting manner.

Mastitis Diagnostic Kit / Mastitis Vaccine

Prof. (R) Dr. Ghulam Muhammad
Department of Clinical Medicine and Surgery,
University of Agriculture, Faisalabad

Challenges/issues

- At least 20% cows and buffaloes in Pakistan produce unwholesome milk because of mastitis (inflammation or swelling of udder).
- Most of the diseased animals are affected by sub-clinical or hidden form of mastitis.
- Milk of mastitis affected animals contains higher than normal number (200,000/mL) of white blood cells (pus cells).

Intervention/Technology Brief

- Increased number of white blood cells in milk can be detected by mixing milk with 3% solution of Surf Excel (Muhammad et al., 2010.
- Tropical Animal Health and Production, 42:457-464) in equal proportions (Surf Field Mastitis Test; SFMT).
- Development and Commercialization of Mastitis Vaccine to control the scourge of mastitis, several candidate mastitis vaccines were investigated at the University Agriculture, Faisalabad. The most promising results in mastitis control were obtained with vaccine incorporating a biofilm producing local isolate of *Staphylococcus aureus*.

Outcomes

- Both SFMT kit and mastitis vaccine available as an output of an agreement inked between Business Incubation Center, University of Agriculture, Faisalabad and UM Enterprises, Karachi.

Way Forward/Future Strategy

- Massive campaign to create awareness among livestock farmers for the control of this disease in cows and buffaloes.

Swab Test on Animal Food (STAF) for the Detection of Antibiotic Residues in Meat, Milk and Eggs

Dr. Sajjad ur Rahman
Dr. Sultan Ali
Institute of Microbiology
University of Agriculture, Faisalabad

Challenges/issues

- Indiscriminate use of antibiotics as therapeutic in the production of livestock and poultry reflect as residues in the animal food like meat, milk, and eggs. Such residues in the animal food chain may pose different threats to the consumers; moreover, the drug residues will also cause rejection or condemnation of the processed meat, milk and egg products thereby causing economic loss.
- For the detection of antibiotic residues in the animal food, the option of expensive and time-consuming methods like HPLC are in operation.
- In parallel to the international US and European standards all the animal foods must be free from antibiotic residues or possibly under permissible concentration as detected through PHAST and STOP test, respectively.

Intervention/Technology Brief

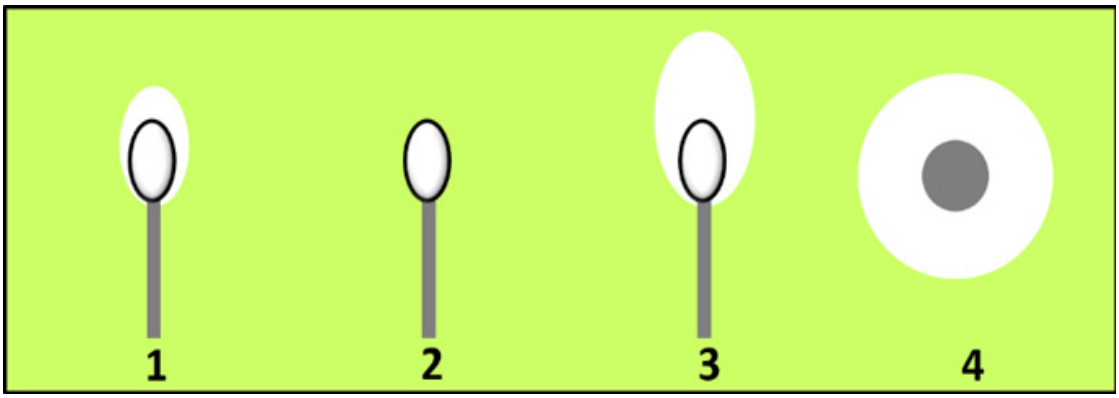
- Swab Test on Animal Food (STAF) was developed indigenously for screening the animal foods for the detection of antibiotic residues. In this test local isolated culture of *Bacillus subtilis* was characterized and used as an indicator microorganism due to its high sensitivity to detect a wide range of antibiotics (sensitive to 30 antibiotics) commonly recommended for treating various animal disorders.
- In a separate study conducted in the Institute of Microbiology, UAF, the optimum concentration of $1X10^5$/mL (spore suspension) was established to promote reproducible results with best sensitivity.
- The medium was formulated which promoted the active growth of *Bacillus subtilis* (JS2004) at 30°C under aerobic condition. Polystyrene plates were designed to hold the sterile medium along with the required organism culture intact and the ready to use plates are available for one month under refrigeration temperature.
- The STAF test technology was further improved in 2016 where the agar overlay method was found more suitable and results may be visible from 16 hours onward instead of 24 hours of incubation.
- Special nutrient agar was used to hold the spore suspension. At the specific concentration, the inhibition zone around Neomycin control disc remained around 16 mm which served as test control.
- Appearance of clear zones of growth inhibition around test swab samples containing absorbed food (within 16 hours) at room temperature was well illustrated in Plate A

Outcomes

- We have developed and standardized STAF test technology applicable for better care of the quality and health safety concerns.
- Test swab with zone measuring less than 2 mm is considered as negative and indicating antibiotics residues present in food within the permissible level.
- Test swab samples showing no zone of inhibition are negative for antibiotics residues.
- Test swab samples showing more than 2 mm wide inhibition zone is considered as positive for the presence of antibiotic residues indicating the food containing the antibiotics beyond their permissible level thus declared as unfit for human consumption.
- Neomycin (5µg) with more than 16 mm zone diameter is used as test control

Way Forward/Future Strategy

- This widely applicable microbiological test, was standardized to screen out animal foods (Eggs, Meat and Milk) containing antibiotic residues



BIOMOSKILL PLUS: A Technology for the Control of Mosquito Larval Population in Water

Prof. Dr. Sajjad ur Rahman
Dr. Rizwan Aslam
Institute of Microbiology,
University of Agriculture, Faisalabad

Challenges/issues

- During the first outbreak year (2011) of dengue fever in the country efforts were made to curtail the spread in the community.
- We took the specific task in the biological control of mosquito population using *Bacillus thuringiensis.*
- The initial results with the suspension culture of *Bacillus thuringiensis* alone were encouraging enough to go for its application strategies.

Intervention/Technology Brief

- This Biomoskill Plus tiles were introduced for the first time and its successful trails were accomplished with the control of Ades, Culex and Anopheles larvae in the water.
- Only mosquito larvae are killed and the presence of *Bti* does not harm the other invertebrate larvae, moreover, the water remained fit for animal consumption.
- The active ingredients of *B. thuringiensis* and *B. sphaericus* showed their equal larvicidal potential against all the major types of mosquito population. The ratio of 1:1 proved optimal for the control of larvae.
- One tile is sufficient to control mosquito larvae in 150 gallons of water

Outcomes

- Appropriate management of vector control is essential to curtail the further spread of mosquito born infection in the public community.

Way Forward/Future Strategy

- Biomoskill plus provide best biological control strategy which is easy to use and safe for sustainable control of mosquito population in the environment.

Bio-Dewormer Powder

Dr. Rao Zahid Abbas, Associate Professor
Department of Parasitology,
Dr. Muhammad Sharif, Associate Professor
Institute of Animal and Diary Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Livestock sector is facing a great threat of parasitism which ultimately badly affects the production of animals mainly in terms of reducing weight gain and milk production.
- This is very hard to control this problem by using the chemical drugs because of development of drug resistance with additional disadvantage of drug residues issues.

Intervention/Technology Brief

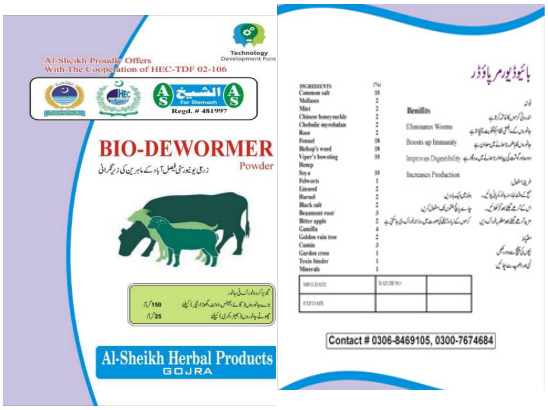
- This product is developed by indigenous herbs having medicinal properties especially having ability to reduce the worm burden along with having positive effects on live weight gain and production performances.
- This product is multi-mode and has no harmful metabolic residues. For that reason this is an eco-friendly product having no negative impact on public health.
- This is a palatable mixture which improves digestibility so that feed intake is also enhanced having a number of associated effects.

Outcomes

- Introduction of herbal dewormer in the market, Veterinarians and farming community
- Organic farming Feasible
- Eco-Friendly product in hand
- Indigenous industry flourished

Way Forward/Future Strategy

- Publicity of this product up to national level.
- Marketing of this product in all the Provinces.



Golden Nuggets: Animal Feed from Citrus Pulp Waste

Dr. Muhammad Sharif, Associate Professor
Dr. Fawwad Ahmad, Associate Professor
Institute of Animal and Dairy Sciences
University of Agriculture, Faisalabad

Challenges/issues

- Animals are generally fed fodders and crop residues which fulfill their maintenance requirements.
- However, less nutrients are available for diverse biosynthetic activities for productivity. To meet the productive requirements of nutrients, concentrate feeding is frequently practiced. However, due to ever increasing prices of ingredients, concentrate feeding seems difficult.
- It makes the livestock enterprises uneconomical, thus interfering with exploitation of optimum genetic potential of the animal, resulting in poor performance.
- This problem can be overcome with the use of agro-industrial byproducts which are good source of energy and protein.

Inventions/Technology Brief

- Different agro-industrial by-products especially fruit wastes can be used as an energy source for feeding livestock.
- Citrus pulp is an important by-product obtained after extraction of juice from the citrus fruit.
- A large quantity of pulp is being produced in Pakistan which is not commonly fed to animals.
- It causes disposal problems as well as environmental pollution. Citrus pulp consists of peels, inside residue and culled fruits. It can be used as a substitute of cereal grains in the diet of ruminants. Small quantity of fresh citrus pulp is being used successfully in animal feed in areas situated near the citrus juice processing units.
- It has excellent profile and can be used round the year in animal feed if conserved properly.
- The waste is conserved through drying and ensure its availability for animal feeding. Citrus pulp is dried mechanically.
- For this purpose, fresh citrus pulp will be treated with calcium oxide and then passed through press to remove the extra water. Afterwards, Dehydration is carried through dryer. The air velocity and temperature combination has been optimized to reduce the burning and nutrient losses.
- After preparation of the product, certain treatments are done to improve the nutritional worth of the product.
- The dried citrus pulp is packed in polythene bags and stored at room temperature before further analysis or usage.
- The samples are taken and analyzed for dry matter and crude protein, neutral detergent fiber and acid detergent fiber.
- Citrus pulp is marketed to the feed mills and common farmers for utilization in animal feed that will assist in cost effective feed formulation.

Outcomes

- itr has been planned to expand the business on commercial basis.
- An industrial partner is responsible to provide required infrastructure (office, building for machinery and staff) and shall be responsible for the maintenance of machinery and running / operation of machinery at its maximum level.
- The partner will bear the expenses/cost of the production and marketing of the final product (Dried citrus pulp) i.e. labor charges, electricity charges, gas charges, diesel charges, raw material cost, packing cost, transportation and marketing expenses as running cost for industrial operation of the production unit. He shall be responsible to keep the financial record and shall facilitate the University students for internship and research.

Way Forward/Future Strategy

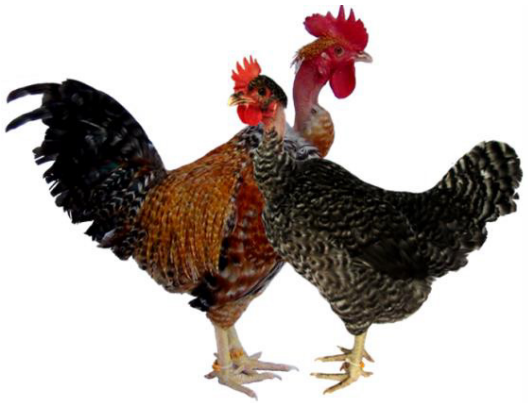
- Agreement has been signed with the industrial partner for the further execution of the project. Involvement of industrial partner with the institute for next 5 years is itself a breakthrough and indication of the success of the technology regarding citrus pulp processing (Golden Nuggets) and its commercialization.

UniGold-A Naked Neck Poultry Breed

Prof. Dr. Muhammad Sajjad Khan,
Institute of Animal and Dairy Sciences
University of Agriculture, Faisalabad

Challenges/issues

- In Pakistan, poor production potential of local/rural poultry breeds make them less profitable but still they have their cultural importance especially in case of Aseel breed which is mainly raised for cock fighting.
- Local chicken breeds are the only birds which are being raised and utilized by poor and landless farmers in villages.
- Desi hens are found in every village of Pakistan but facing threats from exotic breeds by being replaced progressively by crossbreds of Fayoumi and Rhode Island Red which are disseminated by Poultry Production Department.



- These birds are being produced by using two exotic parent breeds. Therefore, need was felt to develop our own local breed that can perform better under village conditions and could be propagated locally to save cost of import of exotic germplasm.

Intervention/Technology Brief

- Development of Rural UniGold is a newly developed egg laying breed for backyard poultry production.
- Breed has been developed at the University of Agriculture Faisalabad with the help of funds from Punjab Agriculture Research Board (PARB). Locally available indigenous and adapted breeds have been used to have barring as the main color.
- Two strains (full neck and naked neck) have been developed and tested for their performance under low to medium input systems in central and southern Punjab.

Outcomes

- Breed has capacity to produce as high as 210 colored eggs with average weight of 50g as reported by Poultry Research Institute of Government of Punjab

Way Forward/Future Strategy

- Upscaling of the breed is expected at UAF in the near future.

PB-896- A Promising Cotton Line at Final Stage of Approval as Variety

Prof. (R) Dr. Iftikhar Ahmad Khan
Prof. (R) Dr. Faqir Muhammad Azhar
Prof. (R) Dr. Hafeez Ahmad Sadaqat
Prof. (R) Dr. Tanwir Ahmad Malik
Dr. Tariq Manzoor Khan, Associate Professor
Dr. Masooma Naseer Cheema, Associate Professor
Dr. Muhammad Tehseen Azhar Associate Professor
Department of Plant Breeding and Genetics
University of Agriculture, Faisalabad

Challenges/issues

- Keeping in view the importance of cotton in economy of the country, Cotton Research Group in the Department of Plant Breeding and Genetics is maintaining and developing new germplasm having more ginning turnout, good fiber quality traits, and tolerant to biotic and abiotic stresses.

Intervention/Technology Brief

- Under the current scenario of climate change, cotton research team has developed an elite line PB-896 that showed overwhelming performance and secured top position among non-Bt group in National Coordinated Varietal Trials (NCVT)- 2015-16 in Punjab province, conducted by Pakistan Central Cotton Committee (PCCC) at various research institutes/centers.

- This bulk is developed by hybridization of local and exotic genotypes available in the germplasm available with group. The bulk has produced 39% higher production than CIM-573 (standard).

- This strain has potential of 3000 to 3500 kg/ha. It has 40% GOT and 30 mm staple length. Because of high GOT and staple length it would also be preferred by cotton ginners as well as textile industrialists. This elite line has good tolerance against cotton leaf curl disease which is one of the factors for reducing yield in Indo-Pak continent.

Outcomes

- PB-896 addresses the issues in an excellent manner because it possesses hairiness traits which protect from infestation of sucking insects i.e. whitey and aphids.
- In near future, there will be shortage of female pickers in cotton growing areas of Pakistan. To overcome this up-coming problem, PB-896 is suitable for mechanical picking due to its semi-erect plant shape and uniform boll opening.
- In next year cotton season, the potential of PB-896 will be explored by using various agronomic practices with collaboration of Department of Agronomy, UAF

Way Forward/Future Strategy

- This line can tolerate heat and water stress; therefore, it has potential to boost production in different agro-ecological zones of Punjab.
- Therefore, it is believed that it would be approved as commercial variety by the Government of the Punjab.

Natural Menthol Crystals

Dr. Muhammad Asif Hanif, Associate Professor
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University of Agriculture, Faisalabad

Challenges/issues

- The world menthol mint essential oil production is estimated to be more than 50,000 tons. The major menthol producing countries are India, China, Brazil and Japan. Although, Pakistan is an agriculture country, but it imports all of menthol that is used indigenously.
- The yield of menthol crystals is low by all previously used methods. This adds a lot of cost to menthol crystals.
- Another problem with all previous methods is that they become less effective if mint oil contains more than 50% menthol. This is the reason that peppermint oils cannot be previously used for production of menthol crystals as content of free menthol in these varieties is usually below 50%.

Intervention/Technology Brief

- Stripping crystallization (SC) is a new separation technique that combines distillation and crystallization. In SC the process is conducted at a triple-point condition to simultaneously vaporize and crystallize liquid component due to the existence of three-phase equilibrium.
- In principle, the SC process is sustained until feed containing only the pure solid menthol crystals and the liquid phase is completely eliminated. Thus, only pure solid crystals are obtained and no impurities are left on crystals surface on completion of SC.
- The mint-based products including dementholized oil (DMO) and menthol crystals are used in several industries including cosmetic, food, flavor and fragrance, and pharmaceutical industries. Pakistan has suitable environment for the cultivation of mint crops and it will benefit specially small farmers.
- The cost factor was major barrier in the commercialization of menthol crystals.

Outcomes

- Local production of menthol to save revenue, utilization of new novel methodology for low-cost production as compared to other countries, better equipment for continuous production of menthol and by products, most importantly development of essential oil processing industry.
- A pilot scale plant for the menthol crystals by Stripping crystallization (SC) and molecular crystallization (MC) can be used for commercial crystals production.
- A testing facility to test essential oils and menthol crystal purity has been developed.

Way Forward/Future Strategy

- The menthol crystals production methodology will be available for large scale commercialization.

Portable Solar Umbrella

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Dr. Hafeez Anwar
Shamoon al Islam
Muhammad Bilal
Department of Physics
University of Agriculture, Faisalabad

Challenges/issues

- The outdoor temperature in many areas in Pakistan reaches up to 52°C. The Traffic wardens, vendors, students, Pilgrims, passengers and labor working in sunshine are under high risk of sunstroke.
- People working outside need a smart shelter system that may facilitates them with proper arrangement of fan, light, mobile phone charger and auxiliary power outlet to run basic electrical appliances, and further it can be installed at any place without hassle and can be folded into wheeled bag for smart movements.

Intervention/Technology Brief

- A smart, self-contained, rechargeable, low-cost portable solar umbrella is developed that takes free energy from sun, provides very necessary facilities like fan, light, mobile charger, laptop charger, temperature sensor and long power backup under powerful solar roof.

Outcomes

- Three designs have been optimized after a comprehensive survey and public demand.
- Personal Solar Umbrella; for common people, students and pilgrims,
- Smart Solar Umbrella; for vendors, lawns, traffic wardens etc.
- Portable Solar Umbrella; for small scale cafes, canteens, lawns, hotels, canteens, huts, bus stands, parking, public places and remote areas where electric supply is not available.

Way Forward/Future Strategy

- This product is useful for travelers, particularly the pilgrims. It is useful for all those people who have to stay/work in sunshine for long day hours.
- It has applications in the dessert areas and those rural areas where electricity supply is not feasible. In future it will be transformed into a small-scale business resulting in employment of skilled persons.

High Yielding Sorghum for Kharif Fodder

Prof. (R) Hafeez Ahmad Sadaqat
Dr. Amir Bibi, Associate Professor
Masood Qadir
Department of Plant Breeding and Genetics
University of Agriculture Faisalabad

Challenges/issues

- Although Pakistan has one of the best kinds of livestock in the world. The existing livestock feeding practices are inefficient to meet the domestic requirement of milk and meat.
- There is inadequate supply of good quality fodder in required quantity.
- Shortage of green fodder during Kharif season is a serious issue. A prolonged period of high temperature along with drought stress causes extensive damage to crops or prevents their successful growth in Kharif season.
- There are two major crop options in kharif; maize and sorghum. Maize is consuming more water. Farmers are looking for water saving alternative of maize, so sorghum is getting popularity.

Intervention/Technology Brief

- University of Agriculture Faisalabad (UAF) has developed a unique germplasm of sorghum consisting of 250 cultivars. These maintained cultivars offer significant amount of variation for various purposes; high tonnage/biomass yield, protein contents, sugar contents, lodging resistance and stay green trait.
- Almost all kind of gene sources including resistance to biotic and abiotic stresses are available at UAF. Six elite lines (open pollinated) genotypes of sorghum are being made to address the issue of Kharif fodder shortage production, having high yield and better nutritional quality.
- These elite varieties have very thick and juicy stem, broader leaves with no sharp margins and are free of pubescence.
- These elite lines have been evaluated in Preliminary yield trials (PYT) and two seasons of Advanced Yield Trials (AYT).
- In Pakistan, so far, varieties of fodder sorghum are registered and approved only for high fodder yield and no single variety is registered for better quality
- UAF plant breeders have concentrated efforts on nutritional characters, which are directly related to palatability with higher sugar content than available sorghums. The sweet sorghums are less liable to cause HCN poisoning

Outcomes

- Sorghum tolerates heat and drought stress in Kharif season. Sorghum (*Sorghum bicolor*) is a multiuse crop grown both for feed, food and bioenergy.

Way Forward/ Future Strategy

- In Pakistan, so far, varieties of fodder sorghum are registered and approved only for high fodder yield and no single variety is registered for better quality.

Vermitechnology: Converting Trash into Cash

Dr. Zubair Aslam, Associate Professor
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University of Agriculture, Faisalabad

Challenges/issues

- There are two main issues in Pakistan Agriculture, one is excessive and injudicious use of chemical fertilizers due to high population pressure, polluting the underground water and causing health hazards and other is wastage of excessive amount of Agricultural Solid Waste (ASW) (in the form of kitchen waste/vegetable waste in market as well as at home, cotton sticks, rice husk, rice straw, sugarcane bagasse, sugarcane husk and dry leaves, poultry, farm yard manure, etc.) which, if used properly, can be a rich source of nutrients for sustainable crop production to feed increasing population.
- The efficiency of synthetic fertilizers is also very low, for example, in the case of nitrogen fertilizers 50% is lost and in the case of phosphatic fertilizers only 10 to 30% is helping in plant growth; the rest of the70 to 90% becomes part of the soil.
- The prices of chemical fertilizers are becoming out of reach of farmer and their timely availability is a big issue.

Intervention/Technology Brief

- Vermitechnology is the technology which produces good quality organic manure by the use of suitable earthworm species from the waste material in which the earthworms develop a strong interaction with different microorganisms and fauna of decomposer community and modify the physical and biochemical properties of raw material.
- The nutrients contained in the organic matter are partly converted to a more bioavailable form. It is a peat like fine structured material that has high porosity, good aeration, drainage, microbial activity, high water-holding capacity, rich nutrient status and with good buffering capacity, and ideal physiochemical characters important for plant growth and soil fertility.
- The excessive availability of hormones and enzymes acquired while passing the organic matter through the earthworm gut can boost plant growth and discourage the plant pathogens and hygienically safe products are obtained.
- Vermicomposting process is 2-5 times faster than thermophilic composting to produce valuable biofertilizer.
- Different organic wastes have been tested as feed material for earthworm species; sewage sludge, paper-mill industry sludge, paper wastes, crops residues, animal-dung, biogas slurry, etc.
- Among the vast community of earthworms only very few species can be used for vermicompost production. They are *Eisenia fetida* (Red worms), *Perionyx excavatus* (Indian blueworm) and *Eudrilus eugeniae* (African night crawler).

Outcomes

- A vermicompost center has been established at Student Research Farm, Department of Agronomy, University of Agriculture, Faisalabad. A lot of farmers, researchers and students have been trained for this technology and many farmers are working on this technology to earn money.
- Around 40 kg earthworms have been distributed to farmers.

Way Forward/Future Strategy

- This technology may be commercialized and farmers can get benefits by selling earthworms, vermicompost and organic foods/products which are usually more than double of inorganic price.

***Eisenia fetida* (Red worms)**

Vermicompost (Final Product)

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