Annual Report

2023-24

Pakistan Agricultural Research Council

Dr. Ghulam Muhammad Ali, Chairman, PARC alongwith Ms. Jessica Mudjitaba Fernandez, Program Manager, USDA, Mr. Asmat Raza, Agricultural Specialist, USDA, Ms. Hillary Mehl, Research Plant Pathologist, USDA and Mr. Babar Ehsan Bajwa, CABI's Senior Regional Director, Asia during a USDA-PARC CABI meeting on regulatory Harmonization in Pakistan for MRLS and Biopesticides at NARC

Honorable Federal Minister for the Ministry of National Food Security and Research, Dr. Kauser Abdulla Malik, Dr. Cho Gyoung-Rae, Project Director (KOPIA) Pakistan, Dr. Ghulam Muhammad Ali, Chairman, PARC and Scientists are present at Green/Screen houses for Pakistan-Korea joint program on Certified Seed Potato Production System at NARC.

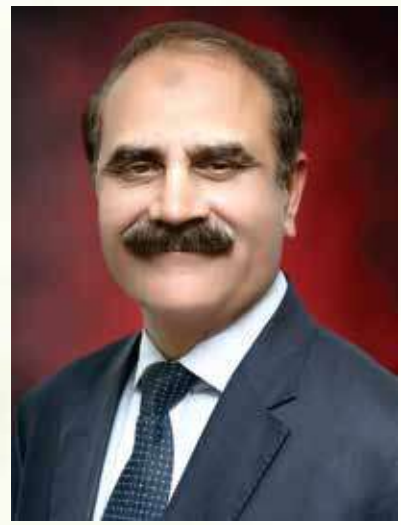
PARC
Annual Report
2023-24

PARC

http://www.parc.gov.pk

CONTENTS

FOREWORD FROM THE CHAIRMAN



Agriculture remains the backbone of Pakistan's economy, playing a central role in ensuring food security and driving rural development. A robust and sustainable agricultural sector is essential for social and economic progress. Achieving sustainable growth in this sector is imperative for economic stability, and the key to this transformation lies in innovative agricultural research and development.

The sector confronting numerous challenges, particularly climate change and rapidly growing population. The future of food security depends on embracing innovation—precision farming, biotechnology, artificial intelligence, and climate-resilient cropping systems. By integrating these advanced technologies, we can enhance productivity, minimize resource wastage, and ensure food security for its growing population. Pakistan Agricultural Research Council (PARC), as a leading research institution, is committed to revolutionize agricultural research by integrating cutting-edge technologies that enhance productivity and ensure food security.

PARC has initiated several key interventions to enhance crop productivity. These include genomics-based crop variety development, hybridization of vegetable seeds, promotion of mechanized farming, and ensuring access to certified and high-quality seeds. Additionally, we are advancing aeroponics technology for nucleus potato seed development, pioneering intelligent greenhouses, and fostering controlled breeding techniques for livestock improvement. Our focus is on promoting sustainable practices such as regenerative agriculture, climate-resilient cropping systems, and precision irrigation technologies.

In the realm of plant sciences, our research is directed towards developing high-yielding and climate-resilient crop varieties. Advanced breeding techniques, including hybridization and speed breeding, are being employed to enhance productivity and adaptability. Breakthroughs in genetic engineering and bioinformatics are unlocking new frontiers in crop improvement, making them resistant to diseases, pests, and environmental stress. Our partnerships with national and international research organizations further strengthen our ability to address key challenges in crop production and sustainability.

The Natural Resources Division (NRD) has made remarkable progress in land and water conservation, agro-forestry, and climate-smart agriculture. Notable initiatives include redefining agro-ecological zones, piloting responsive drip irrigation, integrating solar energy with high-efficiency irrigation systems, and advancing bio-fertilizer development. These initiatives are pivotal in ensuring the sustainable utilization of natural resources for long-term agricultural prosperity.

Animal Sciences Division (ASD) has also made significant strides in genetic improvement of livestock breeds, optimization of artificial insemination techniques, and vaccine development against diseases such as lumpy skin disease. Innovations in veterinary sciences and controlled breeding technologies are

revolutionizing livestock productivity and disease prevention. Our efforts extend to enhancing fisheries productivity through the development of mono-sex tilapia fish farming.

Social Sciences Division (SSD) play vital role in policy backstopping. The currently established Pakistan Food System Transformation Secretariat and Food System Dashboard at SSD, PARC are milestones in evidence-based policy decision and inferences. This division play central role in follow up of United Nation Food System Summit stock taking moment and look after the Zero hunger SDG indicators. Recently the development of feasibility analysis of three major investment proposals -- 10,000 camel rearing, 10,000 dairy animals rearing, and 30,000 calf fattening--, development of business plan for seed potato and impact assessment of Productivity Enhancement of Rice project are commendable.

In agricultural engineering, the focus has been on designing and promoting precision agricultural machinery, including small-scale mechanization solutions developed in collaboration with international partners. Our scientists have achieved a milestone in the development of regenerative agriculture machinery, which is set to revolutionize sustainable farming practices in Pakistan.

Planning and Development Division has played a crucial role in the successful implementation of Public Sector Development Program (PSDP) projects and has streamlined research funding through competitive grants under the Agricultural Linkages Program (ALP). These efforts are ensuring that innovative research continues to drive agricultural advancements in the country.

Agriculture is no longer just about traditional practices—it is about harnessing science, technology, and innovation to create a sustainable future. Through pioneering research, smart farming technologies, and scientific breakthroughs, we are paving the way for an agricultural revolution that ensures prosperity for our farmers and food security for our nation.

The research and development initiatives undertaken by PARC are shaping a more resilient, technologically advanced, and sustainable agricultural landscape in Pakistan. With continued investment in research, innovation, and technology transfer, we remain committed to transforming Pakistan's agriculture sector for a prosperous future.

Dr. Ghulam Muhammad Ali
Chairman, PARC

PICTORIAL GALLERY

Dr. Ghulam Muhammad Ali, Chairman, PARC during an interview with Ptv program "Subh e Pakistan" at NIGAB on Jan-15

Accountant General of Pakistan, Mr. Ahmar Ellahi called upon Dr. Ghulam Muhammad Ali, Chairman, PARC visited various research facilities at NARC.

Dr. Ghulam Muhammad Ali, Chairman, PARC addressing the worthy scientists, officers and staff members of PARC on the occasion of start of new year-2024 at NARC

Dr. Ghulam Muhammad Ali, Chairman, PARC presiding over the 53rd meeting of Technical Advisory Committee of Board of Directors of ALP at PARC

Animal Sciences Institute, PARC hosted National Training Workshop on "Sperm Sex Sorting and Cryopreservation Techniques in Water Buffalo" and "Laparoscopic Artificial Insemination in Sheep and Goat" at NARC, Dr. Ghulam Muhammad Ali, Chairman, PARC, graced the event as the chief guest

Dr. Kauser Abdulla Malik, Federal Minister, NFS&R, alongwith Ms. Jessica Mudjitaba Fernandez, Program Manager, USDA, Mr. keith Metzner, USAID, Dr. Ghulam Muhammad Ali, Chairman, PARC & Mr. Babar Ehsan Bajwa, CAPI's Senior Regional Director, Asia, presiding a dialogue on regulatory harmonization in Pakistan for maximum residue limits and Bio-pesticides

Dr. Kauser Abdulla Malik, Federal Minister for (NFS&R) chairing the stakeholders meeting of fertilize right pakistan project organized by PARC, ICARDA and USDA at NARC on Feb-19

Captain (R)Muhammad Asif, Federal Secretary for M/o (NFS&R) Chief guest, Dr. Ghulam Muhammad Ali, Chairman, PARC, Norwegian Ambassador to Pakistan, Dr. Knut Ingolf Dragset, leading scientist from Geno Global Norway during an international seminar on "Genetic potential and economic impact of Norwegian Red Dairy Cattle at NARC

Dr. Ghulam Muhammad Ali, Chairman, PARC addressing the National Consultation Workshop on Adopting Food Systems Transformation into Curriculum as Chief Guest.

Chairman PARC, Dr. Ghulam Muhammad Ali Presenting PARC Shield to Federal Minister for NFS&R, Rana Tanveer Hussain During his Visit to NARC Islamabad.

Chairman PARC Dr. Ghulam Muhammad Ali in a meeting with the Vice Chancellor, Kohsar Universityl, Murree, Dr. Syed Habib Bukhari to discuss matters of mutual interest

Dr. Ghulam Muhammad Ali, Chairman, PARC in a meeting with honorable Member, National Assembly of Pakistan, Dr. Nafeesa Shah during her visit at NARC.

Dr. Ghulam Muhammad Ali, Chairman, PARC addressing the Annual Rice Research Planning & Review Meeting at NARC

Dr. Ghulam Muhammad Ali, Chairman, PARC addressing Training workshop on Enhancement of Agricultural Productivity by Different water efficient Techniques at NARC, Islamabad on 20-05-2024

A group photo of chairman PARC, Dr. Ghulam Muhammad Ali alongwith the participants of the Mid-Career Management Course from National Institute of Management, Lahore

Chairman PARC, Dr. Ghulam Muhammad Ali chaired the National Seminar on "Validation & Establishment of Intensive Production Packages for High Value Fishes"

Dr. Ghulam Muhammad Ali, Chairman, PARC briefing the representatives from leading media networks of Pakistan on the latest research activities being carried out at NARC

Dr. Ghulam Muhammad Ali, Chairman, PARC during an interview with the ABN news discussing the notable accomplishments of PARC in the realms of agricultural research and innovation.

Dr. Ghulam Muhammad Ali, Chairman, PARC along with senior Natural Resources Specialist ADB, Ms. Noriko Sato and Principal Economist ADB, Dr. Takashi Yamano during a workshop.

Dr. Kauser Abdulla Malik, Federal Minister for M/o NFS&R chairing the 47th meeting of PARC Board of Governors at NARC.

Dr. Ghulam Muhammad Ali, Chairman, PARC is meeting with Ms. Eleanor Dean, General Manager Outreach & Capacity Building ACIAR, at PARC

Dr. Ghulam Muhammad Ali, Chairman, PARC in a meeting with Dr. Babar Ehsan Bajwa, CABI's Senior Regional Director, Asia. Dr. Imtiaz Hussain, Member PSD/Liaison officer CABI also present in the meeting at PARC

Dr. Ghulam Muhammad Ali, Chairman, PARC and Dr. Mark Smith, Director General, (IWMI) exchanging files after signing a letter of cooperation to strengthen collaboration and establish connections for conducting applied research on agricultural farming systems in Balochistan.

Dr. Ghulam Muhammad Ali, Chairman, PARC held a meeting with Dr. Thakur Prasad Tiwari,the Country Director of CIMMYT Pakistan, at NARC to discuss the matters of shared interest and collaboration.

Dr. Ghulam Muhammad Ali, Chairman, PARC and Dr. Cho Gyoung-Rae, Project Director, KOPIA Pakistan Centre signing TCPs for the construction of Green/Screen houses at NARC.

Dr. Ghulam Muhammad Ali, Chairman, PARC exchanging Letter of Intention with Mr. Li Zhaohu president Huazhong Agricultural University P.R. China at NARC

Dr. Ghulam Muhammad Ali, Chairman, PARC briefed a gathering of journalists from print, electronic & Social media regarding initiatives being undertaken at NARC.

Joint PARC-ZTBL Webinar on "Climate Resilient Agricultural Practices for Food Security" at PARC.

Honorable Federal Minister for M/o NFS&R Dr. Kauser Abdulla Malik in a meeting with Dr. Ghulam Muhammad Ali, Chairman PARC during his visit to PARC Hqs.

Dr. Ghulam Muhammad Ali, Chairman, PARC during an interview with Pakistan Television Program " Subh e Pakistan at NIGAB, NARC.

H.E. Jane Marriott British High Commissioner to Pakistan visited National Agricultural Research Centre, Islamabad

PLANT SCIENCES

PLANT SCIENCES DIVISION

The Plant Sciences Division (PSD) is dedicated to undertaking, supporting, promoting, and coordinating agricultural research. It is responsible for executing activities in coordination, research, and development pertaining to crop improvement, crop management, plant protection, plant genetic resources, food quality, and value addition.

National Coordinated Research

The Plant Sciences Division (PSD) oversees seven national coordinated research programs focusing on Wheat, Rice, Maize Sorghum Millet and Fodders, Pulses, Oilseeds, Sugar, and Horticultural crops. These programs are tasked with acquiring and distributing germplasm, conducting national testing, as well as planning and monitoring research activities in a coordinated manner. In accordance with the Seed (Amendment) Act, 2015, and Seed (Business Regulation Rules, 2016, the Pakistan Agricultural Research Council (PARC) is responsible for the impartial evaluation of varieties/hybrids developed by the National Agricultural Research System (NARS) in the country.

Germplasm Sharing

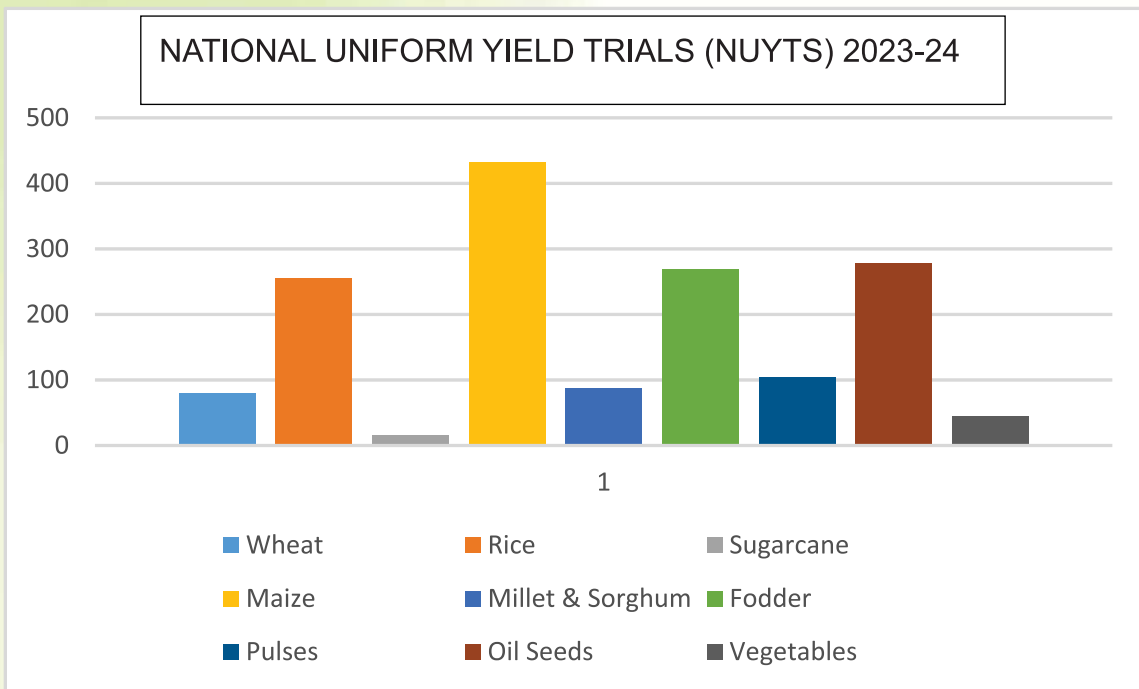
In 2023-24, the Plant Sciences Division (PSD) disseminated over 6,329 local and exotic germplasms of Wheat, Rice, Maize, Sorghum, Millet, Potato, Sugarcane, Soybean, and Pulses to relevant partners within the National Agricultural Research System (NARS). This initiative aimed at facilitating the development of improved and climate-resilient varieties/hybrids.

National Testing

The PSD conducted more than 1000 National Uniform Yield Trials (NUYTs) of different crops across multi locations nationwide, evaluating candidate varieties/hybrids spanning field and horticultural crops.

Variety Evaluation Committee (VEC)

Following Variety Evaluation Committee (VEC) meetings were conducted in 2023-



24. Among them the recommended verities/ hybrids of different crafts are listed in Table-1. These recommendations were based on the two years' performance data gathered from National Uniform Yield Trials (NUYT), and the endorsed varieties/hybrids were subsequently proposed for enlistment by FSC&RD or registration by Provincial Seed Councils.

Table 1. Details regarding varieties / hybrids recommended from VEC

Name of Crop	No. of Proposals Presented	No. of Varieties/ Hybrids Recommended
Rice	47	18 Hybrid, 3 OPV Basmati, 1 OPV Long Grain & 2 OPV Coarse
Wheat	07	06
Maize, Sorghum, Millet & Fodder	193	111 Maize, 03 Sorghum, 02 Millet, 33 Fodder crops
Pulses (Chickpea)	10	10
Oilseeds	23	01 Rapeseed, 03 Mustard & 04 Sunflower, 01 Groundnut & 01 Soybean
Potato	13	08
Sugarcane	04	02

Travelling Seminars

National Coordinated Programs organized Traveling Seminars on wheat, rice, pulses, and sugarcane, with the participation of 83 individuals from various institutions within the National Agricultural Research System (NARS).

- A 12-day Traveling Wheat Seminar was conducted from February 28 to March 11, 2023. Around 25 wheat stakeholders from Research and Development (R&D) institutes participated. The seminar aimed to evaluate the crop growth and performance of advance wheat lines in NUYT across various ecologies. It was noted that the wheat crop exhibited better growth due to favorable climatic conditions, increased use of certified seeds, and timely planting.
- Rice Travelling Seminar / National Uniform Yield Trials Evaluation 2023 was organized by the Plant Sciences Division (PSD) of Pakistan Agricultural Research Council in two phases (09-19th October 2023 and .23-26 October 2023).
- A Sugarcane Traveling Seminar spanning 13 days (December 08-20, 2023) was conducted, bringing together 11 sugarcane scientists from various Research and Development (R&D) institutes and private sugar mills across the country. The seminar involved the assessment of Sugarcane NUYT and the observation of sugarcane fields in diverse ecological settings.
- Travelling seminars for Rabi season pulses (chickpea and lentil) and kharif seasons pulses (Mung,Mash & Kidney Beans) were conducted involving 20 scientist from NARS system partners in 2023.

Annual Planning Meetings

National Coordinated Programs arranged Annual Planning Meetings for wheat,

pulses, and sugarcane, drawing the participation of over 50 individuals from diverse institutions within the National Agricultural Research System (NARS).

- The Annual Planning session for Wheat, held on October 09-10, 2023, at NARC Islamabad, brought together over 60 stakeholders. The meeting focused on addressing wheat-related concerns and concluded with a recommendation that wheat breeders should actively engage in developing varieties through local hybridization programs. This approach was seen as crucial for enhancing wheat productivity in Pakistan.
- Annual Rice Research and Planning meeting was held from 21-23 May 2024 at NARC.
- Annual Review Meeting was held in 2023, wherein progress of all stakeholders was discuss in details and future road map for sustainability in pulses production.

FIELD CROPS RESEARCH

Crop Improvement

Wheat

- Based on performance 16 advance bread wheat lines were provided for testing against different diseases in National Wheat Diseases Screening Nursery (NWDSN). 02 bread wheat lines were sent to FSC&RD for DUS study and 13 advance lines were contributed to the Provincial Uniform Wheat Yield Trials in the different provinces. As result, 05 advance bread wheat lines were contributed for testing in the National Uniform Wheat Trials (NUWYT). Two advance lines (NR 683 and NR 682) performed well in first year of NUWYT and got first and 8th position at Pakistan level under rain fed conditions. These lines will be released as varieties next year.

Hybridization

- 310 wheat populations from F0 to F6 generations rapidly. These wheat generations just took 12 to 14 months from the first filial generation to the sixth filial generation through this speed breeding facility, otherwise, they take 6 years in the field. Rapidly developed 800 wheat lines through this technology having different valuable traits are now under field trials for evaluation and selection by Speed Breeding Facility NARC.

Hybridization in Speed Breeding facility

Rice

- Evaluated multi-location yield trial with 25 lines across eight locations. Identified 12 top-performing genotypes from AYT for final station evaluation; advanced 6 lines to National Uniform

Molecular evaluation of Rice Germplasm (XA 21 marker on Advance GSR Lines; XA 07 marker on Advance GSR Lines

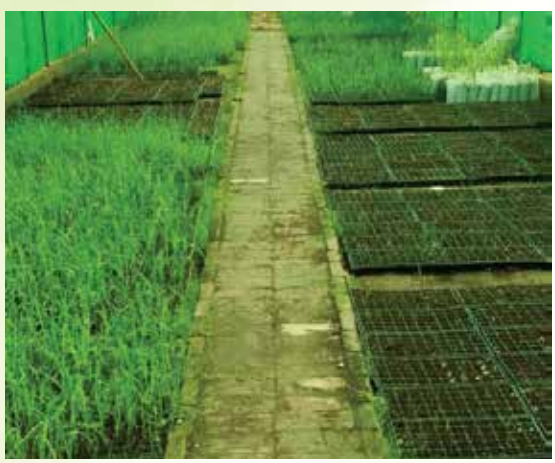
Yield Trial (NUYT).

- Developed new combinations with traits like high yield and BLB resistance; raised and advanced various filial generations (F1 to F4); performed marker-assisted selection.
- Evaluated 10 rice genotypes under controlled flood conditions using three treatments (control, ethylene-treated submerged, untreated submerged). Identified six submergence-tolerant genotypes (GSR-5, GSR-61, GSR-13, GSR-2, GSR-4, and Chenab basmati) using SSR marker-based genotyping.
- Conducted TGMS line development and crossed 25 GSR lines with TGMS source genotype, achieving 26 successful cross-combinations.

Rice Transplantation at beds

Sugarcane

- A total of 7500, 695, 71, 35 and 7 respectively sugarcane lines were tested in 1st, 2nd, 3rd and 4th cycle. The respective genotype number of promoted genotypes to next stage were 3150, 172, 37, 10 and 6 respectively
- A total 6 promising sugarcane genotypes, i.e. Th-2107, Th-2108, Th-2112, Th-2120, Th-2124 and Th-2126 along with check variety i.e Th-2109 were tested. Resultantly, 4 genotypes i.e. Th-2107, Th-2112, Th-2120 and Th-2126 were selected for next stage.
- A total 5 sugarcane varieties i.e. Th-2009, Th-2026, Th-2041, Th-2042 and



Sugarcane Seedlings developed through bud chip technology at PARC-NSTHRI

Th-2043 developed from local fuzz along with check variety Yt-55-Thatta was re-tested for confirming previous results.

- Two promising sugarcane lines Thatta-1909 and Th-318 of NSTHRI Thatta were selected for NUVYT, which were planted at 9 different institute.

Oil Seeds

- Sunflower hybrid SMH-1900 J developed by NARC scientists submitted to PARC Variety Evaluation Committee for recommendations in 2024. Sunflower hybrid NARC-SUN-2020 developed by NARC scientists submitted to PBR for patent protection. 61 and 173 inbred lines (A, B & R) of sunflower and rapeseed, respectively and 600 accession/lines of soybean were planted for screening, purification, maintenance and seed increase. Twenty two (22) and twenty eight (28) new hybrid combinations were, respectively made in sunflower and rapeseed during 2023- 24
- Groundnut variety NARC-Nawaz (PG-1254) developed by NARC scientists submitted in PARC Variety Evaluation Committee for recommendations.
- Soybean variety NARC-Golden-Soy developed by NARC scientists submitted in KPK Seed Council for registration for the commercial cultivation in KPK province

Pulses

- Two new varieties of Lentil (NARC Lentil 24) and Mung bean (NARC Mung 24) have been recommended from VEC for approval from seed councils in the 2nd meeting of the Pulses VEC held on April 16, 2024 at PARC. The proposals for the approval from seed councils are being prepared.
- Two advance lines of Lentil (LS-21-01 and LS-21-02) completed 2 years of NUYT and DUS and DNA fingerprinting and the case is being prepared for recommendation from upcoming Pulses VEC.
- In Pothwar conditions, Abbas Mung outperformed other recent varieties, including (NM-21, NM-11, NM-16, AZRI-21 and Jumbo Mung).25 kg/ha seed rate along with 30 cm row spacing for mash candidate line (NMS-21-02) may be recommended for getting its higher production in Pothwar conditions.

NARC Lentil 24

NARC Mung 24

Fodder

- Germplasm evaluation, purification and seed multiplication of sorghum (120 line); Millet (180 lines); Oats (170 lines); Sudan grass (21 lines); Barley (34 lines); Vetch (13 lines); Cowpea (30 lines); Maize (50 lines)
- Selection and evaluation of 48 oat genotypes on the basis of green fodder yield, lodging resistance, stay green characteristics (late maturing)
- Refined production technology of six major fodder crops (oat, vetch, mott grass, maize, Sorghum and millet)
- Six oat, five ryegrass, four vetch and four millet advance lines were

contributed in National Uniform Fodder Yield Trials (NUFYT)

Maize sorghum & millet

- 470 inbred lines were evaluated, and generations were advanced. Twenty-seven distinct maize inbred lines were assessed for heat stress tolerance.
- A total of 180 new hybrid cross combinations were developed, and in the Preliminary Yield Trials (PYT), 125 hybrids were evaluated. The most promising hybrids were selected for further testing.
- 29 more proso millet genotypes were obtained from PGRI and were subsequently planted in the PGRI glasshouse in collaboration with Director PGRI. Among the 29 newly acquired genotypes, 2 were identified as foxtail, and two were not germinated.

Haq Nawaz Gold a Maize

NARC POPs a Maize Variety

Seed Production

- During 2023-24 about 365 tons of wheat seed of different categories was distributed among 30 public/ private seed companies and farmers. During this cropping season 2023-24 about 330 tons of seed has been produced and is expected to be available for the next cropping season (2024-25).
- Pulses seeds comprising Mung bean (1800kg), Mash (835kg), Chick pea (1600kg) and Lentil (710kg) was produced.
- Oilseeds Program produced 267 tons of soybean (produce 150tons&117tons quality seed) and NARC Sarson (6.83 ton), Groundnut (0.05 ton), linseed (0.085 ton) and sunflower (0.48 ton) quality seed provided to farmers .
- Established stool beds of Apple (MM 111, M 26), Pear (Quince), Cherry (Colt) and plum root stocks.
- Planted 2,000 cuttings and grafted 1,000 seedling rootstocks of kiwifruit cultivars for the production of true to type plants.

TEA & HIGH VALUE CROPS

- Selected superior cultivars of kiwifruit i.e. Hayward, Hongyang, Bruno, Hort-16 and Allison on the basis of plant growth, yield potential and fruit quality under the local climatic conditions. The following intra and interspecific crosses were carried out at NTHRI and farmers kiwifruit orchard (Baffa) for cultivars improvement through hybridization.

{a. Hayward (♂) × Hongyang (♀) b. Hayward (♂) × Bruno (♀), c. Hayward (♂) × arguta (♀) d. Arguta (♂) × Hongyang (♀), e. Arguta (♂) × Bruno (♀), f. Arguta (♂) × arguta(♀)}

- 196.9 liters of olive oil was extracted out of 1,912 kg olive fruit collected from farmer's fields. The average percentage of olive oil is 10.30%. 9,000 disease free and healthy nursery fruit plants were produced during the year 2023-24 at PARC-PFRS Tarnab Peshawar. Budded/grafted 4,000 rootstock plants of various fruits species for the propagation of temperate fruits species. Collected 35 cultivars of various fruits species from reputable organizations for introduction and evaluation

under the local conditions. Established adoptability trials of kiwifruit cultivars in Gilgit-Baltistan, Swat and Shangla on farmer's fields. Processed pulp of Peach (140 kg), Plum (200 kg), Apricot (200 kg), Apple (250 kg) and persimmon (150 kg).Produced 2,500 jam bottles of different fruits.

Dr. Ghulam Muhammad Ali, Chairman PARC, Briefing Chinese Tea Experts at NTHRI, Shinkiari

Kiwifruit Nursery and Orchard at NTHRI, Shinkiari

Olive Nursery and Orchard at NTHRI, Shinkiari

HORTICULTURAL CROPS

PAKISTAN AGRICULTURAL RESEARCH COUNCIL

HORTICULTURAL CROPS

Fruits

Razaki seedless variety of Grapes was approved from KP seed council. The Fruit Crops Research Program acquired Grape germplasm from Turkey and evaluated at HRI, NARC. Results revealed that 'Razaki' is very early maturing variety in comparison with the check variety 'Superior Seedless approved as Shogra-1' and have the potential to be cultivated on commercial scale in sub-tropical areas of the country including Khyber Pakhtunkhwa and Potohar region of Punjab. On the basis of encouraging results obtained in terms of fruit production and quality, a complete package of production technology has been developed at HRI, NARC. The technology developed by the scientists has a special significance because early crop harvest would bring higher returns to growers.

Spot examination

i. Selected 04 Citrus cultivars out of evaluated 19 exotic citrus germplasm & 02 rootstock out of 08 citrus rootstock. Registration with FSC&RD is in process.
ii. Selected 04 Avocado lines for registration and approval out of evaluated 08 avocado lines.
iii. Evaluated 08 kiwifruit cultivars at NARC Islamabad.
iv. Evaluated 02 Dragon fruit germplasm for adaptability.

CROP IMPROVEMENT & MANAGEMENT

1. Establishment of Germplasm Unit (GPU) of fruit plants at NARC

Established GPU of different fruit plants (Fig, Peaches, Grapes, Plum, Apricot, Pear, Litchi, Citrus, Pecan nut, almond and Kiwi). Most of the available fruit varieties were planted in the foundation/evaluation block and some registered varieties were also planted in the multiplication blocks. Graft wood and bud wood of different registered varieties were collected from registered GPUs and grafted/budded on local root stock under the supervision of FSC & RD to produce true to type plants of the registered varieties. Now the plants planted in GPU are healthy, well managed and growing vigorously.

Plantation of plants in GPU under the Supervision of FSC & RD

Bio-economic analyses of pear plants planted at low and high densities at HRI, NARC Islamabad.

From the results of the experiment, it is obvious that shading at high density has adverse effect on fruit set, fruit yield per plant and total yield and income per acre. The best results were obtained when pear plants were planted at the recommended row to row and plant to plant distance of 20 feet.

2. Impact of hand thinning on the qualitative and quantitative attributes of peach

Thinning practice optimized for 5 days after petal fall and at 10cm fruit distance The

following orchards were established on farmer field with the technical support of scientists of Fruit Program, HRI. The activities for the establishment of orchards right from providing plant materials plantation, management till fruiting were carried out under the supervision of scientists from Fruit Program, HRI.

3. Evaluation of Citrus varieties under Potohar Region

Fruit load management in peaches

Evaluated exotic and local citrus varieties including Cara Cara, Beyanda V, Tangor, Hamlin, Mars Early, Blood Red, Moro, Toroco, Salustiana, T. Malta, Sangunelo, W. Noval, V Late, Hockney, R. navel, Clementard, Fisher, Mc.Valancia Daisy Madarine, Keenan V, Nules, Handerson, Caffin, Lane Late, Sherkhan-1, Succari, Fremont, Berry V, Shamber and W.Pumelo in the evaluation blocks of GPU.

4. Evaluation of Kiwi varieties under Pothowar Region

Citrus Varieties

Eight varieties of Kiwi (Actinidia spp.) viz., Hayward, Hongyang, Hor 16A, Jinyan, Actinidia argute, Actinidia farinose, Allison and Bruno with their respective male varieties are being evaluated at HRI, NARC for adaptability.

Kiwi Varieties

5. Evaluation of different Citrus rootstocks for growth performance of scion varieties under field conditions

Citrus root stock Cox, Troyer citrange and Carrizo citrange showed promising results in terms of growth performance for Kinnow and Tarocco scion varieties. Rootstock Cox interacted significantly with Tarocco for graft union dia (18mm A), leaf area (50.9cm2) and root length (18.33mm) whereas Troyer and Carrizo citrange interacted ominously with Kinnow for different growth parameters. For leaf nutrient composition, Carrizo absorbed more Zn (21.07 ppm), Fe (46.13 ppm) and Cu 16.15ppm) whereas, Cox accumulated more P and K showing1.12%and 2.85 %respectively. Distinctness uniformity stability studies (DUS) of above mentioned rootstock for the 1st year were conducted by FSC&RD officials.

Citrus Rootstock

6. Optimization of Clonal Propagation in Avocados Objective(s)

To optimize asexual propagation technique for mass scale production of true-to-type avocado plants, the study was planned to evaluate four different grafting techniques (Cleft, Tongue, Patch and T-budding) in ten different cultivars of avocado. The outcomes suggested that Cleft grafting was most suitable one among all other evaluated techniques. The highest survival rate (27.40%) was recorded in cleft grafting. Moreover, vegetative characters, i.e., no. of leaves & leaf area, no. of internodes & inter-nodal length, shoot length & diameter were also higher in cleft and tongue grafting as compared to other grafting method. Among cultivars, NARC-Feurte and NARC-Purple give the best outcomes.

Clonal Propagation

Developmental Activities

1. Nursery Plants Production Through Sexual means

- Guava = 500
- Citrus Rootstock = 2000
- Loquat = 500
- Avocado = 2500
- Pecan = 3500

Through Asexual means Cuttings

- Fig = 1400
- Grapes = 2100
- NARC-Mexican Lime = 2500
- Sweet Lime = 2000

Grafting/budding

- Citrus = 2500
- Peach = 2700
- Avocado = 300
- Plum= 200
- Apricot= 350
- Almond= 350

Construction and Inauguration of Green House under TIKA Project

- This semi-controlled green house facility will increase the survival rate of both exotic and local fruit germplasm.
- Facility will be utilized for handling high value fruits including Dragon fruit, Blue berry, kiwifruit, avocado and others.

FLORICULTURE

FLORICULTURE

A. Varietal development

Six varieties of flowers have been developed at floriculture Program, HRI, NARC. Two years DUS for three varieties have been completed (NARC-Snow-1, NARC-Nargis-Yellow & NARC-Nargis- White) while 2nd year DUS of other three varieties (NARC IRIS yellow, white and purple) will be completed in the next year season.

NARC-Snow-1

NARC-Snow-1 is potential Cut variety of Chrysanthemum with stem length more than 30 cm and flower head maximum diameter of 8cm and maximum shelf life in field as well as in vase. It is bushy in nature and Semi-upright inflorescence.

NARC-Nargis-Yellow

NARC-Nargis-Yellow are bunch flowered, annual and bloom in winter. Scape length of flower is 27.7 cm with more than 7 flower in single spathe. It is fragrant, early maturing and had good shelf life.

NARC –Nargis-White

NARC-Nargis-White are bunch flowers with leaf length more than 47 cm. Scape length of flower is 32cm with than 9 flowers in single scape. They are fragrant with good shelf life.

NARC- Iris-White

NARC-Iris-white are seasonal with more than 67cm of height. The flower size is large with 43 cm of peduncle length. Filament color is white and maximum shelf life from yellow and white. Variety is potential cut variety of Iris.

NARC-Iris-Yellow

NARC-Iris-Yellow are seasonal with plant height more than 57cm of height. The flower size is medium with 36cm of peduncle length. The variety is potential cut variety having flame like spot on blade.

NARC-Iris-Purple

NARC-Iris-Purple is seasonal with 53 cm length. The flowers are early maturing with small size as compared to others with 21cm of peduncle length. The filament color is purple with flame like spot on blade of outer tepal.

Breeding, Selection and F1 hybrid seed production in Lisianthus (Eustoma grandiflorum) for different color combination.

Double petal broad ruffled flowers, green and blue showed maximum mean value for required market value parameters which are plant spread (23 cm), stem length (32 cm), number of flowers (15.333 cm), flower diameter (8.733 cm), and bud diameter (9.52 cm).

Crop management and introduction of Novel specialty cut flowers

1-Effect of Salicylic Acid and Magnesium Sulphate on vegetative and reproductive growth of Dutch Iris

Various concentrations of magnesium sulfate (MgSO4) and salicylic acid (SA) were applied as foliar spray as different treatments (Control, 1% SA, 2% SA, 1% MgSO4, 2% MgSO4 and combination of 1% SA & 1% MgSO4. The study had shown that foliar application of 1% Salicylic Acid (SA) along with 1% Magnesium Sulphate (MgSO4) had a significant impact on vegetative as well as floral growth in iris plants. Foliar spray of 2% Salicylic Acid (SA) was found highly effective to produce largest size of bulb (3.52a±0.34cm) as well as maximum number of bulbs (6.60a±0.20).

2. Efficacy of various postharvest applications and preservative solution for extended vase life of specialty cut flowers.

Significant improvements in post-harvest parameters, including increased vase life (up to 12 days), reduced water uptake, and lower bacterial growth in treatments with citric acid and salicylic acid. Additionally, these treatments exhibited improved stem freshness, flower color retention, and reduced wilting, indicating enhanced water relations and stress tolerance.

3. Genetic diversity and performance evaluation of marigold based on morphological characters.

Significant variations were achieved that will be utilize for hybrid development. The marigold genotypes demonstrated the best results in “flower color” varying from white to golden yellow and “flower diameter” range from 54.44 mm to 94.6 mm, with more number of flowers per plant (12-46) and larger blooms that make them suitable for further evaluation and hybrid development.

C. Training Workshop for Floriculture & Flower arrangements for Capacity Building

Conducted training on “Cut Flower Production and Flower Arrangements” for capacity building. Trained more than 70 participants to coup farmers, researchers from different research organizations and universities with the production technology of ornamental flowering plants.

Floriculture program has marvelously projected PARC's excellence across 11 esteemed institutions and organizations in 33 different categories of competition during 2023-24

POTATO PROGRAM

Screening of Potato Germplasm Against Viruses

Eighteen potato clones were used for screening against important viruses viz. potato virus Y (PVY) and potato leaf roll virus (PLRV). For screening against PLRV, chip grafting method was used. For confirmation of viruses ELISA was used. PVY was mechanically transmitted. The screening experiment conducted under controlled conditions in the glasshouse showed that out of eighteen lines/approved varieties, two were found highly resistant against PVY i.e. VRI &VR2, while VR4 &VR7 showed resistant response, VR5, VR10, VR12, VR14, VR15 moderately resistant response, VR11, VR13 &VR16 showed moderately susceptibility response, VR3 was susceptible against PVY. PLRV was chip grafted. The screening experiment conducted under controlled conditions in the glasshouse showed that out of eighteen clones/approved varieties, five were found highly resistant against PLRV I.E. VR1, VR2, VR3, VR13, VR15. VR4 & VR9 showed resistant response, VR5, VR7, VR10, VR12, VR16 exhibited moderately resistant response. VR6, VR8, VR11 and VR17 showed moderately resistant response. One clone VR14 was susceptible to PLRV.

Already infected potato with PVY & PLRV

Potato clones before and after inoculation

Evaluation of Potato clones for high yield and quality attributes

Evaluation of fifteen potato clones for high yield, dry matter, and value addition was done. Results revealed that G13 exhibited the highest number of tubers per plant (16) and the greatest tuber weight per plant (1.56 kg), while G5 had the lowest in both categories. G4 had the smallest tubers (107), but G6 excelled in medium tubers (101), and G14 led in large tubers (64). G4 also had the heaviest small tubers (2.71 kg), G6 had the heaviest medium tubers (6.22 kg), and G8 had the heaviest large tubers (12.43 kg). G6 had the highest total number of tubers (224), whereas G14 had the heaviest total tuber weight (17.61 kg). G8 achieved the highest yield (45.64 ton/ha), and G9 had the highest dry matter content and specific gravity (22.1 and 1.089, respectively).

Vegetable Crops

184 advanced lines of indeterminate tomato were grown for their seed increase, general assessment of performing attributes and disease (Early blight & Tomato Leaf Curl New Delhi Virus). Yield potential ranged from 64.27 to 54.31 t/ha in comparison to the checks (51.20 to 30.01 t/ha). 37 advanced lines were found resistant against the emerging Tomato Leaf Curl New Delhi Virus.

REGISTRATION OF PRODUCTIVE CHILLI LINES FOR VARIETY RELEASE:

04 advanced lines of chillies have been selected for variety approval.

BASELLA; A NEW INTRODUCTION IN PAKISTAN:

(Basella rubra L.), vine spinach can be used as vegetable and an ornamental, grown through seeds and cuttings with edible leaves, twigs, stem and seed. It is ready for final approval.






NEWLY DEVELOPED SCREEN HOUSES FOR FACILITATING BREEDING ACTIVITIES IN DIFFERENT VEGETABLE CROPS:

Cabbage

Sixteen genotypes of cabbage have been maintained in screen house. Maintenance of sixteen genotypes under controlled pollination (selfing) was ensured to retain S1.


Cauliflower

Eighteen genotypes of cauliflower were characterized and seed was maintained under screen house.



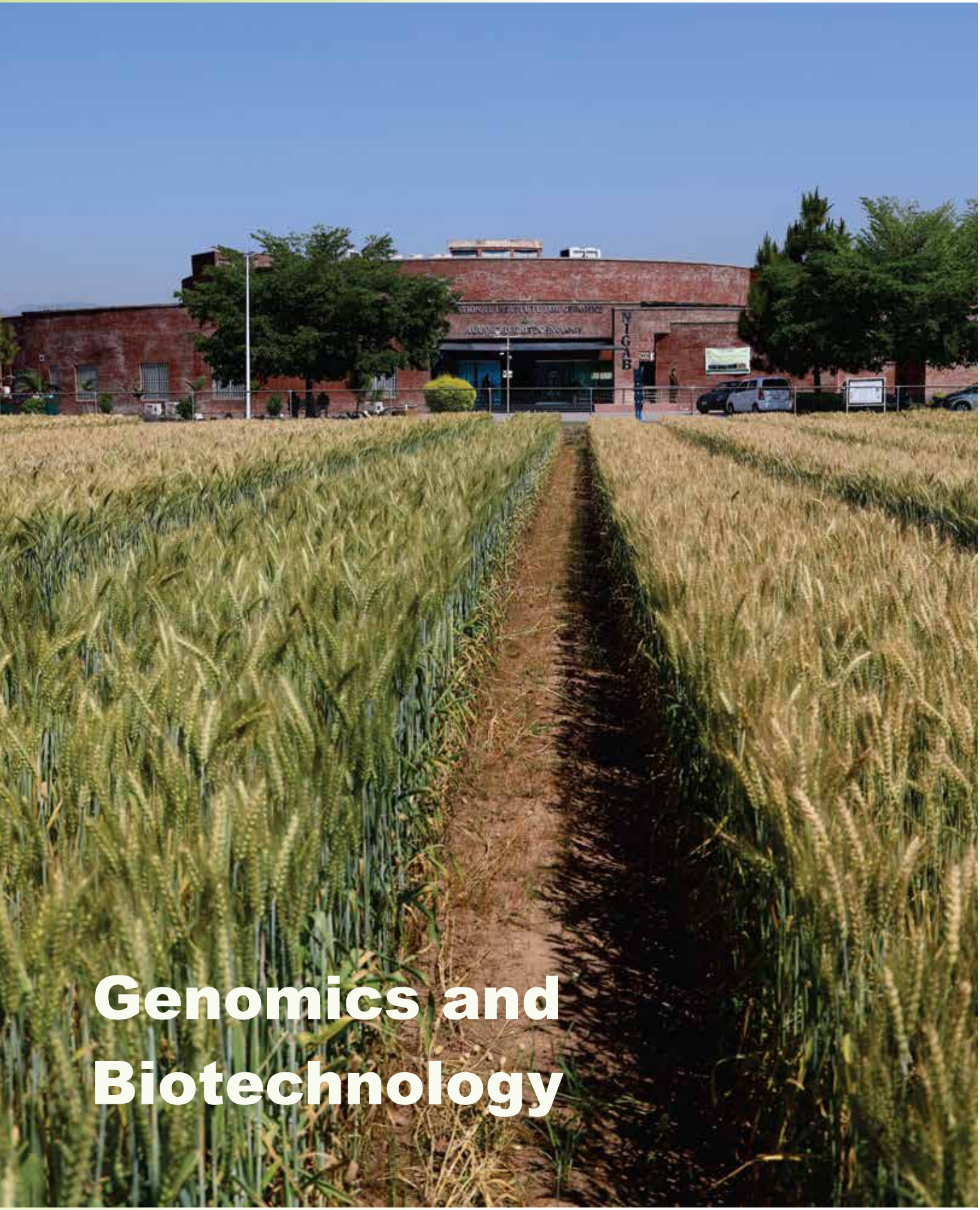


Turnip

Seed of twenty genotypes of turnip was maintained under the screen house facility.

Seed maintenance of non-traditional vegetables

Seed of non-traditional winter vegetables (Kale, Brussel sprout, Pak choi, Kohl rabi, Broccoli, Chinses cabbage, Rocket salad, Chicory, Asparagus, Artichoke, Celery, Sweet pepper, Parsely, Iceberg, Red lettuce, Leek & Swiss chard) was maintained under screen house facility at HRI, NARC.

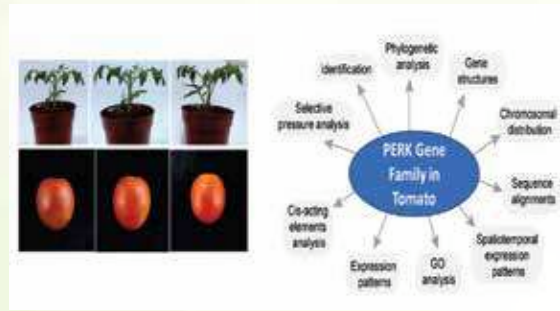


Genomics and Biotechnology

Genomics and Biotechnology

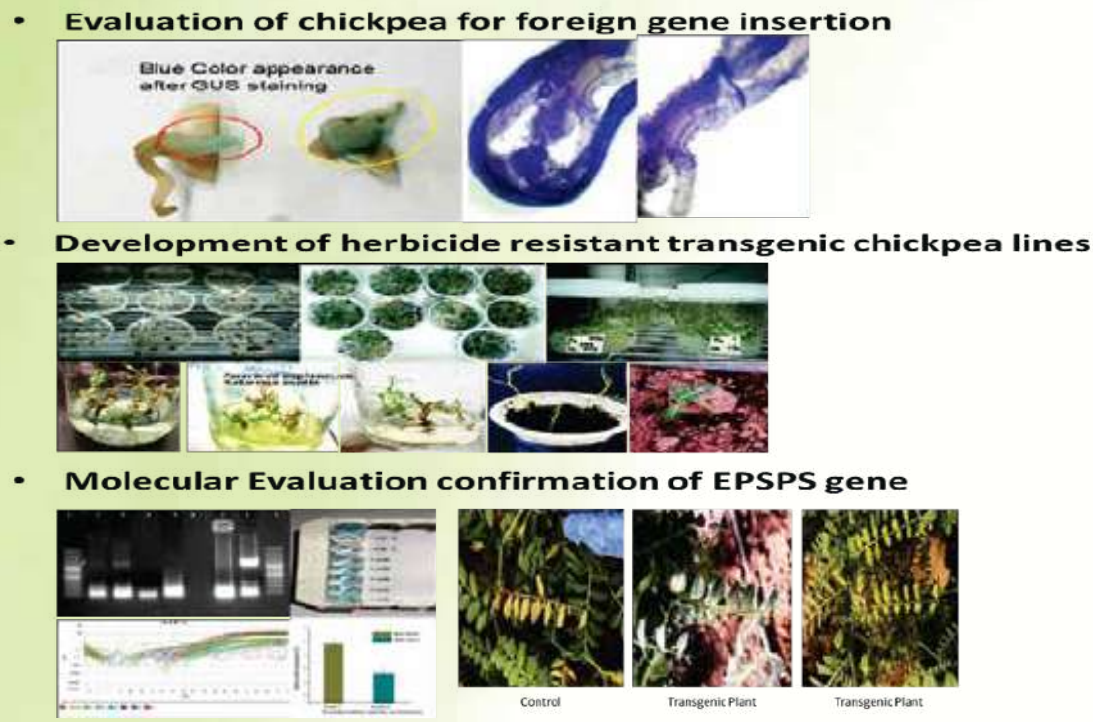
Transgenic Research

- Genome wide identification of PERK gene family was find out under abiotic stresses in tomato through various computational tools (Figure 1).



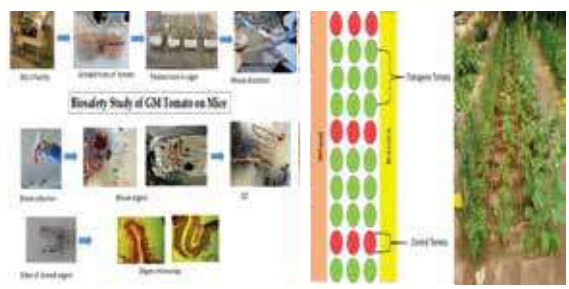
Identification of PERK gene family in tomato

- Herbicide resistant gene (EPSPS) was transformed into two cultivars of chickpea. Transgenic chickpea was advanced to T4 generation under control condition and molecular evaluation confirmed the presence of transgene in T4 generation (Figure 2). One patent was submitted from this finding to IPO-Pakistan.



Development of herbicide resistant transgenic chickpea plants

- First round of biosafety testing trials of transgenic cold tolerant tomato on environmental and health related aspects were performed successfully for assurance to ascertain their safety. Second round of biosafety trials on mice health are under process.

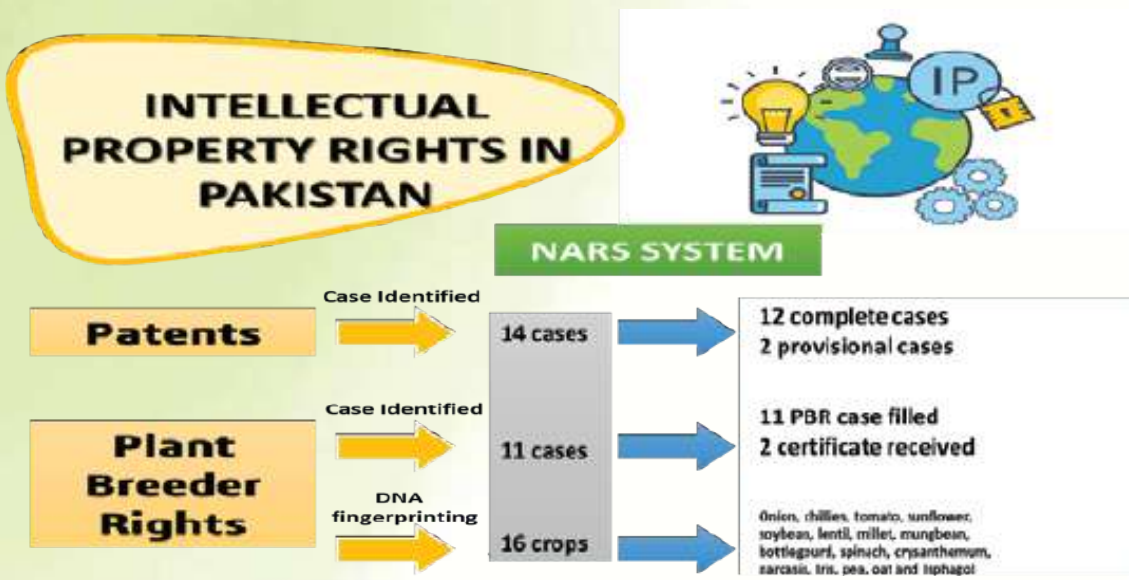


Biosafety testing of GM tomato (Health and environmental safety)

- Strengthening of IPRs for NARS technologies project activities; we have filed 14 patent and 11 PBRs cases (4 Rice varieties (GMALI-48, RICE-GMALI-76, RICE-GMALI-5, KM-52) 1 sunflower variety (NARC-SUN-2020), 2 Banana varieties (NIGAB-1, NIGAB-2) 2 Wheat varieties (NARC Super, Galaxy

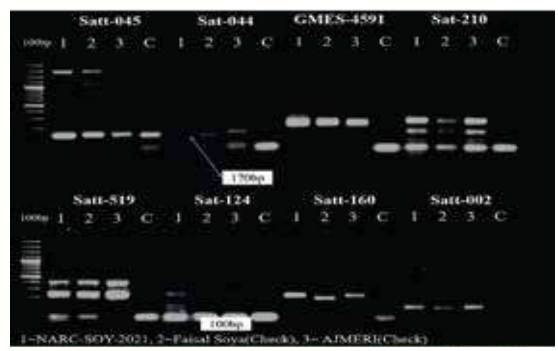
2019), 2 Soyabean varieties)

Sr#.	Patent Application Number	Title
1	589/2020	Cradle for laparoscopic Artificial insemination and embryo transfer in Goats
2	67/2021	Transgenic maize with improved salt tolerance
3	68/2021	Transgenic Tomato DNA with improved Cold tolerance
5	325/2022	A thermostable formulation of pest des petits Ruminants (PPR) vaccine using local isolate
6	543/2022	Improved Portable Precision Seed Planter
7	583/2022	Genetically Modified Peanut (Arachis Hypogaea L.) for Glyphosate Herbicide Tolerance
8	888/2020	A DNA based method for identification of olive cultivars
9	542/2022	Integrated pest management of ectoparasitic mites, varroa destructor and Tropilaelaps clareae in honey bee, Apis mellifera colonies
10	423/2022	A quick DNA based method for identifying date palm gender
11	297/2023	A precision seed metering roller for seed planter
12	742/2023	Method of herbicide resistance gene and codon optimization in Chickpea
13	482/2023	A novel DNA Markers based method for identification of sugarcane varieties
14	108/2024	Psyllium Core Separator and Husk Classifier



IPRs Identification and filing for NARS Technologies

- DNA fingerprinting of 16 crops (Onion, chillies, tomato, sunflower, soybean, lentil, millet, mungbean, bottlegourd, spinach, crysanthemum, narcasis, Iris, pea, oat and Isphagol) were completed and their results were dispatched to the relevant institutes for their PBR cases compilation/submission.



- We have organized two awareness workshops related to agricultural IPRs at AWKUM and university of Swat.

- CRISPR-Cas9-based Genome Editing for Reduced Enzymatic Browning in Potato Tubers. Fresh internodes of potato plantlets were isolated and infected with transformed Agrobacterium having pCAMBIA1300 2xsgRNA-Cas9 for 20 minutes. The explants were shifted to Cocultivation media for 2 days in dark at 22 °C. After two days of cocultivation, the washed and filter dried explants were shifted to pre-selection media. The plates were incubated in 16/8 light/dark period at 22°C for 07 days. After 07 days, explants were transferred to selection media having 50 mg/L Hygromycin as a plant selectable marker. The explants were regenerated on selection media (Figure 6 and 7). 5 cm long shoots were shifted to rooting media and were incubated in 16/8 light/dark period at 22°C for 3 weeks. During this period roots were developed by the regenerated shoots. Healthy shoots with well-developed roots were acclimatized and transferred to soil.

Shoot regeneration from internodal parts on shoot Regeneration Media

A. Inter nodal parts of potato as ex-plants, B. Ex-plants on regeneration stage, C. Ex-plants on selection stage, D. Regenerated plant on shooting stage

A, Root regeneration from shoot; B, Acclimatized plantlets in soil

- Four advanced rice lines developed through Conventional and genomic approaches have been recommended by Variety Evaluation Committee in March 2024. Moreover, 02 rice lines are in the second year of evaluation in NUYT.
- In Next Generation Sequencing, upgradation of software and programs in SP-100, DNB loader and T7 sequencer was done. Procurement of Tape-station, Nanodrop and consumables.Successful completion of 32 rice WGS, 48 samples of tomato, 14 samples of wheat and 16 samples of rice for RNA-Seq.
- Lectin Gene Transformation in Cotton for Increased Resistance against Sucking Insects (Aphid). Successfully Design gene specific primers and confirmation of lectin gene construct. Reproduced Agrobacterium mediated gene transformation of Lectin gene in cotton variety at NIGAB.
- Down regulation of StDMR6 gene through CRISPR/Cas9 genome editing in potato for increased late blight resistance. Confirmation of CRISPR Cas9 based vector for DMR6 gene. Confirmation of Transformed vector to Agrobacterium tumefacien.
- In Green Super Rice project, already developed twenty-eight hybrid rice combinations were evaluated for yield and yield related traits at NARC and Dokri Sindh using LP-18 and LP-26 commercial hybrids as checks. Four best combinations were identified compared to check hybrids. The experiments have been set at NARC for pilot scale hybrid seed production during kharif 2024.
- Identified proper ecology for maintenance of TGMS lines in temperate regions of Pakistan. Seven different F4 populations were advanced to next filial generation during kharif 2023. Bulk breeding method is in progress. The F1 seeds of 26 different combinations were grown and ten different F1s were backcrossed with recurrent parents. Four BC1s were successfully developed during Kharif 2023. Targeted traits are aroma, grain yield and BLB resistance. Moreover, all 26 combinations were allowed to self-pollinate and F2 seeds were harvested. Spot examination experiments for four VEC recommended rice lines were set in Punjab and KP during kharif 2023. DUS experiment was conducted at NARC. 592 rice lines were multiplied and conserved in gene bank facility of PGRI. Morphological descriptors of 552 lines were prepared during kharif 2023. DNA fingerprintings of eight VEC recommended rice lines were furnished and submitted to FSC&RD. Applications have been submitted for four VEC recommended rice lines to Plant Breeders' Right Registry for varieties protection. 550 GSR lines were screened for submergence tolerance at germination and seedling stage. The 35 promising submergence tolerant rice lines were identified and were further screened with different markers related to Sub1A genes. 200 advanced rice lines were screened

Screening of Developed Germplasm against Bacterial Leaf Blight

Representative picture of hybridization experiments

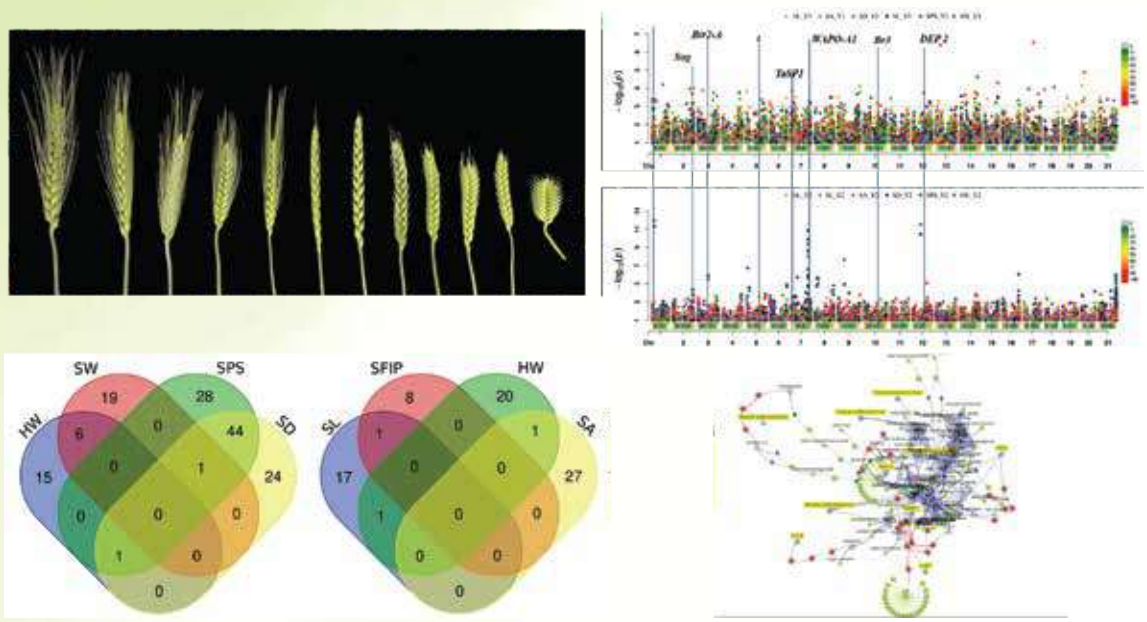
for cold stress under natural temperate region at Upper swat and based on cold tolerant index and mean productivity, the 50 promising rice lines were selected for molecular screening and second year field trial. 552 rice lines were screened against Bacterial Leaf Blight (BLB) in field condition (Figure 11). Twenty-eight (28) lines were found resistant and 340 lines showed moderately resistant reaction against BLB. VEC recommended rice lines were screened for different major BPH resistant genes. Expression analysis of four BPH resistant genes were also carried out after exposure to BPH. 200 advanced rice lines were screened for salinity stress under natural saline condition at Pindi Bhattian and based on salt tolerant index and mean productivity at 6-8ds/m saline soil, the 35 tolerant rice lines were selected for molecular screening and second year field trial. Calibration and optimization of high throughput phenotyping (HTP) of rice field was done. NDVI, plant height and yield estimation models have been developed (Figure 12). The validation of optimized protocol will be done in coming seasons. About two (02) tones seed of four VEC recommended lines were produced during Kharif 2023.

2. Functional Genomics and Bioinformatics

1. Genomic selection and genome editing in rice, wheat, sugarcane and tomato

Acquired/developed a total of 315 rice germplasm line including; 268 from IRRI and 47 from CAAS China. Among these, evaluated 268 IRRI lines for genomic studies, 20 backcross population along with parent, 11 salt tolerant population, 8 grain quality and yield, 6 bacterial blight resistant at NARC in 2023.Two lines with best yield, quality and BB resistant traits were selected for NUYT submitted to FSC&RD. Developed crosses between basmati/non-basmati rice and 2 TGMS, salt tolerant and BB lines. CRISPR/Cas9 expression cassettes were constructed using golden gate ligation method to knockout the GS2 and GS3 genes for yield enhancement. Unveiled the regulatory network by expression profiling of lncRNAs, miRNAs and mRNAs in response to alkaline-salt stress. RNA-Seq based transcriptomic study for two contrasting rice genotypes for tolerance to salt stress was conducted. Findings revealed 3982 and 3463 differentially expressed genes in salt-susceptible S3 and salt tolerant S13 genotypes.

In wheat under Sino-Pak project evaluated diverse germplasm of wheat acquired



GWAS for spike architecture traits in landraces panel of wheat

from different sources CIMMYT, UAF, AARI, BZU and CAAS, China. Evaluated 26 wheat lines at 6 multi-locations across the country since last two years, evaluated 150 advanced lines in preliminary yield trials, selected 30 advanced lines for station yield trials. Developed HTP phenomics platform, drone-based data acquisition of NDVI, canopy temperature, crop growth rate. Root, spike, canopy and grain architecture, tiller angle phenotyping via imaging analysis (Figure 13). NGS data acquisition and analysis of association panel: DArTSeq genotyping (75K SNPs) of landraces (n=161), GBTS (50K) of historical cultivars (n=195) and Axiome capture method (30K SNPs) of diverse wheat germplasm (n=336) was performed. After acquiring 2nd year field data, GWAS analysis were performed, identified 9, 4 and 6 candidate genes for root, canopy and spike architecture traits respectively.

In sugarcane, maturity parameters, and various other morphophysiological traits data were collected including the Brix % and yield estimate of sugarcane lines developed from acquired material (88 crosses) from China. Selected 59 and 12 sugarcane lines were cultivated in Nursery 2 and 3, respectively. 16 sugarcane lines have shown a yield potential of >150 t/ha. Multi-location evaluation trials were conducted at four provincial sugarcane research institutes in Pakistan including SCRI, Mardan, SRI, Faisalabad, SSRI Jhang and NSTHRI, Thatta.

Maintained the developed germplasm repository of 58 Sugarcane approved varieties and lines. Vector construction was done using the CRISPR/Cas-9 mediated gene editing for Vacuolar Invertase to enhance sucrose biosynthesis in sugarcane. Utilizing the Axiom 100K SNP genotyping array, developed KASP genotyping protocol for fingerprinting of sugarcane germplasm and performed population genetic diversity analysis including Multi-correspondence (MCA), Admixture and phylogeny analyses which revealed ancestry relationship among sugarcane genotypes and the percentage among population makeup and their genetic share (%) in making a genotype where suitable K value remains equal to 7.

Research activities for CRISPR/cas9 mediated disruption of VIS1 gene in tomato for shelf-life enhancement under ALP project were carried out. Newly constructed the CRISPR/Cas9 expression vector was used for transformation of and got 4 putative transgenic tomato plantlets. Presence of Cas9 gene is confirmed by PCR. 10 putative transgenic plants are on acclimatization 50 regenerated plantlets are on different doses of hygromycin selection (Figure 16). For detection of editing, putative transgenic T0 plants were subjected to T7 endonuclease assay.

Acclimatization of selected putative transgenic (T0) plantlets

2. Next-generation Sequencing Data Analysis

The ultra-high throughput DNBSEQ-T7RS NGS platform in NIGAB has generated Whole Genome and RNA-Seq data, the details are shown (Table 2). The data is under process and is at different stages of WGS and RNA-Seq pipelines.

Plant Tissue Culture

In “Commercialization of potato tissue culture technology in Pakistan” project “Acquired potato germplasm of three potato varieties “Bartina, Sante and Camel” from local and foreign sources. Registration of 2 potato varieties “Bartina and

Sante" was approved in VEC/FSC&RD (Figure 18). For in vitro multiplication, 100 meristems were excised from virus indexed plants of (Lady Rosetta, Asterix, and Bartina and NIGAB germplasm). Produced 34,000 in vitro plantlets of Lady Rosetta, Asterix and NIGAB germplasm. Hardened, 34,000 invitro plantlets were shifted in NIGAB screen house and KOPIA Aeroponic tunnels. Nucleus seeds (80000) G0 were harvested from NIGAB screen houses and 232401 from KOPIA greenhouses. Seed potatoes (G1) 2.0 tons were harvested. Crop was inspection by FSCRD and approved as Pre-Basic–I. 25000 G0 seeds provided to IAK Seed Company and they harvested 100000 G1 from 10000 autumn crop as G1 and 15000 G0 is under multiplication at Sudhen Galli AJK as a summer crop. Crop and seed inspection has been done by FSCRD issued the tags.

- 25 varieties viz 1. GN1,GN3 ,Santee, Shepody, Sahiwal white , J_8, PRI red, Mosica, HZPC Astrix, Favorite, Cardinal, Kuroda, GN1, Sadaf, Ls5, LS3, Roco, Ruby , Hermes, Lara, Desiree, LR, GN2, NG2, Favorite and highly selected potato breeding line NIGAB 21-9-12 were planted for flowering and breeding at Sudan Gali Kashmir and Babusar village during 19th May and 4th June, 2024.
- Previous, 186 highly selected breeding lines (Germplasm) were planted and harvested from NIGAB, field NARC field during October 2023. After 120 days, 186 lines were harvested. Sorting, scoring and counting the harvested breeding material .Total 49104 tubers of F1 generation were harvested. These 186 lines were display on Potato Day at NIGAB, Narc. The PARC and NARC experts' panel selected 67 lines for further multiplication trails
- DNA fingerprinting and varietal identification of 67 potato breeding lines and 14 mother varieties including (Bartina, Santee and Kuroda) were done through reported SSR marker specific to diversity.
- For cold tolerant variety development of potato, for this purpose reported 7 genes have been identified for SSR primer synthesis.
- Training/farmer day conducted at Astore GB on August 7, 2023, June28, 2024 at Babusar village and potato day for new varieties evaluation conducted on 11th March 2024 at NIGAB. Annual 2nd steering committee meeting of this project held on August 22, 2023 and 1st PAC meeting conducted on August 17, 2023 at NIGAB, NARC. Project Revision Meeting DDWP was approved on 18th October 2023. Construction of screenhoues and Cold store is in progress.
- In Project "Self-sufficiency of virus free potato seed multiplication by Aeroponic technology" (Completed) on December 2023, for in vitro multiplication, new meristems (300) were excised from virus indexed plants of (Lady Rosetta, Asterix, and Bartina). Hardened 26,880 invitro plantlets were shifted in screen house and hardening room, 863,797 nucleus seed (G0) harvested from KOPIA

Micropropagation of potato | Hardening at NIGAB screen houses | Hardening at hydroponic room | Plantation at Kopia greenhouses | View of Aeroponic crop

green houses. Total 982,576 tubers of seed potatoes (G1) were harvested in 2021-2024. Crop inspection was done by FSC&RD and approved as Pre-Basic–I. Crop and seed inspection has been done by FSCRD issued the tags. Total 292 training and farmer days were conducted at Astore GB on August 7, 2023, June 28, 2024 at Babusar village and 5 press release.

- Under "Potato varieties development through marker assisted selection (MAS) & speed breeding" project, the 1st activity of this project is, 169 harvested barries of 36 crosses from 4 different locations (Murree, Babusar, Sharan and Chillas) were planted in pots at NIGAB screenhoues during 27th November 2023 and seedlings/plants raised form barries were transferred individual pots for further tubers development. Total 2601 seedlings/Pots were germinated from 169 berries 29th Jan to 20th Feb, 2024. Harvested 22,720 minitubers from 2601 seedlings during 10th -20th May, 2024. Sorting, grading and counting of harvested TPS were shifted to Khan Cold Store Gondal, Attock 27th May, 2024.
- The 2nd activity of this project is, Morphological plant data of 186 highly selected breeding lines (Germplasm) were recorded from breeding material planted at NIGAB field, e.g. (germination breeding line data, frost and disease resistant data, Plant height, No. of stems, Inter. Distance, No. of com. Leaves and Land cover and color of leaves from sowing to harvesting after different interval days 50 days, 70 days, 90 days and 120 days. Tubers morphological data were also recorded at different intervals 50,70,90 and 120 days to check the bulking/maturity of 186 lines, which involved many parameters like Color of tuber, No. of Tubers, Tubers/plant wt., wt. of bag, Tubers/plant wt, No. of Tubers <35g, No. of Tubers 35-55g, No. of Tubers >55g, No. of Tubers >55g, Total tubers wt. >55g, Smaller Tuber Wt. , Small Tuber L/W, Large Tuber Wt., Large L/W, Large Tuber wt. in water, SG= wt. in air-wt in water/wt in water. Proline and Membrane stability analysis of 186 lines were done at FSCRI at NARC (Figure 20).
- The 3rd activity of this project is, for proximal analysis e.g. (Specific Gravity, Dry matter content, ash content, Minerals, Phenolic Content, Starch content, reducing sugar contents). Randomly 5 tubers were taken from selected each line. These analysis were performed at FSCRI at NARC. These analysis are still in process.
- The 4th activity of this project is, DNA extraction of selected primarily 186 lines were done planted at NIGAB field. 50 SSR trail linked markers were synthesized against Dry Matter, Drought, and Starch and Disease resistance. 10 SSR reported trait linked dry matter specific primers were optimized and amplified for MAS studies against 67 highly selected breeding lines.

- In "Micropropagation of elite ginger germplasm" project, seed of seven ginger genotypes (Sourced from Faisalabad, Thailand, Turkish, Indonesia, Indian, Chinese and Burma) were selected for Tissue culture and field plantation. Produced 20,000 in vitro plants and 10,000 plants were shifted for hardening at in NARC. 2500 plants were survived (650 plants were distributed among farmers, 1850 plants were planted at different locations in Pakistan. From previous planted material, harvested 100kg ginger in which 61 kg was derived from rhizomes and 39kg was from tissue culture plants. For genetic diversity of ginger germplasm, 29 Samples of Ginger were collected from different sources and reported 25 ISSR and 16 SSR primers were optimized at 29 ginger germplasm. One day hands on training of "Mass scale production elite ginger through Tissue culture" was organized at 6th March, 2024.In "Micropropagation of elite banana germplasm",

Sprouting of ginger rhizome

Culture initiation

Micropropagation of ginger

Invitro plantlets of ginger were hardened in cups

Harding in hydroponic room

Hardened plants shifted in Field

Harvesting of Ginger rhizomes

Plants distributions

Training of Ginger

during 2023-2024, 400 suckers were collected from Sindh for invitro culture initiation of 4 banana varieties (NIGAB-1. NIGAB-2, NIGAB-3 and NIGAB-4. Produced 10,000 invitro cultures of four banana varieties. 4500 invitro plants were hardened at NIGAB screenhoues in which 100 hardened plants of NIGAB-3 handed over to Comsats University for research purpose, 1300 plants of NIGAB-3 and NIGAB-4 sale through PATCO. Hardened 1000 Plants of NIGAB-3 and 1000 plants of NIGAB-4 ready for plantation to maintain GPU

Hardening of Banana varieties

Marker Assisted Breeding Program

- NIGAB Sweet Peas (new advance-line). The new advanced line "NIGAB Sweet Peas" is ready for submission this year for NUYT This line is high yielding, resistant to diseases and characteristically sweat in taste making it best candidate for salad peas.
- Development of Wheat Advanced Lines (2023-24) for Rain fed Conditions. The testing and evaluating advanced wheat lines to determine their performance and yield potential under rain-fed conditions. Based on the results of the conducted experiments, 30 promising wheat lines have been identified for their superior yield and resilience out of 98 lines tested. These lines were previously genotyped for rust resistance genes using DNA markers. These selected lines are intended for PYT and AYT.

Drought			
Sr.#	Lines	Ton/hac	Monds/acr
1	K5S-1	7.4	74
2	C-123B	7.0	70
3	CMT-216	6.6	66
4	C-126	6.5	65
5	CMT-114	6.5	65

- NIGAB Real-Time Environmental Sensor by using IOT-Internet Of Things. The NIGAB Real-Time Environmental Sensor Project represents a significant advancement in environmental monitoring at the institute. The core of this project involves the deployment of a sophisticated environmental sensor system, leveraging cutting-edge Internet of Things (IoT) technology and cloud computing. This initiative utilized the BME680 sensor, developed by German scientists, to continuously monitor and analyze the quality of the environment at NIGAB. This sensor, known for its precision and reliability, measures multiple environmental parameters, including temperature, humidity, pressure, and air quality (including gas concentrations). It provides real-time data essential for understanding and assessing environmental conditions that affect research and agricultural activities. At NIGAB, the real-time data from the environmental sensors is displayed on a 32-inch LED screen which provides a dynamic and visual representation of current environmental conditions, making it easy for visitors and staff to monitor real time happening. The project has been completed successfully, with the sensor system functioning effectively and providing real-time data now.

- DNA finger printing of different crops. DNA extraction of 37 Maize samples with four replicates. The 50 SSR primers were completed and report was sent to the concerned person. Another

task 6 Maize lines for genetic diversity using (SSR Markers) 50 primers were completed. In potato, screening of 9 samples with 50 SSR primers out of 50 only 40 primers gave significant results report was submitted to concerned person. In Brassica, screening of 7 samples with 50 SSR primers out of 50 primers 47 primers gave significant results and report was sent to the concerned person. In Avocado, DNA extraction of 12 varieties with 4 replicates. PCR of 26 SSR and 16 INDELS primers completed.PCR were completed on 36 SSR primers. In Rice, screening of 14 samples with 50 SSR primers out of 50 primers 43 primers gave significant results and report was sent to the concerned person. In Citrus, screening of 43 citrus varieties with 50 SSR primers, out of 50 only 40 primers gave significant results report was submitted to concerned person.

Screening of Historical Wheat varieties of Pakistan to train and validate a genomic selection model to speed-up the selection and prediction process of breeding lines.

a. Screened 206 Historical Wheat varieties for drought tolerance using PEG induced drought stress (15% PEG).

b. Screened 206 Historical Wheat varieties for drought tolerance using controlled conditions in pots (Drought imposed by limiting the irrigation to 30% field capacity) and growth of lines was monitored according to Zadok's Scale. Data was recorded for other yield parameters as well No. of tillers /plant, plant height, spike length, No. of Spikelets/Spike, 100 grain weight and grain yield per pot. Proline contents were also determined for all these genotypes.

c. Screened the 224 (220 lines + 4 checks) Historical Wheat varieties for drought tolerance by planting and evaluating in rainfed conditions. Growth of lines was monitored according to Zadok's Scale. Data was recorded for other yield parameters as well No. of tillers /plant, plant height, spike length, No. of Spikelets/Spike, 100 grain weight and grain yield per pot.

d. Planted the same set of historical lines in irrigated condition to be considered as control for experiment (c). All these experiments (a) to (d) have been performed to generate data in maximum circumstances in order to train and validate a genomic selection model for efficient prediction and selection of breeding lines in future.

5. Animal Biotechnology Program

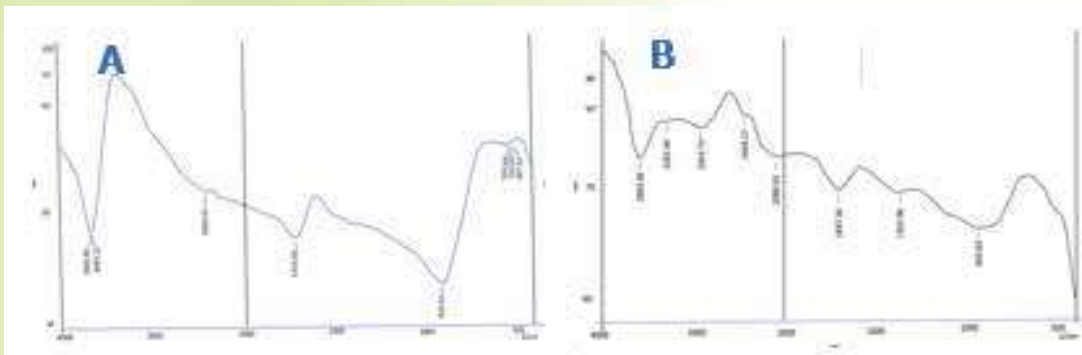
Genetic improvement of indigenous livestock breeds is of utmost importance. Despite the good genetic potential, the productivity of local animals is very low. Modern dairy breeding involves the identification of candidate genes /potential

Sampling of Goat, Buffalo and Cattle

SNPs related to milk, meat & disease resistance etc. and their variants that can be incorporated into breeding programs. So, unraveling genetics of milk production and growth in indigenous livestock breeds is one of the major thrusts. Exploring the genetic potential of indigenous livestock is currently being carried out using innovative Genotyping and WGS approaches in potential cattle breeds e.g Sahiwal & Tharparker cattle is underway.

The current research activities include an extensive visit in the field to collect blood samples and phenotype data of purebred Sahiwal cattle from Sahiwal cattle breeders' association having been categorized into the national elite club called as Red Gold Club (RGC) for genome studies. Similarly, selected animals of Sahiwal, Tharparker cattle and goat breeds were analyzed using Illumina Bead-chip of 100K/70 K SNP Array. After initial analysis of raw data, the data was analyzed for Population Stratification using principal component analysis, admixture analysis and Genome wide Association Studies using FarmCPU model resulting in significant SNPs identification based on p-value<0.05. Annotating the significant SNPs revealed potential genes harboring the most significant SNPs. Establishment of molecular diagnostic for cattle Inherited Disorders (BLAD and Citrullinemia) is underway.

Antimicrobial resistance (AMR) in animals and development of alternative therapy. Unsupervised use of antibiotic in animal is creating problem of antimicrobial resistance (AMR) worldwide. Hence, testing of AMR residues detection in animals-based products has been initiated. In this regard, monitoring of AMR residues by high performance liquid chromatography (HPLC) is being established. Similarly, to deal with ongoing issue of AMR, nanoparticles based alternative therapeutics is under development. For this purpose different types of nanomaterials were prepared and its antibacterial activity was checked against different bacterial pathogens such as E.coli and Staphylococcus aureus.

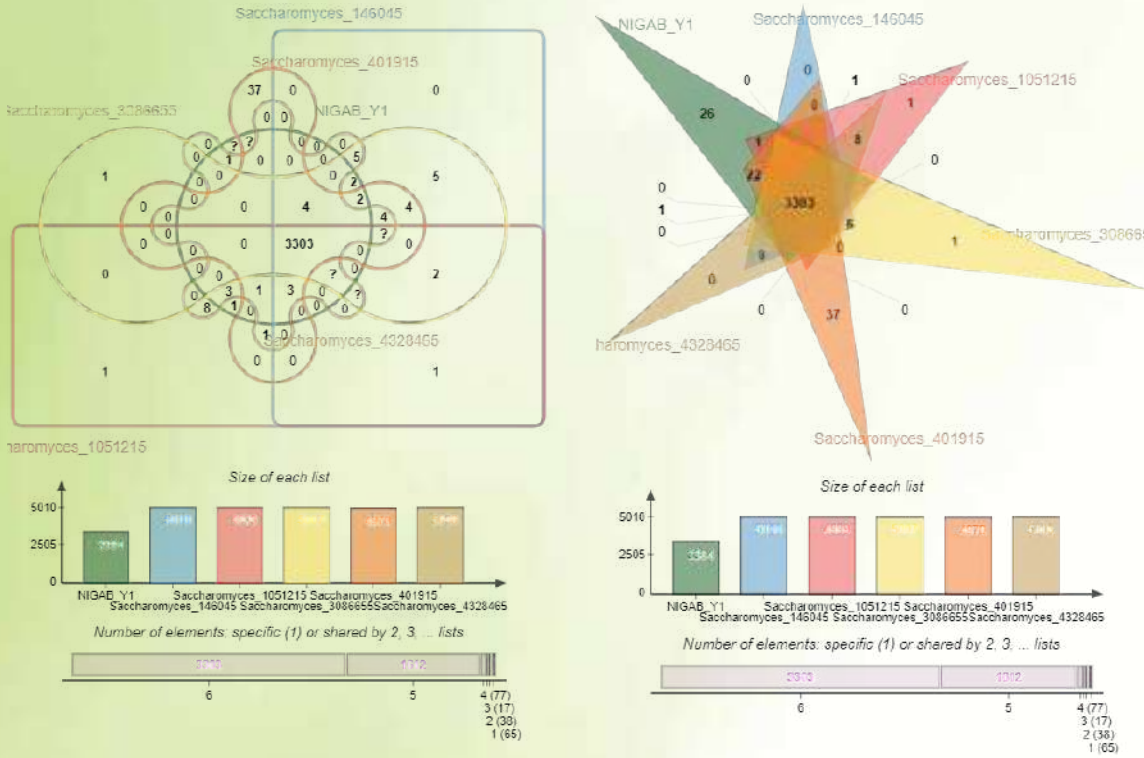


(A) FTIR Spectrum of leaf extract *(B) FTIR Spectrum of biosynthesized Au-NPs*

Indigenous Yeast Extract Products. Successfully identified and characterized the diverse range of indigenous yeast (n=10) and bacterial (n=8) strains that can be used as an alternative to commercially available yeast and bacterial based products. Successfully developed protocol that provided the efficient amount of the yeast extract (YE) by using local raw material (molasses). YE used in media preparation in lab scale level. Beta-glucan has been successfully isolated purified from yeast strain. That will be used in poultry feed. Isolation and characterization of microbes is a routine activity for which we preserved FAO/WHO approved, WGS characterized microbial strains (n=20 yeast n=8 bacteria) available for development of indigenous feed/ food products.

- Developed local indigenous probiotics for milk productivity enhancement in buffalo.

- Production of yeast extract from locally isolated yeast strain to be used in beverages food product as taste enhancer and lab purpose.
- Production of local beta glucan from yeast stains to be used in poultry feed

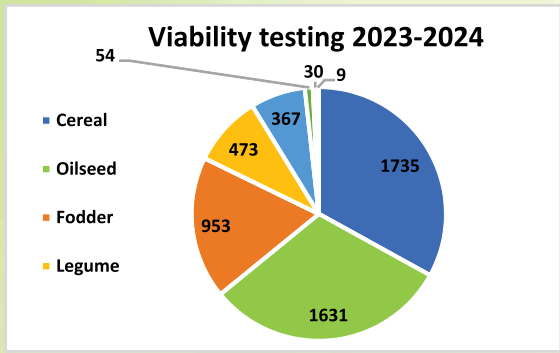


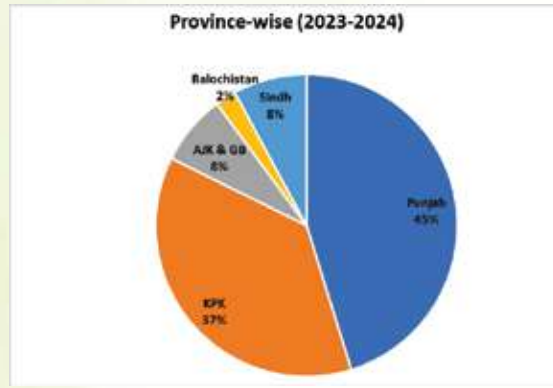
- Animal cell culture and vaccine development. Recently an ALP funded project has been completed entitled “Development of Monoclonal Antibodies against local strains of PPRV in Sheep and Goat”. The significant outcomes were as following: Hybridoma has been developed using local stains of PPRV.

- Last year another viral disease of animals named as Lumpy skin Disease (LSD) spread in Pakistan's livestock sector. Due to emergence of this disease following project titled “Selection and characterization of Vaccine Candidates for the future development of cost-effective vaccine against Lumpy Skin Disease (LSD) Virus in Cattle” has been started.

Genetic Resources

- During 2023-24 , the National Genebank of Pakistan received 161 seed requests from various institutions and universities. After verifying that the requests complied with required SOPs, 9,477 accession samples of diverse crops were provided to breeders, researchers, and universities nationwide.
- Approximately 4,549 samples of various crops, including wheat, vegetables, and medicinal and aromatic plants (MAPs), were added to the Genebank collection this year. These additions resulted from acquisitions, collections, and generous donations from multiple sources. This expansion enhances the diversity of the Genebank's holdings, solidifying its role as a crucial resource for future agricultural research and crop improvement.
- The viability of conserved germplasm accessions is routinely assessed at regular intervals to maintain up-to-date information on their status. This ongoing





monitoring is essential for ensuring the longevity and quality of the stored genetic material. Over the past year, 5,276 accessions were tested for viability, demonstrating the Genebank's commitment to safeguarding these valuable resources.

Medicinal Aromatic Plants and Herbs Program

Management and adaptibility of herbs:

Multiplication of MAPS (Withania coagulans, rosemary, lemongrass, thyme, stevia, sweet basil, oregano, lavender mint, pennyroyal mint, and lavender) was carried out through stem cuttings, and plants were subsequently transferred to the field at PGRI. Musk bala (Valeriana wallichi), moosli, anjbar, asparagus, and mint collected from Murree and Nathiagali were acclimatized in a glasshouse. Albizia, oregano, moringa, papaya, rocket, and fenugreek were propagated from seeds.

A clonal repository was maintained in both the glasshouse and field at PGRI. Total phenolic content was determined for 49 fenugreek accessions to assess antioxidant properties. Total phenolic and flavonoid content, as well as antioxidant potential through DPPH assays, was determined for 43 Ajwain accessions to evaluate antioxidant properties.

PLANT PROTECTION

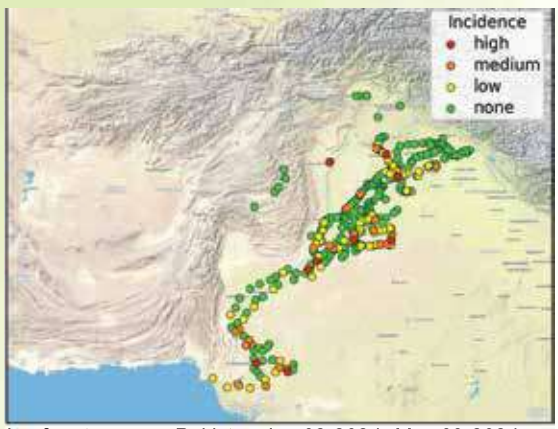
Crop Diseases Research Management

Wheat: National Wheat Disease Screening Nursery (NWDSN) and National Uniform Yield Trial (NUYT) 2023-24

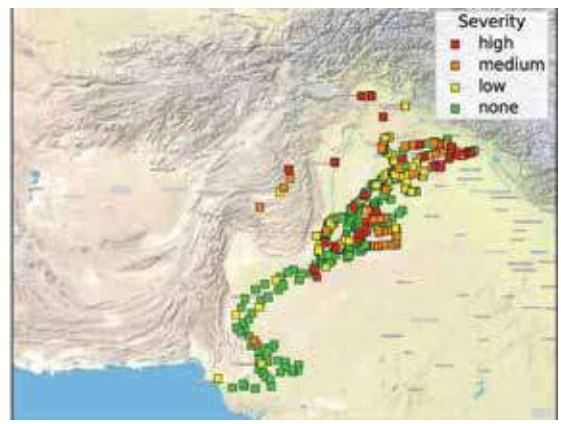
Among 914 NWDSN wheat lines, only 10 lines that showed the desirable ACIs for all three rusts. One hundred and forty-six lo leaf and yellow rusts, one to leaf and stem rusts, 4 to stem and yellow rusts. While 189 lines had ACIs below yellow rust, 134 to leaf rust, and four to stem rusts. Among them, some of the resistant lines will attain the status of the candidate lines. The NUYT were comprised of 80 promising candidate lines of bread wheat received from the nationally coordinated wheat program, PARC, Islamabad. Ten lines V-20337 (WRI- Faisalabad), RUSTAM-21(JSC-Rahim Yar Khan), TRB-23-116S-57 (ARI-Ternab, Peshawar), HUM-2 (Hazra University, Mansehra), SWB-15 (ARS-Swabi), TRB-13-140 (ARI-Ternab, Peshawar), PR-149 (CCRI, Nowshera), TP-GOLD (V-Gro, RY Khan), CT-18062 (NIFA-Peshawar), and N-Gandum 8 (NIBGE, Faisalabad showed desirable RRI 6 and above to leaf and yellow rusts during two consecutive years. Six candidate lines TP-626 (V-Gro, RY Khan), 10HP-428 9NIBGE-Faisalabad), MA-9-19 (ARS-Mansehra), NR-582 (NARC-Islamabad), TWS-1902 (AZRI-Bhakkar), and NR-583 (NARC-Islamabad) showed desirable relative resistant index to Yellow rust only. Similarly, one candidate lines SN-022 (ARS-Bannu), showed relative resistant index to stripe rust only to leaf rust for the years 2022-23 and 2023-24.

Wheat Disease Early Warning Advisory System (DEWAS)

- Leaf Rust was reported in 122 out of 423 fields surveyed (29%). Moderate to high incidence of leaf rust has been seen in 33 fields (27% of infected fields). Moderate to high severity of leaf rust has been seen in 53 fields (43% of infected fields).
- Stripe Rust reported from 165 out of 423 fields surveyed (39%). Moderate to high incidence of stripe rust has been seen in 45 fields (27% of infected fields). Moderate to high severity of stripe rust has been seen in 83 fields (50% of infected fields).
- Eleven rust advisories were issued and the recommendations were made based on the surveillance results. The risky areas were specially focused and farmers were guided.



Leaf rust surveys Pakistan Jan 02-2024- May 09-2024



Yellow rust surveys Pakistan Jan 02-2024- May 09-2024

Rice

Screening of NUYT and advanced lines against Bacterial blight of rice

Fifty-six OP rice varieties (43 fine and 27 coarse) and 131 rice hybrids and several

advanced lines were screened against bacterial blight (BB) of rice (Fig. 1). Forty-five-day-old seedlings were inoculated by the leaf clipping method in the field. Disease assessment was done 14 dpi; as follows: 0-5cm=R, 6-10cm=MR, 11-15cm= MS, above 15cm= S. Lesions were measured starting from the tip of the leaves until the end of the water-soaked lesion.

Data scoring and response of rice germplasm against X.oryzae pv. oryzae

Monitoring of rice diseases and collection of disease specimens

A survey of rice-growing areas of Punjab was conducted from 10-15 October 2023. Ninety disease samples were collected and brought to CDRI for further studies. BB disease incidence ranged from 50-70% in different districts. In Punjab, the incidence of brown leaf spots varied from 25% to 100%; false smut was observed in Gujrat, and sheath blight incidence was up to 20% in Gujranwala.

From the 2022-23 sample collection, 50 Xoo samples were confirmed (Multiplex PCR) and stored. The fungi isolated from these samples included 13 Rhizoctonia isolates and 3 isolates of Thanatephorus cucumeris. So far, more than 180 Xoo samples have been collected.

(A)False smut of rice, (B) Rice Blast (C) Bacterial blight of rice (D) Stem rot or rice

Determination of race spectrum of Xoo in Pakistan

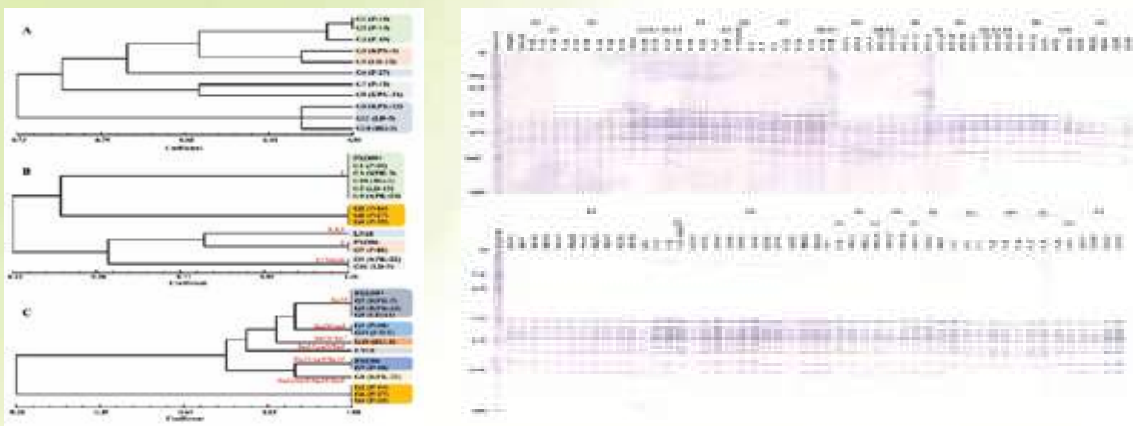
One hundred and forty eight (148) isolates were tested for pathotype analysis. The tested isolates belonged to 14 pathotypes. Pathotype 7 (Batagram, KP) is virulent on almost all major Xa/xa genes. Pathotype 6 (Batagaram, Lower Dir and Sialkot) is similar to pathotype 7, except it is non-compatible to Xa21. Virulent Pathotype 1 (KP and Punjab) is the most dominant incompatible to (xa5, xa13, Xa21 and Xa23). xa13 is the most effective resistance gene, though it has MR/MS reaction against

pathotypes 6 and 7. Xa21, Xa23 and xa5 are also incompatible with most of the pathotypes but they are compatible with few pathotypes. No Xa/xa gene alone is fully effective against all Xoo pathotypes. So xa13, Xa21 and Xa23 should be pyramided in combinations to have broad host resistance against all Xoo pathotypes.

Tale-based genetic diversity among Pakistani Xoo isolates causing bacterial blight of rice

Transcription Activator-Like Effectors (TALEs) are proteins that are an important part of Xanthomonas arsenal used to successfully attack plants. Tale-based genetic diversity of 101 Xoo isolates was studied. Total genomic DNA was extracted. DNA samples (3 µg) were digested with BamHI and SPhI at 37C0 for 4h, separated in 1.2% agarose gels, and then transferred to Amersham HybondTM-N+ Membrane (GE Healthcare, Buckinghamshire, USA). A DIG High Prime (Roche, Sweden) labeled 3-1kb internal SphI fragment of avrxXa10 was used as a probe to detect tale genes in each strain. Labeling, hybridization, and detection procedures were performed following the manufacturer's protocol. 101 Xoo isolates have been studied for the presence of tal genes by Southern blotting he SB analysis revealed 16 to 20 putative tale fragments. The strains are classified into 11 genotypes. Southern blot analysis revealed that all the genotypes contained similar fragments of PthXo1, seven genotypes [G1, G2, G3, G4, G9, G10 and G11] harbor potential fragments of PthXo2 and the AvrXa7 fragment was not matched with any of the genotype (Figure 3). Interestingly, majority of the strains contained both PthXo1 and PthXo2, which implies that these strains possess the capability to simultaneously activate OsSWEET11a and OsSWEET13.

TALE diversity analysis by clustering the presence and absence of BamHI fragment using NTSYS 2.02e tool classified the 11 genotypes into 5-clads. Interestingly, the clads pattern was somehow in congruence with the geographic distribution of the strains i.e. genotypes from Punjab G1, G2, and G4; G6 grouped into clad-1 and clad-3, respectively. The other genotypes belong to KP i.e. G3 and G5; G8, G11 and G10 were grouped into clade-2 and clade-5, correspondingly.



Tale based genetic diversity of Xoo

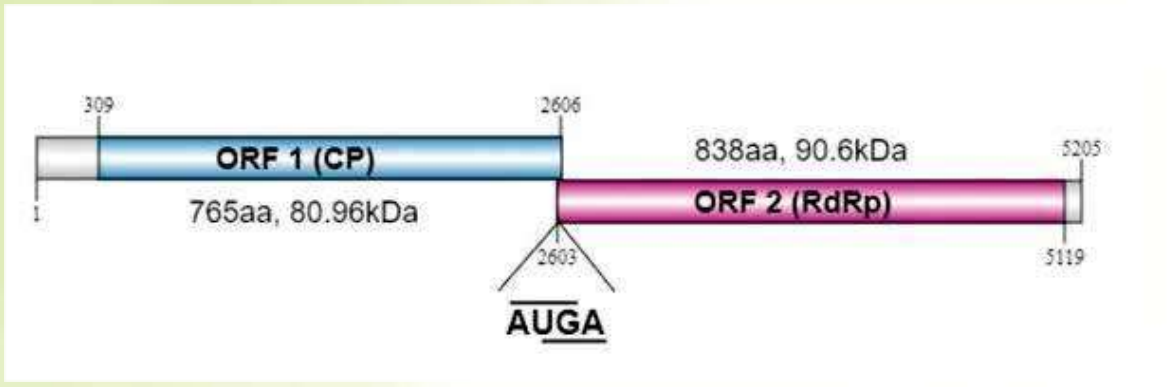
Evaluation of chemicals against bacterial blight of rice

Evaluation of eight chemicals in field conditions was performed by artificial inoculation with the most virulent Xoo isolates on Super Basmati. A two-factor factorial experiment in Randomized Complete Block Design (RCBD) with seven treatments and three replications was done. All the recommended agronomic practices were adopted during the experiment. Chemicals were tested for their preventive (pre-inoculation (4 and 14 days) application) and control (post-

inoculation (4 and 14 days) application) efficacy. Inoculation was done by the leaf clipping method at the maximum tillering stage. Data on lesion length and disease severity were recorded 21 days after inoculation. The lowest disease severity (27%) was recorded with Oxost (Oxolonic acid17%+Streptomycine3%): when applied as a preventive treatment, followed by BN-Zole (Benzisothazkine 2%+Tebuconazole 25%).

Samples were revived, and RNA was extracted from two-year-old samples. cDNA was synthesized, and PCR was performed from the collected samples. Fifteen samples were tested, and 93.3% (14/15) were found to be infected with the southern rice black-streaked dwarf virus (SRBSDV), which was the leading cause of dwarfness in rice in the 2022 rice cropping season (Figure 2). Rice black-streaked dwarf virus (RBSDV) was also found to be present in 40% of samples (6/15).
Molecular confirmation of southern rice black-streaked virus and rice black-streaked dwarf virus infecting rice in cropping season, 2022.

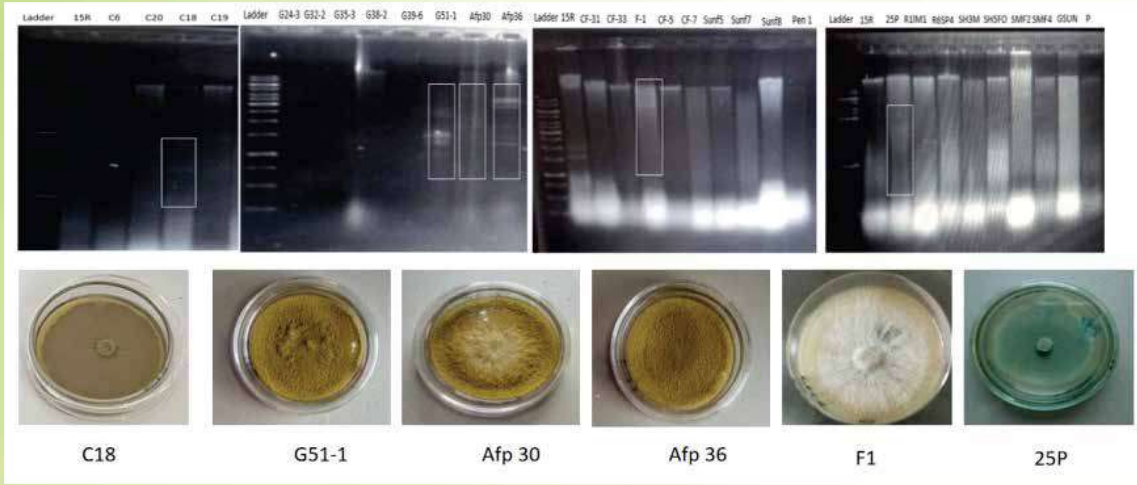
Identification and characterization of mycoviruses
A mycovirus was molecularly identified from Botrytis cinerea causing grey mould. A victorivirus designated as BcVV1a was identified and molecularly characterized. The complete genome of BcVV1a was 5205 bp in length (Fig.1). It encoded two ORFs. ORF1 was 2298 nt (nt 309 to 2606) in length, and encoded a coat protein (CP) of 765 amino acids with a molecular weight of 80.9 kDa. ORF2 was 2517nt (nt 2603 to 5119) and encoded a RNA-dependent RNA polymerase of 838 amino acids with a molecular weight of 92.4 kDa. The untranslated regions (UTRs) at the 5' and 3' ends were 309 nt and 86 nt, respectively. ORF2 was translated by a stop/start translation mechanism mediated by AUGA tetranucleotide. Moreover, an H-type pseudoknot was also predicted upstream of the AUGA motif. The complete genome sequence was deposited in GenBank (accession number OR180511.1).



Screening of mycoviruses
Total nucleic acid extraction of fifty five fungal cultures was carried out to detect mycoviruses using small scale extraction method. Six mycoviruses were identified from different fungi viz. Aspergillus flavus, Penicillium sp and Aspergillus sp

Aflatoxin control in Pakistan (Lab trials for the manufacturing of Bio-pesticide)
A biocontrol product (substrate and active ingredient; atoxigenic fungal strain) manufacturing trial was conducted in the lab and the sporulation of product was tested at different temperatures. After six days the highest percentage of

sporulation was observed at 31 °C (Fig.3). Moreover, the quality control of product was also checked on two medias i.e., Malt extract and Violet red bile dextrose agar (VRBD). The quality control showed significant sporulation of the active ingredient on both Malt Extract Agar and Violet Red Bile Dextrose Agar (VRBD) media. No bacterial contamination was observed. Pot trial was conducted after hydropriming product and significant sporulation was observed after ten days (Fig.4). Bio-pesticide was also applied in the field for testing the efficacy of product in field conditions. Sporulation was seen after five days of application of bio-pesticide.



First report of Tomato leaf curl Karnataka Virus Infecting Parthenium in Pakistan

Parthenium plants showing severe leaf curling, shoestring type appearance, and mild mosaic were collected. Total genomic DNA was extracted and subjected to downstream applications i.e. PCR, sequencing etc., from ten symptomatic and one asymptomatic leaf samples, to study the root cause of the disease. Out of ten, eight samples were positive to begomovirus without the asymptomatic sample. The expected amplicons (~485 bp) were sequenced in both directions by Macrogen sequencing services, South Korea and resulted sequence of 458 nucleotide genome comprising the viral coat protein of DNA-A was submitted to GenBank (Assession No. PP695176). Phylogenetic analysis using Maximum likelihood method in MEGA v.11.0 revealed a scenario of interrelation with the isolates of ToLCKV and other begomoviruses. The viral transmission was investigated in glasshouse under controlled environment using chip graft inoculation assay (CGIA), from the naturally infected P. hysterophorus to healthy plants of P. hysterophorus, and Nicotiana sp. (5 plants each). P. hysterophorus and Nicotiana sp. both showed mosaic like symptoms 20 days post inoculation and the CGIA inoculated plants were tested 30 days post inoculation using gene specific primer for ToLCKV with an amplification size of ~300 bp. Eighteen inoculated plants were found to be positive in PCR against ToLCKV and the nucleotide sequences of all the positive amplicons were sequenced and found to be identical to previously submitted sequence of mother source i.e. PP695176. ToLCKV may pose a serious threat to the production of numerous economically significant crops in Pakistan (Islam et al., 2018), as its host range is increased with a wild weed (P. hysterophorus). As far as we are aware, this is Pakistan's first report of ToLCKV infecting Parthenium weed.

Significant Achievement:

Identification of the tomato leaf curl Karnataka Virus as the cause of leaf curling, shoestring type appearance, and mild mosaic symptoms infecting Parthenium weed.

· Whole genome Sequencing of the Pakistani Isolates

• Pakistani stripe rust isolates were assessed for whole genome sequencing in Australia.

• The difference between Pakistani and other populations is that Pakistani isolates have much higher diversity.

• The major lineage looks pretty distinct, so it seems that whole genome SNPs resolved them well.

• A clade immediately splits between the Pakistani population and PstS7 Warrior (Himalayan origin) so that's interesting.

• A small clade in the Pakistani population has consistently longer branch lengths than others, which could be self-crosses. Perhaps we can test this hypothesis by comparing it with the selfing sexual population from this paper (Xia C., et al 2020). It could also just be clonal. It would be good to draw a tree subset just for the Pakistani population and annotate it with sampling dates and provinces. Maybe even a phylogenetic network to see if there's a recombination signal. LD decay, etc

• The complete analysis will be available in the month of December, 2024

Screening of Soybean National Uniform Yield Trial candidate lines for resistance against MYMV

Screening of 19 soybean NUYT entries for resistance against mosaic. Out of 19 entries, 04 were found resistant, 03 were moderately resistant, 06 were moderately susceptible, 02 were susceptible and 04 were highly susceptible to soybean mosaic.

Food Quality and value addition

Grain Quality Evaluation of Wheat

· 355 wheat samples (varieties/line/flour) from different research institutes/centers were were evaluated for moisture, test weight, 1000 kernel weight, protein, gluten (wet, dry, index), falling number, farinographic properties (water absorption, dough development time, dough stability, mixing tolerance index, Farinographic Quality Number etc.) and mineral analysis (Iron, Zinc etc.) etc.

· Significant difference in mineral content and physicochemical properties of 48 wheat varieties. The mean value for protein content ranged from 9.15 to 12.62%. The highest protein content (12.62%) was observed in Paroula-16 while lowest (9.15%) was noted in Bakhar-2002. The highest (431) falling no was observed in Gulzar-19 while lowest (239) was found in Khyber-87. The mean value for iron content ranged from 20.40 to 76.50 mg/kg. The highest iron content (76.5 mg/kg) was observed in Johar-16 while lowest (20.40 mg/kg) was noted in Shaan-21. Similarly, the highest zinc content (51.60 mg/kg) was observed in KPK-15 while lowest (19.10mg/kg) was noted in Shaan-21.

Grain Quality Evaluation of Rice:

· 844 samples from National Coordinator (Rice), Rice Research Program, NIGAB, NARC, Rice Research Institutes of Sindh, Syngenta, etc. were evaluated against more than 19 different milling, physical (Grain Length, Breadth, L/B ratio, Thickness of paddy and polished rice), nutritional (Moisture, Ash, Protein, Fe & Zn) cooking (bursting, aroma, elongation ratio, amylose) quality parameters.

· Highest thickness (1.923 mm) was noted in GSR-42 while lowest (1.22 mm)

was recorded GSR-72. In the same way the findings revealed that the maximum head rice (180) was noted in GSR-442 while minimum (74) was recorded GSR-200.

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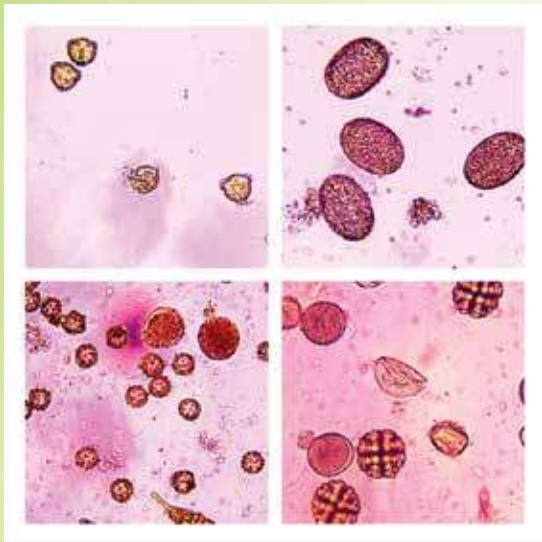
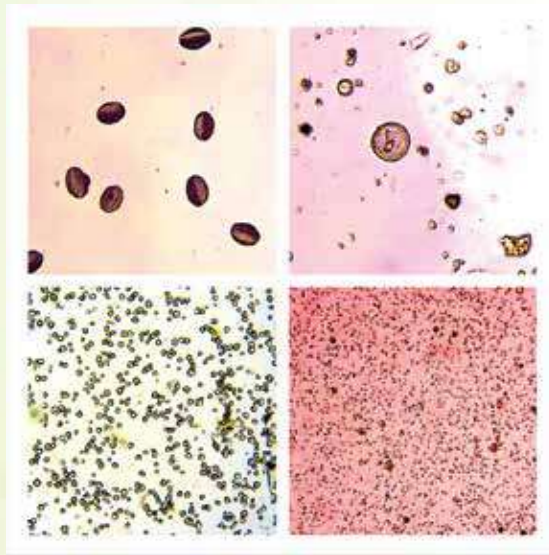
Microscopic Study of Pollen Spectrum of Different Honey Flow Seasons

Reference pollen database has been established for 25 honey floral types including Sider, Granda, Bhaikar, Robinia, Russian Olive, Buckwheat, Clover, Alfalfa, Thyme, Caper bush, Kapok bush, Dandelion, Parthenium, Sider, Mustard, Turnip, Broccoli, Canola, Caulflowers, Tomato, Bottle brush, Avocado, etc.Microscopic particles of common adulterants i.e Sucrose and Starch were identified and their reference images were added to lab database.





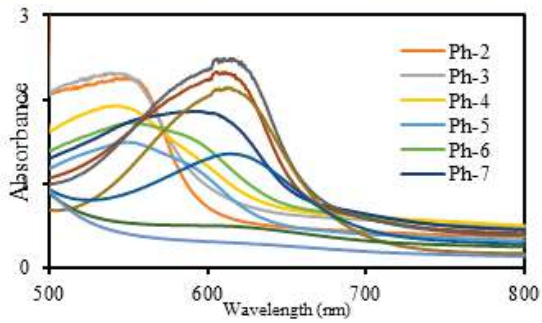
Southern Agricultural Research Center (SARC), PARC Karachi

Food Quality & Safety

Research Activities

1. Nanocomposite biopolymer films for food packaging applications.

Silver Nanoparticles were synthesized employing citrates and borohydrates, subsequently optimized for enhanced stabilization. The study examined the pH-dependent color and spectral properties of Red Cabbage Anthocyanin (RCA) solutions, noting significant color transitions across pH levels and corresponding shifts in absorption peaks due to structural modifications in anthocyanins. These properties were evaluated for their potential as freshness indicators. The synthesized silver nanoparticles (AgNPs) exhibited expected optical properties with a surface plasmon resonance (SPR) band at 410 nm, confirming successful synthesis. The chemical composition and bioactive components of films revealed interactions between RCA, AgNPs, and the biopolymer matrix, altering the film's hydroxyl and carbonyl functionalities and affecting total phenolic and anthocyanin contents.



2. Improvement in functionality of composite flours for intended applications

Results indicated that stable gluten index, despite reduced gluten content, suggested that functional quality was preserved, being crucial for maintaining dough performance in baking applications. The increased water absorption and dough development time with higher lotus flour substitution levels indicated that lotus flour components interact with gluten, affecting dough hydration and elasticity. The varied MTI and dough stability responses emphasized the need to optimize blanching methods and substitution levels to achieve desired dough characteristics, underscoring the complex interplay between flour composition, processing treatments, and functional outcomes. The addition of corn flour to wheat flour significantly impacted the fiber, ash, and fat content. Gluten quantity and strength decreased with higher corn flour replacements as the lack of gluten-forming proteins diluted and hindered gluten network formation, leading to lower gluten content in the composites.

3. Establishment of Rishi mushroom tissue culture and spawn technology

Established a pure and healthy master culture of Rishi mushroom (Ganoderma lucidum) using the tissue culture technique, ensuring high-quality and contaminant-free fungal cultures and spawn for further propagation/cultivation. By isolating and sterilizing mushroom tissue samples and culturing them on Potato Dextrose Agar (PDA), the technology ensured production of pure, high-quality mycelium. This mycelium, in turn, was used to inoculate sterilized sorghum grain substrates, resulting in premium-grade spawn. Such approach leaded to noticeable improvements in quality and quantity produce.

4. Development of Rishi mushroom production technology at PARC-SARC.

Selection of substrate, being critical factor in mushroom cultivation, significantly influence yield, size and overall quality. Substrate provisions necessary nutrients and environmental conditions for production, whereas an optimal substrate enhances productivity and economic returns. Resultantly Rishi mushroom developed successfully in ten out of ten wheat straw bags, yielding mushroom 100/ bag with an average size of produce measuring 14 x 10 cm. On the contrary, three to four sawdust bags substrate yielded produce 10g/bag with an average size of produce measuring 4 x 6 cm. Wheat straw as superior substrate for Rishi mushroom cultivation, bearing high yield in terms of size in contrast to sawdust.

5. Assessment of toxigenic potential of A. flavus and status of total aflatoxin in spices, dry fruits, and rice sold at retail outlets of different districts of Karachi, Pakistan.

Quality assurance of rice, spices, and dry fruits available in different districts of Karachi with respect to fungal load, aflatoxin contamination along with evaluating toxigenic potential of fungal strains spread over Karachi markets was undertaken. Results illustrated that rice, dry fruits and all spices sold in retail outlets of different districts of Karachi were contaminated with different fungus (i.e. Aspergillus Nigar, Aspergillus flavus, Aspergillus paraciticus, Fusarium sp. & Rhizopus sp.) and aflatoxins. The resulting toxigenic potential of contaminating strain varied from atoxigenic to toxigenic nature. 70% of contaminating fungal strains bore moderate toxigenic & 25% found highly toxigenic in nature which could destroy the quality of goods sold in retail outlets. The correlation coefficient is r = 0.217 showed weak correlation among aflatoxin and prevalence of A. flavus, indicative of low fungal load capable of higher aflatoxin level or vice versa which was totally dependent on the toxigenic potential of fungal load present at specific area. Adoption of moisture-control measures at warehouses of retailer to promote improved shelf life, which ultimately minimizes risk of aflatoxin contamination. 5% of isolated A. flavus was atoxigenic in nature which can be used as biocontrol agents in reducing aflatoxin contamination risk. Formation of A. flavus library, initiated by preserving single spore pure culture of different A. flavus strains, isolated from different sources in shape of slants and water vials. Such library will serve in identifying appropriate biocontrol material in future.

6. Method development and validation for active ingredients of buprofezin and pendimethalin in pesticide formulation samples by HPLC with UV detector.

Method development and validation of the active ingredient of buprofezin insecticide and pendimethalin herbicide were done successfully. During this study, different wavelengths of 270, 230, and 254 nm were used with different mobile phases. Best results were obtained at 254 nm wavelength with a mobile phase mixture of methanol water in a ratio of 70:30. Linearity of the chromatographic results was checked between the range of 0.5 to 300µg/mL and was found to be 0.999. LOD and LOQ of the method were found to be 4 and 12 µg/mL respectively, whereas reliability of method was good up to a concentration level of 300µg/mL. Method validation tests ensured proposed method had good precision and accuracy. This method can be efficiently used in those laboratories involved in quality inspection analysis of commercial pesticide formulation samples by helping them in saving analysis time as well as less use of solvents.

7. Simultaneous qualitative and quantitative determination of deltamethrin, cypermethrin, chlorpyrifos, dimethoate, and metalaxyl residues in rice samples.

Five pesticide standards, including four insecticides and one fungicide, were selected for their method development on HPLC with DAD detector. Firstly, mixture of five pesticides, i.e., deltamethrin, cypermethrin, chlorpyrifos, dimethoate, and metalaxyl, was prepared and run on LC using the DAD detector. Acetonitrile and water were used as the mobile phase. Composition of mobile phase was optimized in order to get best separation of five pesticides and their sharp peaks. Compositions of mobile phase were run as isocratic elution first, then gradient elution was designed according to feedback of isocratic elution. A seven-minute run was successfully prepared with gradient elution at 40 C with 210nm wavelength of DAD detector.

8. Studies on use of apical or axillary shoot material for initiation of papaya

One of the key decisions in tissue culture protocols is the selection of explant type, particularly whether axillary or apical shoot material could be used. The results indicated that both axillary and apical shoot materials were viable for th e initiation of papaya tissue culture. Axillary shoots demonstrated slightly higher initiation percentages and shoot numbers per explant compared to apical shoots. The results, presented in Table 1, showed a notable difference in the initiation efficiency between these explant sources. The apical shoots demonstrated a superior initiation percentage of 85.0%, which was significantly higher than the 78.5% observed in axillary shoots. Additionally, the number of shoots produced per explant was greater in apical shoots, averaging 4.2 shoots compared to 3.8 in axillary shoots. Furthermore, the shoot length was also greater in apical shoots, with an average of 3.5 cm, compared to 3.0 cm in axillary shoots.

9. To explore Alternative Natural Sweeteners and development of value-added products.

Study investigated impact of date syrup and date sugars on sensory and technological properties of cookies and cupcakes. Date syrup provided pronounced flavor difference, subtle sweetness without significant changes to texture. Both alternatives showed potential as substitutes for conventional sweeteners, subject to adjustments in formulation to match sweetness levels and consumer preferences.

10. To optimize the technological processes and development of value-added products.

Studied/ examined the effects of different foaming agents on drying process of jujube fruit to produce powder. Usage of different foaming agent significantly affected the quality of jujube fruit powder and its suitability in food products. Egg sourced agent was recorded to be the effective in producing high-quality jujube powder with desirable characteristics for incorporation into end products. Hydrocolloid, while improving drying efficiency, resulted in less favorable powder quality and product integration.

11. Application of Wastewater treatment technologies: Constructed wetland for municipal sewage waste.

Constructed wetlands (CW) are man-made structures used for treatment of wastewater streams where plant species, substrates and microorganisms representing natural reclamation processes in a controlled environment. CWs are getting more popular as a treatment option for a variety of wastewaters, including industrial, agricultural, and household wastewaters, landfill leachate, and stormwater runoff. Phragmites karka (Commonly known as the Indian Reed or Common Reed) is a genus of four species of large perennial grasses found in wetlands throughout temperate and tropical regions of the world. It is reported that wetland was efficient for removal of various physico-chemical and biological contaminants eg. biochemical-oxygen-demand (77.1%), chemical-oxygen-demand (64.9%), turbidity (68.3%), suspended-solids (63%), total-phosphorus (58.7%), nitrate-nitrogen (33%), fecal coliforms (96.8%), and total coliforms (95.6%).

Trials pots for constructed Wetland plant, Common reed (Phragmites australis) respectively resulted in varied EC, pH, and TDS parameter. Derived that Inlet sewage EC 2.92-3.02 mS, pH 7.8-8.1 and TDS 980-1290 ppm was found, while after 3 to 4 days, the outlet water EC, pH and TDS ranged from 2.02-3.20 mS,7.7-8.0 and 442 to 780ppm respectively.

12. Extraction of Calotropis procera and Datura innoxia in search of potential insecticidal agents.

Botanical pesticides are derived from plants. They degrade rapidly and therefore are considered safer to the environment than the common synthetic chemicals. Among widely distributed wild solanaceous plants, the (Devil's apple) or Datura innoxia known to have potential pesticidal activity. The phytochemical studies showed that Datura species are rich in alkaloids (e.g., hyoscyamine, hyoscine, atropine, scopolamine), saponins, flavonoids, phenols, essential oils and cardiacs glycosides. Calotropis procera or milkweed naturally grows in southern parts of Pakistan. Some publications have described antibacterial, analgesic or schizontocidal activities for the latex of Calotropis procera.

Extraction performed with 80% methanol (v/v). LC50 of Datura innoxia found at 40ppm of extracted compound. Calotropis procerathe LC50 was found at 25ppm of extracted compound. Evidently insecticidal activity when extracted with 80% methanol, 512 ppm and 256 ppm recorded with mortality rate 78% & 95% for Cx. Quinquefasciatus and An. Stephensi respectively.

13. Polysaccharides polymer extraction and their potential for sustainable agricultural application.

Polysaccharide source available at PARC-SARC was collected and extraction made with exoskeleton of Mollusca. Resulting germination of okra seed (in-vitro) was unsatisfactory. Hence, shrimp's exoskeleton recorded as bio-stimulant agent instrumental in sustainable agriculture.

Crop Diseases Research Institute (CDRI) Karachi

Stem Rust of Wheat

Out of 914 lines /entries of NWDSN, the data revealed that 495 lines (54.15%) were Moderately Susceptible to Susceptible (MSS), 244 lines (26.69%) were Moderately Resistant to Moderately Susceptible (M), 91 lines (9.95%) were Susceptible (S), 13 lines (1.42%) Moderately Susceptible (MS), 22 lines (2.40%) were found Moderately Resistant (MR), 2 lines (0.21%) were Trace Moderately Resistant (TMR), 01 line (0.10%) was Resistant to Moderately Resistant (RMR), 5 lines (0.54%) were complete immune Resistant (R), 01 line (0.10%) was Trace Resistant to Moderately Resistant (TRMR), 59 lines (6.45%) showed Variable in reaction (V). Out of 80 lines of NUWYT, 56 lines (70%) were Moderately Susceptible to Susceptible (MSS), 14 lines (17.5%) were Susceptible (S), 7 lines

(8.75%) were found Moderately Resistant to Moderately Susceptible (M) and 3 lines (3.75%) were variable(V) in reaction.

Leaf Rust of Wheat

Out of 914 lines, data revealed 96 lines (10.50%) were Susceptible (S), 631 lines (69.03%) were Moderately Susceptible to Susceptible (MSS), 74 lines (8.09%) were Trace Moderately Susceptible to Susceptible with low frequency (TMSS) and 80 lines (8.75%) were Resistant (R).Out of 80 lines of NUWYT, data revealed that 71 lines (88.75%) were Moderately Susceptible to Susceptible (MSS), 3 lines (3.75%) were Resistant (R), 3 lines (3.75%) were Susceptible (S) and 3 lines were Trace to Moderately Susceptible to Susceptible low reaction (TMSS).

Epidemiology of Wheat Rusts

- Leaf Rust Trap Nursery data revealed that Lr22b, Lr1, Lr2a, Lr2b, Lr2c, Lr3, Lr3Bg, Lr9, Lr10, Lr11,Lr12 Lr13, Lr14aa, Lr14b, Lr15,Lr16 Lr17, Lr18, Lr19, Lr20, Lr21, Lr 22a, Lr23, Lr24, Lr25, Lr26, Lr 29, Lr30, Lr32, Lr33, Lr34, Lr35 Lr36, Lr37, LrB, and Lr13 WL-711 showed Virulence. The Lr3Ka Lr10 and Lr27+Lr31 were resistant a-virulent while Lr28 and Lr19 variable in reaction.
- Under inoculated condition data of Stem Rust Trap Nursery revealed Sr5, Sr6, Sr7a, Sr7b, Sr8b, Sr9a, Sr9b, Sr9g, Sr10, Sr11, Sr12, Sr14, Sr15, Sr16, Sr17, Sr18, Sr19, Sr20, Sr21, Sr27, Sr28, Sr29, Sr30, Sr34, Sr36, Sr38, SrWld-1, SrTmp, Sr21 and Sr27 were virulent reaction.
- Sr8a, Sr9d Sr9e, Sr13, Sr19, Sr22, Sr23, Sr25, Sr26, Sr32, Sr33, Sr35, Sr37, Sr39, Sr40 and Sr2 complex were intermediate to moderate a-virulent.
- Sr24 & Sr31 showed resistant a-virulent against Stem rust.

Pest Management

Assessment of susceptibility of different pulses against Pulse beetle Callosobruchus maculatus under laboratory conditions.

Research findings of study revealed that females of Callosobruchus macultus laid sufficient number of eggs on kidney beans, however, grubs of beetle couldn't penetrate into seed due to its hard seed coat, therefore recorded zero percent damage. Kidney bean is not a host of C. maculatus. The beetle caused (3.7%), (2.5%) and (1 %) loss respectively in cowpeas, green gram and chickpea in one and half month storage period. The least damage (0.3%) was recorded in black gram. It is recommended that maximum care must be taken while storing cowpeas, green gram and chickpea in godowns and grocery stores.

Testing efficacy of different insecticides including neem oil against onion thrips

Onion thrips, Thrips tabaci is serious pest of onion and causes serious damage to crop. Both nymphs and adults cause damage directly through feeding and indirectly through the transmission of lethal plant viruses. Both stages of T. tabaci feed on leaves and may reduce yield up to 50 percent. Keeping in view, the importance of onion crop and damage potential of thrips to this crop and experiment at SARC-Experimental field was conducted to test the efficacy of different insecticides and Neem oil for thrips control. Results of study revealed that Karate (Lamdacyhalothrin) significantly reduced the population of thrips followed by Chlorpyriphos after 24 hours of spray. However, neem oil and Abamectin did not significantly reduce the population of thrips.

Monitoring different fruit fly species by using attractant methyl eugenol at PARC-SARC, Experimental Field

During observation three different species of fruit flies i.e Bactrocera zonata, Bactrocera dorsalis, and Bactrocera correcta were recorded throughout the year. The species Bactrocera zonata was found dominant and its population remained on an average above 90 % throughout the year. Population of Bacrocera dorsalis was recorded higher from August to February and as much as (24.17%) was recorded in the month of September. However, its average percentage remained (10.83%) from August to February. Population percentage of B.correcta remained higher (6.5%) during July and August and then gradually decreased and averagely remained (1.8%) from September to June. Highest (1870) fruit flies per trap were recorded in the month of September. Population of fruit flies started to decline gradually after September and lowest number (81) per trap was recorded in the month of January followed by (89) in February. Again, in the month of March population of fruit flies started to increase and during this month (149) fruit flies per trap were recorded.

Study the field parasitism percentage of Acerophagus papayae in papaya mealybug in Malir-Karachi papaya orchards

Surveys were conducted during 2023-24 in papaya orchards in district Malir

Pictorial view of Research activities of PMRI

Collecting the trapped fruit flies from the Ber plant.

Trap installed in Ber plant.

Translucent trap installed horizontally.

Identification of fruit flies in the lab after collecting them from trap.

Segregation of different species of fruit flies.

100g bottle of Methyl Eugenol.

Karachi to determine field parasitism percentage of Acerophagus papayae, a potential parasitoid of papaya mealybug. The field culture of papaya mealybug was brought in PMRI, Biological laboratory and mummified mealy bugs were observed under microscope. Papaya mealybug was recorded throughout the year. During February, March peak parasitism percentage was recorded and it was up to 21%, however, during colder months parasitism percentage decreased and recorded 8% during December -January.

Vertebrate Pest Management

Detection and augmentation of ecto and endo-parasites of rodent pest

- During reporting period, prevalence of ecto and endoparasites of different rats species were investigated. Highest prevalence rate of ecto parasites observed in Rattusrattus species.Polyplaxspinulosa 45.2%, Xenopsyllacheops 20.3%, Echinolaelaps 10.5%, Xenopsyllaastia10%, and Haemolaelapsrecorded was 9.2%.
- Lowest prevalence of parasites (4.8%) recorded in Ambyloma species. Observed highest infection percentage in Rattusrattus species i.e Hymenolepisswatensissp.n(26.2%) , Heterakissp(25.5%), Aspiculurissp(24.1%), Lutziellamicroacetabularae(23.8%), Syphacia sp(23.4%), Hymenolepisfusa(22.1%,) Lutziellaswatensissp(21.1%), and Hymenolepisdiminuta had lowest infection percentage of (18.6%).
- Incidence percentage of ecto and endoparasites of rats species. Recorded highest incidence percentage for Hymenolepisdiminuta (29%) followed by Syphacia sp (21%), Aspiculurissp(13%), Heterakissp(12%), Lutziellaswatensissp(7.5%) whereas Hymenolepisswatensissp.n bore 7% incidence, Lutziellamicroacetabularae(5.4%) and Hymenolepisfusa with lowest incidence percentage (4.1%).

Isolation, characterization and pest management of secondary metabolites (Strychnine from Strychnos nux-vomica)

Toxicity of extracted Strychnine phytochemical from Strychnos nux vomica examined against Albino rats, pest of multiple commodities using invivo and invitro tests for inspecting overall efficiency against its growth stages. Characterization of strychnine from Nux was evaluated through phytochemical analysis where orange ring was indicated. Anti-feedent index% of adult Albino in response to formulated bio-rodenticides bait after 24hr at 1000ppm were; 1.41, at 2000ppm were; 2.62 and at 3000ppm were; 2.91. After 48hr at 1000ppm were; 2.12, at 2000ppm were; 2.52 and at 3000ppm were; 3.12. Toxicity of strychnine against adult Albinos through IV technique, regression evaluated as:

Vertebrate pest (rats) control through isolated secondary metabolites from mango peel (Mangifera indica), curry leaves (Murrayakoenigii) and moringa leaves (Moringa oleifera)

Purpose of this research was to introduce new green techniques of rodent control. Detected Flavonoid through phytochemical analysis and thin layered chromatography where reddish brown ring in test tubes was indicated the successful extraction flavonoid. TLC result, yellow band with Rf value i.e., 0.46 indicated flavonoid separation. Anti-Feedent Index% Of Adult Albino in response to Formulated Bio-rodenticides bait after 24hr at 1000ppm were; [Moringa: 3.74, Curry: 3.22 and Mango: 7.69], at 2000ppm were; [Moringa: 4.52, Curry: 5.87 and Mango: 8.23] and at 3000ppm were; [Moringa: 7.77, Curry: 15.7 and Mango: 11.2]. After 48hr at 1000ppm were [Moringa: 3.98, Curry: 2.33 and Mango: 7.69], at

2000ppm were; [Moringa: 5.52, Curry: 1.24 and Mango: 8.23] and at 3000ppm were [Moringa: 4.71, Curry: 2.61 and Mango: 11.2]. Toxicity of Flavonoid against adult Albinos through IV technique, regression evaluated as; Mango

Histopathological effects of rodenticides on some functional organs of laboratory rat

Strychnine application, Kidney Showed ++ = moderately severe, diffuse lesions of Glomerularandtubular degeneration and necrosis, Thrombosis and vasculitis. Moringa application Kidney showed ± = Mild, focal lesions; Glomerular and tubular degeneration and necrosis, showed + = Moderate, multifocal lesions of Thrombosis and vasculitis. After mango peel application Kidney Showed + = Moderate, multifocal lesions of Glomerular and tubular degeneration and necrosis, Thrombosis and vasculitis. Strychinine application, Liver Show ++ = moderately severe, diffuse lesions Vacuolar degeneration and necrosis Thrombosis and vasculitis. Strychinine application, Heart Show ++ = moderately severe, diffuse lesions and necrosis show + = Moderate, multifocal lesions of Thrombosis and vasculitis. Brodifaucum application Kidney Showed ++ = Moderately severe, diffuse lesions Glomerular and tubular degeneration and necrosis, Showed + = Moderate, multifocal lesions of Thrombosis and vasculitis. After Brodifaucum application Liver Show + = Moderate, multifocal lesions of Vacuolar degeneration and necrosis, Thrombosis and vasculitis.

Breeding and behavioral studies of albino rats and field rats (Rattus rattus)

· Collected Albino and field Rats from SARC-PARC and HEJ Institute, University of Karachi vicinity. Each collection performed in similar environmental conditions. Albinos gestation period prolonged up-to 21-25 days giving birth to 4-6 babies in a single litter. Animals from both housing conditions were divided in two groups: Light (tested between 8am to 5 pm) and Dark (reside between 7 pm to 7 a.m.; n = 10/per group). Behavioral tasks performed during light phase were conducted under white-light illumination (200 Lux), while behavioral procedures performed during dark phase were conducted under no-light. Conditions utilized to avoid following interfering factors: (i) masking effects (such an increasing in activity when lights are switched off or decreasing in activity when lights switched on); and (ii) phase shifting along days (due the lights being kept on during dark phase or the lights being kept off during light phase).

Occurrence and morpho-taxonomy of helminth parasites of edible fishes from coast of Lasbela, Balochistan (M.Phil. Study)"

· Collection of fishes, detection/identification and record of infectious agents (parasites) of zoonotic importance.

· Out of 153 fishes of 13 different species got examined for helminth parasites.

· Recorded 14.37% infected fishes.

Infected organs were further preserved in 2% formalin for histo-pathological studies.

PICTORIAL ACTIVITIES OF VPCI

Plant Introduction

Introduction of dragon fruit

Dragon (Selenicereu sundatus) was planted at the Institute of Plant Introduction of PARC in Karachi for introduction and propagation. First, DUA Foundation, a Karachi-based NGO, sent 28 dragon fruits (Red H-un datus) of South American origin. Using drip irrigation with marginal quality irrigation having EC of 3.2dSm-1, the cuttings were planted in the field at IPI in 2021. After almost one year the plants were matured, and flowering was started. Few flowerings shed due to high temperature. Three trees bearing dragon fruit were picked for their initial crop. The fruit weighed an average of 370 grams. Overall, Dragon Fruit has performed satisfactorily.

Introduction of Olive plants

Olive varieties including (Arbosana, Arboquina) and other varities like Hagi bananca, Picual Perlilino were introduced from spain and local varieties like Janboui and Manzanilla were introduced and propagated in nursery. Olive plants were delivered to the progressive farmers in potential areas in khirthar range Dadu, Nawab Shah and Gadap Karachi, Sindh under National Olive Project.

Introduction of Quinoa

Using marginal quality irrigation water on Quinoa (Chenopodium quinoa) water productivity under mulch in Indus delta. The experiment was conducted at IPI under marginal quality irrigation water having TDS 1800 ppm by using two irrigation treatments with mulch and without mulch. There were five numbers of irrigation applied on each treatment. The total amount of water applied were 500 m3 per hectare under each treatment. The average plant height, terminal Penicle length and terminal Penicle weight was observed under T1 as 148.6cm, 32.6cm and 34.6gm per plot respectively. However, the average number of branches and

number of spikes per plot under t1 were 25.4 and 12.4 respectively and average weight of grain per plant under T1 was found 140 and 55 gm respectively. However, the average number of plants and weight of grain per plant was found 55 gm. Table 1 shows that the total yield obtained under T1 and T2 was found 1100 and 966 kg. ha-1 respectively. Whereas the total water used under both irrigation treatments were 500m3. ha-1. The water productivity under T1 was found higher as 2.20 kg.m-3 whereas, without mulch (T2) it was observed as 1.93 kg.m-3. Likewise, the harvest index under T1 and T2 were observed as 29.64 and 28.66% respectively.

Introduction of Onion

Onion (Nasarpur) variety was planted on one acre at IPI under furrow mode. Overall germination percentage of onion was recorded 86 percent under furrow mode. Overall, nine (09) irrigation applied using furrow mode. 50 kg of DAP, 100 Kg of NP and 50 Kg of Urea were applied during land preparation. Dual gold weedicide 3 ml/ L (Pre-emergence) sprayed in onion field. 1 bag of DAP applied/ acre. The average diameter of onion bulb was recorded as 6.3 cm with the average weight of onion was observed as 95.23 gm at IPI.

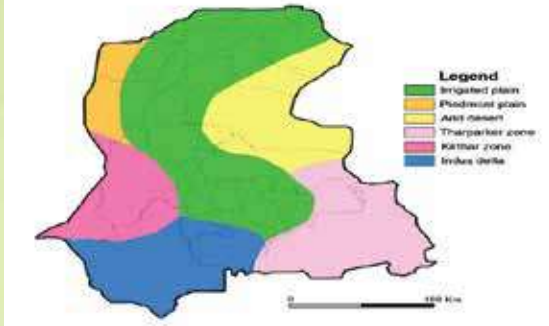
Natural Resources

NATURAL RESOURCES DIVISION

Natural Resources Division (NRD) primarily focuses on sustainable and efficient management of natural resources like soil, water, rangeland, agroforestry and honeybees. The Division works with national & international organizations to enhance productivity in sustainable ways across diverse agroecological zones of the country. NRD performs activities in line with the set priorities to accomplish the research for prosperity vision of PARC through its research establishments across the country. NRD emphasizes to enhance resilience of vulnerable farming communities through climate smart land, water, honeybees, rangeland and agroforestry resources management along with arid and mountainous agriculture.

Sub-Ecological Zonation of Sindh and Balochistan

PARC identified sub-ecological zones in Sindh and Balochistan provinces based on recent agroclimatic, landform, and land use data. Sindh was delineated into Irrigated Plains (37%), Tharparker Zone (18%), Arid Desert Zone (15.3%), Indus Delta (14%), Kirthar Zone (11.1%), and Piedmont Plain Zone (4.7%) and Balochistan into Desert Zone (22.7%), Dry Plateau (16%), Northern Highlands (15.8%), Coastal Zone (14.6%), Dry Uplands (12.3%), Plains (11%), and Suleiman Mountain Zones (7.6%). The Irrigated Plains dominate in Sindh, while Balochistan's largest zone is the Desert Zone, with dry uplands and plateaus covering central and northwestern regions, respectively.



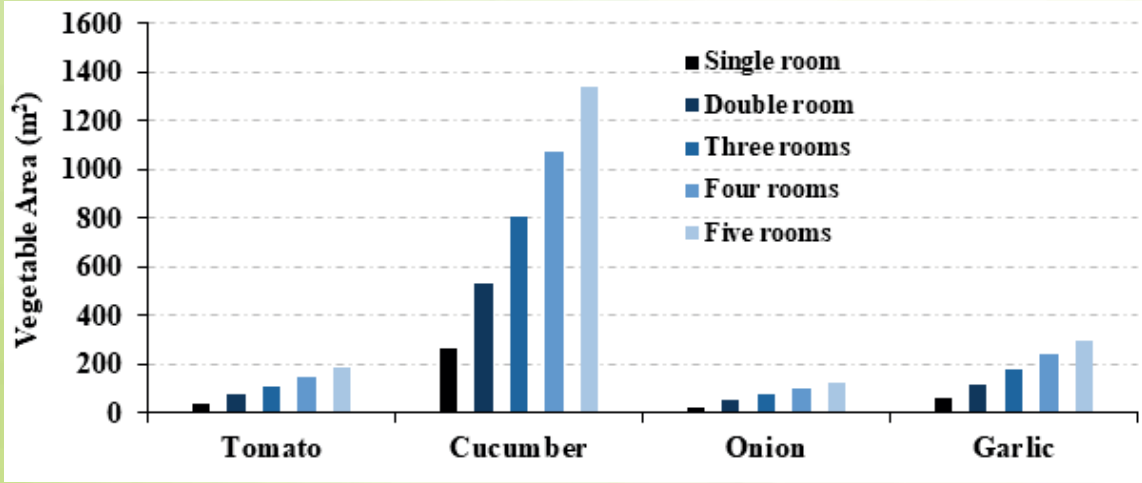
Sub-ecological zones of Sindh province.	Sub-ecological zones of Balochistan province.

Rooftop Rainwater Harvesting

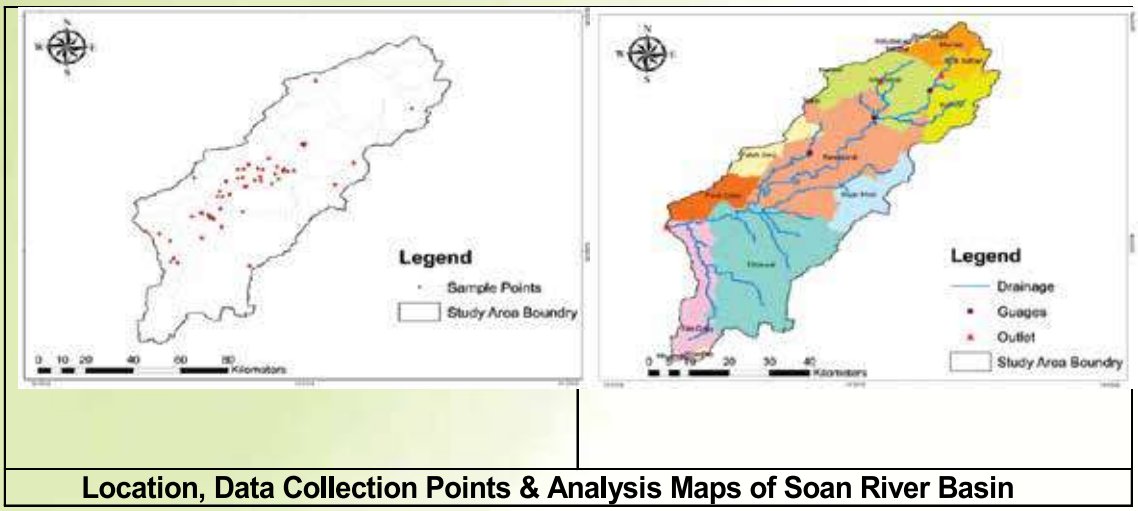
Assessment of rooftop rainwater harvesting in the Rawal Watershed was carried out where the water table is declining over 1 meter annually due to urbanization and climate change. Analyzing 30 years of weather data revealed that rainwater from various household sizes can support vegetable cultivation (onion, tomato, cucumber, garlic) in areas from 25 m^2 to 1339 m^2, using 10 to 59 m^3 storage tanks. Harvesting about 1.2 meters of rainwater annually could help stabilize the water table. This approach not only boosts agricultural productivity during dry spells but also recharges groundwater, benefiting rural and urban areas.

Climate Change Impact on Groundwater-Based Livelihood in Soan River Basin

The impact of socioeconomic factors and climate change on groundwater-dependent livelihoods in the Soan River Basin was assessed, focusing on Persian Wheels and dug-wells. Data from 50 union councils showed that 70% of farmers



acknowledged climate change, with 62% experiencing severe impacts on agriculture and water availability. Farmers' responses revealed hotter summers (92%), milder winters (72%), and reduced rainfall (96%). Groundwater levels have dropped for 72% of farmers, and 80% reported reduced yields. Preferred irrigation methods are drip (60%) and sprinkler (35%), with 95% open to solar pumps to reduce costs. Recommendations include integrating solar pumps with existing systems and shifting to high-value agriculture to boost resilience and productivity.



Location, Data Collection Points & Analysis Maps of Soan River Basin

Integrated Nutrient Management for Improving Wheat Productivity

Ten (10) Integrated Nutrient Management (INM) based wheat demonstrations and experimental trials were carried out all over Pakistan. Results from the countrywide demonstrations and experimental trials showed that wheat yield increased by 15-25% as compared to Farmers' Practice.

Production of Biofertilizer (Biozote)

Land Resources Research Institute, National Agricultural Research Centre produced Biozote for wheat, maize, rice, cotton, groundnut, soybean, mung bean, and sugarcane crops. Around 20 thousand Biozote packets were produced and marketed through PATCO for farmers throughout Pakistan during 2023-24.

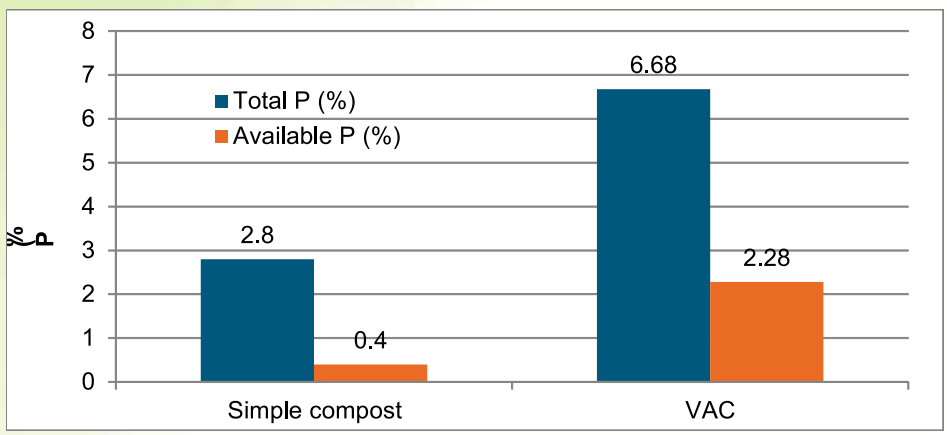
Biozote effect on maize yield

Production of Vermicompost (Vermizote)

Vermi compost production technology was revived and produced 500 kg Vermizote for kitchen gardening and nurseries.

Value-Added Compost

The Value-Added Compost (VAC) was prepared from poultry litter, rock phosphate (partially acidulated) and inoculum of Phosphate Solubilizing Bacteria and evaluated in comparison with the simple compost. The available phosphorus (P) content in the VAC was greater (2.28%) over simple compost (0.4%) showing an increase of P availability of more than five-folds in 120 days of the composting process and total P content in the VAC was also greater (6.68%) than the simple compost (2.8%). The CN ratio of VAC remained 10.88 on day 120 whereas pH remained lower as compared to the other.



Total and available P content of simple and value-added compost.

Poultry litter compost preparation by adding efficient microbes and rock phosphate

Rice Residue Management for Soil Health and Crop Productivity

Pak-Seeder and Super-Seeder were used successfully for timely wheat sowing in the presence of large quantity of rice residues in fields. Mulching and incorporation of rice residue vs residue removal was evaluated for soil health improvement and wheat productivity. Rice residue mulching along with wheat sowing was achieved with Pak-Seeder while rice residue incorporation along with wheat sowing was achieved with Super-Seeder.

Rice residue either mulched or incorporated reported 8-12% increase in wheat yield, reduced bulk density by 5% and increased soil aggregate stability by 16% after four years, increased effective porosity by 4% and refilling porosity by 8%. Mulching with Pak-Seeder conserved 21% while residue incorporation with Supper-Seeder conserved 12% more moisture as compared to Farmers' Practice.

Rice residue incorporation along with wheat sowing with Super-Seeder

Rice residue mulching along with wheat sowing with Pak-Seeder

Adaptability of Exotic Grasses and Forages

Grasses and forages seeds, imported from different countries by private companies, were evaluated for their adaptability in Pakistan. Evaluation trials were conducted in Rangeland Research Institute, National Agricultural Research Centre, Islamabad. Fourteen varieties of grasses and forages were evaluated for their adaptability including 04 of Ryegrass, 03 of Rhodes grass, 04 of Clovers, 02 of Alfalfa and 01 of forage blend. Rhodes grass varieties produced fresh biomass 19 t/h (Tolgar-II), 16 t/ha (Capricon), 12.2 t/ha (Premium Cut) and Ryegrass varieties produced fresh biomass of 27 t/ha (Big Boss), 29 t/ha (Olympic), 16 t/ha (Kohinoor), and 33 t/ha (Milk Plus). Similarly, Clovers included red, white, persian and arrow leaf which produced 14, 10.6, 12 and 9.6 t/ha, respectively. Alfalfa produced 15.7 t/ha (PX1) and 23 t/ha (Green Gold) while Forage Blends produced 19.8 t/ha. As a result of adaptability trials Rhodes grass (Fine cut) has been cultivated over 35000 acres of area in Punjab, Sindh, and Baluchistan for fodder production. Similarly, Ryegrass (Vortex) has been cultivated over an area of 6000 acres in various provinces of Pakistan including Azad Jammu and Kashmir and Gilgit-Baltistan.

Rhodes Grass

Ryegrass

Clover

Alfalfa

Adaptability of Italian and USA Ryegrass Lines in AJ&K

Adaptability trial of seven ryegrass lines was conducted at AJ&K. Seeds of six lines were obtained from KOPIA and one line from USA. USA ryegrass line performed the best producing the highest fresh biomass (7.3 t/ha), followed by Line No. 6 of KOPIA (7 t/ha). Similarly, for seed productivity, the results revealed that Line No. 5 of KOPIA performed the best by producing 610 kg/ha and followed by Line No. 7 producing 562 kg/ha. This shows that one hectare of land has the potential to produce seed to restore 50 hectares of land with ryegrass.

Nutritional profile of Italian Ryegrass lines was investigated from the plant samples collected at maturity. Line Nos. 6 and 3 were found to be more promising having crude protein content of 14.37% and 13.81%, respectively, which is the important factor for animal growth.

Introduction and Propagation of Seedlings in Agroforestry Nursery

Agroforestry Nursery produced more than sixty thousand healthy plants of various species including Robinia, Willow, Paulownia, Sagwan, and Poplar which were successfully propagated.

Potential Fast Growing Hybrid Tree Species in Silvo-Agricultural System

In the Silvo-agricultural system, three sites (Naganwali in district Pindigheb, Tandali in district Muzaffarabad, and Oghi in district Manshera) were selected for agroforestry interventions. Four potential fast-growing plants were selected. A significant result was observed in *Populus deltoides* with an average yield of 5.27 kg/plant and carbon stock of 2.63 kg/plant as compared to the other three species in three sites followed by the *Paulownia elongata* species. Wheat crop was sown in alleys and yielded 32 bags per acre (40 kg per bag) under rainfed conditions. The maximum production of wheat was observed at Naganwali in district Pindigheb.

TIKA-PARC Beehive Products Research Laboratory

Chairman, PARC along with the Ambassador of Turkey to Pakistan (Dr. Mehmet Pacaci), Vice President, TIKA (Dr. Umit Naci Yorulma), Country Head, TIKA-Pakistan (Muhsin Balci) inaugurated the Bee Products Research Laboratory at the Honeybee Research Institute, National Agricultural Research Centre, Islamabad, made possible through the generous support and collaboration of TIKA. Chairman, PARC extended heartfelt gratitude to TIKA for their invaluable contribution and unwavering commitment to strengthening our agricultural research capabilities. This state-of-the-art laboratory marks a significant milestone in our ongoing efforts to advance apiculture research and development in Pakistan.

Inauguration of the bee products research laboratory

Relation of Labellum and Glossae: Bio-Morphological Characterization of Honeybee Workers

Correlation of honey collection potential with the length and width of labellum and glossae in western honeybees Apis mellifera L. depicted that bio-morphological characters of labellum and glossae were significantly correlated with the honey collection potential in Apis mellifera L.

Honeybee worker

Seed Production of High Yielding Wheat and Barley Varieties

Seed production is a major challenge in Baluchistan with farmers lacking quality seeds of high yielding, abiotic stress tolerant and disease resistant varieties of wheat and barley. Baluchistan Agricultural Research and Development Centre (BARDC), Quetta initiated village-based seed production where 300 acres of wheat and 10 acres of barley were planted at different villages to increase availability of quality seed. The yield of wheat genotypes was in the range of 1.5 to 3.3 tons per acre while that of barley varieties was in the range of 1.7 to 3.2 tons per acre. Moreover, wheat varieties showing resistance against yellow rust strain under rainfed conditions.



High yielding wheat and barely growth after clipping

Ispaghol Production

BARDC, Quetta introduced and demonstrated two ispaghol (Plantago ovata) cultivars in four districts of Baluchistan to increase its production and provide farmers with an additional crop under marginal land for improving livelihood. The farmers received an outstanding yield at Kachi (6 maunds per acre) as compared to other sites.


Sesame Seed Production

Two improved sesame varieties (TS-3 and TH-6) were introduced in three districts of Baluchistan (Kachi, Sibi and Jhal Magsi) to increase sesame production under marginal lands. TS-3 performed well in most of the sites with early pod formation and maturity (63 and 120 days, respectively). The TS-3

showed maximum seed yield of 727 kg ha−1 averaged over three locations and minimum seed yield was observed for the local landrace which produced 623 kg ha−1.

Pistachio Characterization and Improvement through Budding Technologies

Pistachio varieties of Baluchistan were classified into three groups: early-season flowering, mid-season flowering and late-season flowering. Eight best performing pistachio cultivars and three landraces were identified. During the study mother orchard was developed at BARDC Farms at Mastung and Quetta. Bud wood from ten females and four males cultivars from different districts of Baluchistan were collected and grafted at Mastung Farm. For the first time in Pakistan, Distinctness, Uniformity and Stability (DUS) data for the registration of three pistachio landraces was collected. Scientists at BARDC Farm successfully budded pistachio plants used various budding techniques to refine the technology to increase success rate.

Pistachio chracterization and budded nursery plants production

Saffron Production and Dissemination

BARDC is thriving to increase saffron production in Balochistan by providing quality bulbs to farmers to increase production of this expensive herb. BARDC produced around 400 grams of saffron during 2023-24.

Olive Production and Value Addition

BARDC, Quetta distributed 82,289 olive nursery plants among the farmers of Baluchistan under PSDP project for olive plantation and production. Moreover, extra virgin Olive oil was extracted from olive berries collected from Loralai, Musakheil, and Pishin districts, Baluchistan and developed pickles.

Planting of olive cuttings

Extra virgin Olive oil extraction

Cotton Productivity in Saline Soils of Cholistan

Cotton sowing techniques under saline soil were evaluated under ACIAR project "Adapting to Salinity in Southern Indus Basin (ASSIB) Project", at farmer's field near Bahawalpur. The study was executed by PARC-Arid Zone Research Institute (AZRI), Bahawalpur in collaboration with Mehran University and MNS University. It was found that flatbed ridges achieved the highest yield (1803 kg/ha), followed by drill sowing (1476 kg/ha-1) and broadcast sowing (1025 kg/ha-1).

Cotton crop at Saline Soil of Cholistan grown under ACIAR-ASSIB Project

Chili Production and Postharvest Management

The KOPIA-Pakistan project, implemented at the Arid Zone Research Centre (AZRC), Umerkot, has introduced significant advancements in chili production and postharvest management in the Thar region. Various drying methods, including open ground, green sheet, solar tunnel, solar-gas hybrid, and solar energy dehydration plants, were assessed for efficiency. Four advanced Solar Energy Dehydration Plants, supported by a 50 kW solar-powered washing unit, installed at the Centre was demonstrated to the local farmers. Farmers were provided free drying services, processing 16,800 kg (420 munds) of fresh chilies and producing

4,800 kg (120 munds) of high-quality dried chilies with a 28% recovery rate. These dryers reduced drying time to 30-35 hours, cutting drying durations by 85-92% compared to traditional open drying methods (8-15 days). Some other high value crops were also dried and commercialized through this method.

Postharvest Management Process under the KOPIA-Pakistan

Vegetables Seed Production in Mountainous Areas

About 130 kg seed of China cabbage, Nipali cabbage and redish was produced at Mountainous Agricultural Research Centre (MARC), Gilgit and around 80 thousand seedlings of sweet pepper, hot chili, tomato, brinjal and onion were grown and distributed among farmers.

Fruit Plants Propagation and Distribution

Rootstocks of 30,000 deciduous fruit plants (Apricot, Apple, Pear, Peach, and Cherry) were grafted at MARC, Gilgit and about 5,000 true-to-type deciduous fruit plants (Apricot, Apple, Cherry, Pear, Plum, Fig, Walnut, and Almond) were produced and distributed to farmers, NGOs, and Government organizations of Gilgit-Baltistan (GB). Distributed 11,000 local olive plants to farmers, NGOs, and Government organizations. To assess the adaptability of olives to local climatic conditions, two adaptability trials were conducted in different ecological zones of GB. Established 09 kiwi orchards in different districts of GB. Furthermore, three cherry varietal experimental orchards were established to test and promote superior cherry varieties for distributing their seeds among private nurseries in GB.

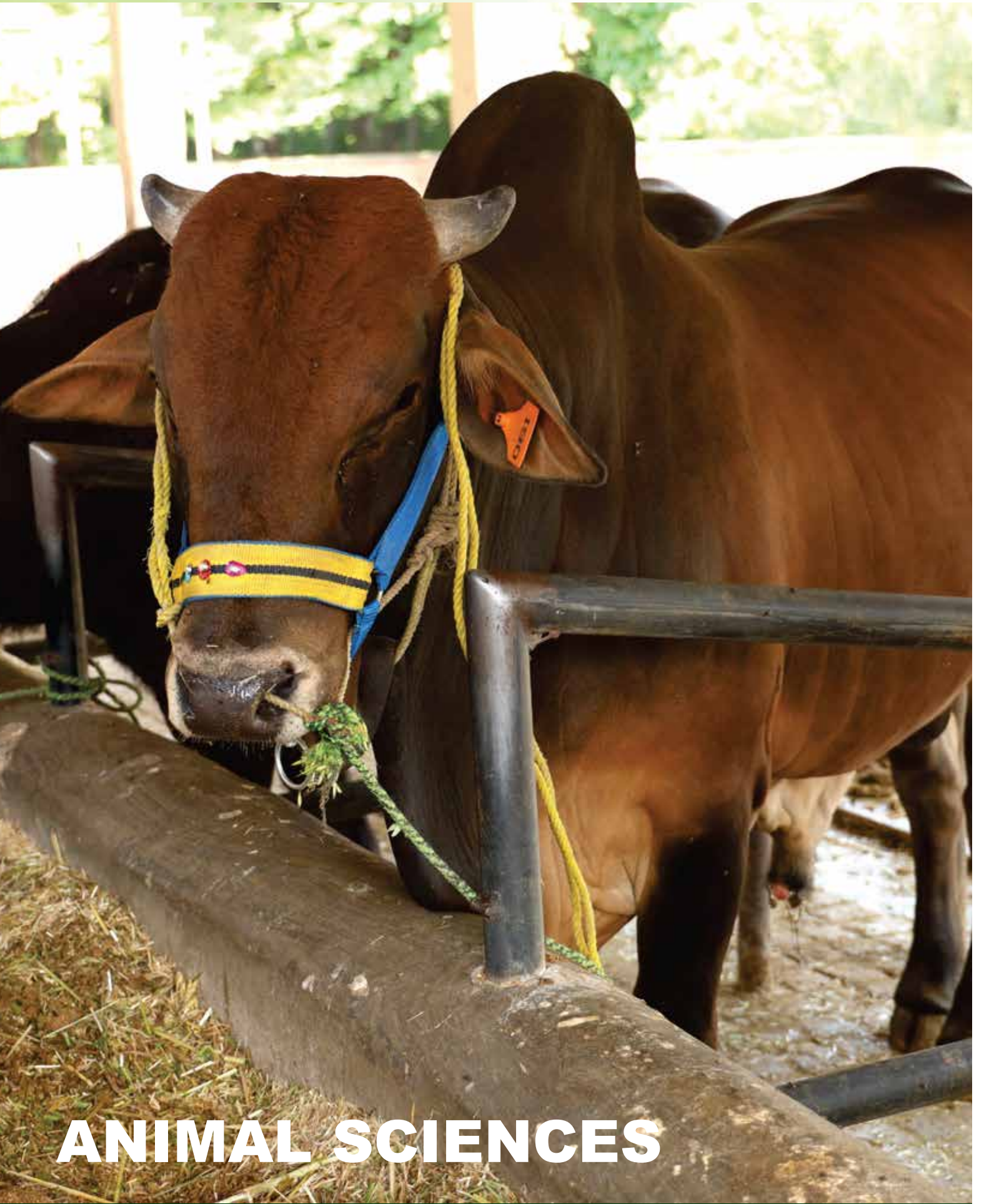
Introduction of Gansu Golden Trout and Improved Variety of Rainbow Trout to Gilgit-Baltistan

About 50,000 eyed ova of Gansu golden trout and improved variety of rainbow trout were brought from Gansu Fisheries Research Institute, China to Trout Research and Multiplication Station (TRMS), Juglote, GB. The fish is going through temperature acclimatization and feeding trials at TRMS. Once successful the fish will be propagated and introduced into the farming community of Gilgit-Baltistan.

Trout Research and Multiplication

Pathogen Identification of Disease Outbreak in Hatcheries of Gilgit-Baltistan

Disease outbreak in hatcheries of GB occurred during 2024. Samples were collected from different hatcheries, identified the disease and suggested the treatment to the local farmers to control the disease.



ANIMAL SCIENCES

PAKISTAN AGRICULTURAL RESEARCH COUNCIL

ANIMAL SCIENCES DIVISION

Animal Sciences Division (ASD) was established in 1980 under the umbrella of PARC. The aim of this division is to improve production potential of food animals. The prime task of ASD is to develop, monitor and evaluate research projects and eventually finding solutions to issues in livestock sector. The broader researchable areas of livestock/poultry/fisheries sector comprising innovation in nutrition, genetics, reproduction, health, dairy value addition and biotechnology. The Animal Sciences Division has several key objectives, including:

- Breed Improvement: To enhance the productivity and quality of livestock through breeding technologies and genetic improvement programs.

- Nutrition and Feeding: To develop and promote cost-effective and nutritionally balanced livestock feed and feeding practices.

- Disease Control: To prevent, control, and manage diseases affecting livestock and poultry, with a focus on vaccine development and epidemiological tools.

- Aquaculture and Inland fisheries: Improvement of productivity in fisheries through breeding, feeding and managemental practices.

- Livestock Extension: To provide training and education to progressive farmers/stakeholders in the livestock/poultry/fisheries sector and disseminate best practices.

- Conservation: To conserve and protect indigenous livestock breeds and genetic resources.

- Environmental Sustainability: To promote environmental friendly sustainable livestock production practices.

- Policy Development: To contribute in formulation process of policies related to livestock/poultry/fisheries sector in Pakistan.

1. RESEARCH COORDINATION, MONITORING AND EVALUATION ACTIVITIES:

Animal Sciences Division, PARC is involved in research coordination, monitoring and evaluation in respect to various disciplines of animal sciences. Followings are the salient outputs in this regard:

a. Technical Evaluation and Monitoring of Research Projects

S. No	Funding Source	Completed	On-going	New Submission	Total
1	ALP	10	9	425	444
2	PSDP/RIAD	1*	-	2	3
3	Others MoU	1	4	4	9
4	PSF	-	1	10	11
5	Concept proposal **	-	-	6	6
Total		**12**	**14**	**447**	**473**

**Component, **Concept proposal submitted to various countries*

b. International Coordination

Organizations	Areas of cooperation
Royal Cell Biotechnology Group, China	• In Vitro Fertilization laboratory • Embryo production
Eastern Mediterranean Public Health Network (EMPHNET)/Global Health Development (GHD)	• Zoonotic Diseases (Brucellosis)
World Health Organization (WHO) /National Institute of Health (NIH)	• One Health • Anti-Microbial Resistance (AMR) • Field Epidemiology & Laboratory Training Program (FELTP)
Food and Agriculture Organization (FAO)	• Livestock Breed Improvement
International Center for Agricultural Research in the Dry Areas (ICARDA)	• Goat breed improvement
Fleming Fund, UK	• Anti-microbial resistance in livestock, poultry and fish
National Academy of Sciences (NAS), USA	• One Health (ticks borne disease) • Surveillance of Avian Influenza • Aflatoxin Bio-control
Korean Program on International Agriculture (KOPIA)	• Cattle Breed Improvement

2. RESEARCH ACHIEVEMENTS

ANIMAL HEALTH PROGRAM

The Animal Health Program aims to improve animal health of livestock to achieve food safety and security in Pakistan. The theme is persuaded by research on better understanding of animal pathogens and disease mechanisms through epidemiological, conventional and molecular tools for the diagnosis and control of animal diseases.

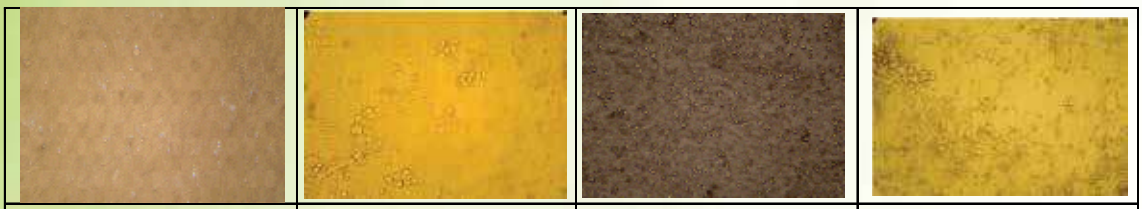
Project 1: One World-One Health: Holistic and Cost-effective Approach to Counter Brucellosis in Sheep/Goats in Pakistan (ALP-AS-156)

- Sheep (n=35) and goats (n=35) were selected for Brucella melitensis Rev 1 vaccine trial at two farms in KahrorPakka, Punjab. Blood samples collected from experimental animals were analyzed using RBPT (Rose Bengal Plate Test).
- All the animals (n=70) were found negative for brucellosis using RBPT. The elected sheep and goats were vaccinated with Brucella melitensis Rev 1 vaccine for vaccine efficacy trial.

Vaccination of animals in the field

Project 2: Field validation of a Newly Developed Homologous Lineage Thermotolerant Peste des Petits Ruminants (PPR) Vaccine for Control of PPR (ALP-AS-385)

- The quality control procedures for PPR vaccine seed were standardized and PPR vaccine seed was revived using Vero cells.
- The revived seed passed the quality control testing i.e., sterility, safety, potency and identity test. The cytopathic effects of PPRV vaccine strain are shown in the pictures below.



a. Un-infected	b. Clumping of cells	c. Rounding of cells	d. Layer detachment

Vero cells (*Magnification* 10^x)

Project 3: Development of Models for Control of Warble Fly in Pakistan(ALP-AS340)

- The project areas (Quetta, Ziarat, Dera Ismail Khan, Fort Munro and Gorikot/Astore) has been visited for the physical examination of animals during spring (March-May, 2023).These areas will again be visited during autumn (September-November, 2023). In these visits, livestock farmers (n=225) holding goats (1,685) and cattle (653) were clinically examined for warble fly infestation.
- An agreement with farmers was signed for support in blood sampling and therapeutic trial against warble fly. The farmers were briefed about the purpose of the project and benefits. The farmers consented to allow collecting blood samples and maintained untreated animals infected with warble fly larvae during April to September.
- Three villages in each unit of the project area, were selected for therapeutic control trials. For each model, 50 goats and 12 cattle were involved. The first control model was based on medication with ivermectin (1ml/50kg body weight) subcutaneously once a year during the first larval stage before appearing nodules in goats and cattle of a selected village.
- Blood samples from 595 animals (500 goats and 95 cattle) were collected from Astore, Bajaur, Dera Ghazi Khan and Quetta and were stored at -20°C for further analysis through ELISA.

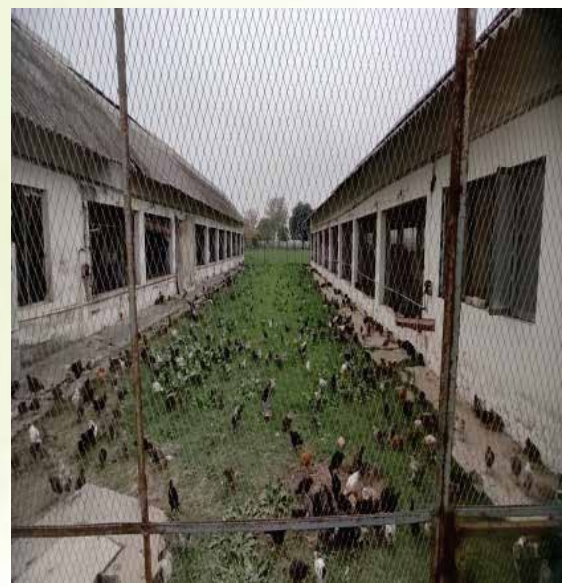
Collection of blood samples from cattle

Collection of blood samples from goats

ANIMAL NUTRITION PROGRAM

The Animal Nutrition Program focuses mainly on nutritive evaluation of feedstuffs, economical feed development using non-conventional feed resources, development of nutritional technologies for efficient livestock production and feed safety issues including mitigation of mycotoxins problem in feeds.

Project 1: Growth Performance of Different Backyard Poultry Breeds on Partial Free-Range System



Rearing backyard poultry in partial free range

- Poultry birds of 3 breeds i.e. Black Australorp (BAL), Rhode Island Red (RIR) and Fayoumi (FAY) were raised on intensive feeding and partial free-range with 30% less feed supplementation up to 16 weeks of age.
- Weight gain in birds on intensive feeding was significantly higher (1,274g/bird) as compared to partial free-range birds (1,109g/bird).
- Feeding cost per kg weight gain during 16 weeks was 10% lower (Rs. 503) with partial free-range as compared to intensive feeding system (Rs. 557).
- Bird survival rates under intensive and partial free-range system were 97 and 96%, respectively.
- Among breeds, BAL birds exhibited significantly higher weight gain (1,242g/bird) as compared to RIR (1,177g/bird) and FAY (1,158g/bird).
- These results showed that backyard poultry can be reared economically on partial free-range system.

Project 2: Mitigation of Salmonella Risk by Controlling Rodents using Different Baits at Poultry Farm:

- Two types of baits (NARC bait and commercial bait) were kept inside burrow (n=18) around poultry sheds and other at high activity zones of rodents at the shed and feed store (n=6) for 5 months.
- More than 40 rats were killed mainly around feed store. The feed bags remained safe from rat damage during study period.
- More than 60% reduction in mortality cases of poultry birds due to Salmonella infection was reported two months after application of the baits.
- Both types of baits were equally effective in controlling rats.

Commercial bait for rat control

Rearing backyard poultry in rat-free environment

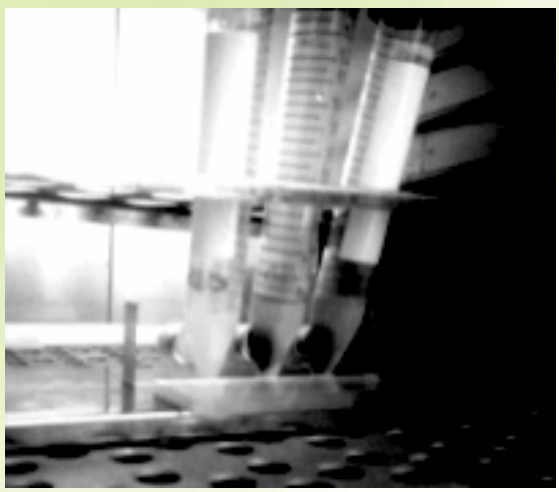
ANIMAL REPRODUCTION AND GENETICS PROGRAM

The main focus of this program is to improve reproductive efficiency and exploit genetic potential of food animals. In this regard, major reproductive tools/techniques i.e. artificial insemination (AI)/laparoscopic AI; controlled breeding, sperm sexing &cryopreservation, ultrasonography and selective breeding are being used for genetic up-gradation of local breeds of cattle, buffalo and goat.

Project 1: Investigations and Optimization of Sperm Sexing and Cryopreservation Techniques in Water Buffalo (ALP-AS-337)

- The paramagnetic nanoparticles (MNPs) based sperm sexing technique was optimized for buffalo spermatozoa with sexing rate of 90% confirmed through RT-PCR and after live births 92% female progeny was achieved.

Validation of sperm sexing technique by real-time PCR



Sperm Sexing in Water Buffalo through MNPs

Artificial insemination with sexed spermatozoa

Project 2: Nanotechnology-Enabled Improvement of Spermatozoa Cryopreservation Technique for Water Buffalos (ALP-AS-341)

- Inclusion of Zinc Oxide, Cerium Oxide and Manganese di-oxide nanoparticles at dose levels 12.29 mmol L-1, 0.43 µmol L-1 and 0.2 to 0.4 mmol L-1 respectively, in tris-citric acid cryo-diluent improved the post thaw quality of water

buffalo spermatozoa.

- Experiment on in-vitro toxicity effects of hydroxyapatite nanoparticles (0.01, 0.02, 0.05, 0.1, 0.20 % and control) on Buffalo Spermatozoa was conducted. The lower doses of hydroxyapatite nanoparticles (0.01, 0.02 and 0.05% in physiological solution) were non-toxic to buffalo spermatozoa.

Project 3: Breed Improvement of Non-Descript Goat

- The high genetic crossbred progeny of Beetal (n=15) and Boer (n=08) bucks were obtained through Laparoscopic Artificial Insemination (LAI) by using frozen thawed spermatozoa.
- Embryo transfer technique has been optimized and standardized for goats. Nine embryos of purebred meat type Boer breed have been transferred through modified LAI technique in local surrogate goats.

Embryo transfer through Modified LAI in surrogate goats

Boer crossbred kid born through LAI with birth weight of 4 kg

Project 4. Introduction of Brahman Beef Cattle through Reproductive Biotechnologies

- Pregnancy was confirmed post artificial insemination with frozen thawed spermatozoa of Brahman in field area of Islamabad Capital Territory.

Artificial Insemination in Cow with Brahman Spermatozoa

Ultrasonogram of Cow Fetus at Day-50 of Gestation

ANIMAL PRODUCT IMPROVEMENT PROGRAM:

Animal Sciences Institute (ASI) has carved the Animal Products Improvement Program (APIP) with a mandate of quality evaluation and value addition through improved handling and processing technologies of animal products which is the

prime purpose of animal husbandry.

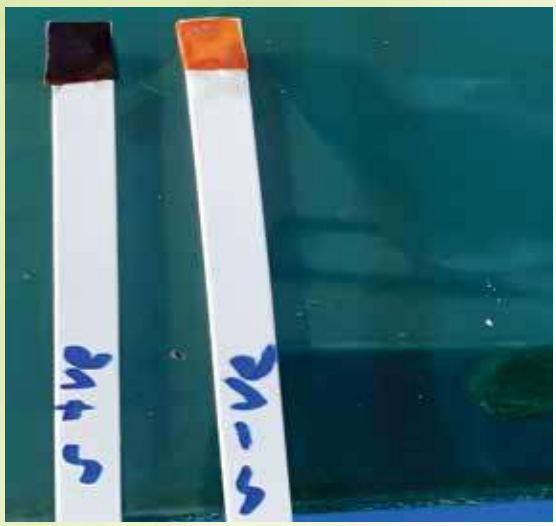
Project 1: Effect of Nisin on the Shelf Life of Raw Meatballs

- Meatballs prepared from chicken minced meat and nisin was added at concentrations of 0g/kg (T1), 2g/kg (T2), 4g/kg (T3), 6g/kg (T4) and 8g/kg (T5).
- The total viable counts (TVC) at day-0 in T1 were log10 6.54±0.73 which increased to log10 8.20±0.76 on day 14 while in T2 (the lowest nisin level tested), TVC were log10 5.49±0.12 on day 0, which increased to log10 6.84±0.29 on day 14. This shows that nisin was very effective in controlling the bacterial growth during refrigerated storage of meatballs (as it kept the count below log 7 cfu/g).

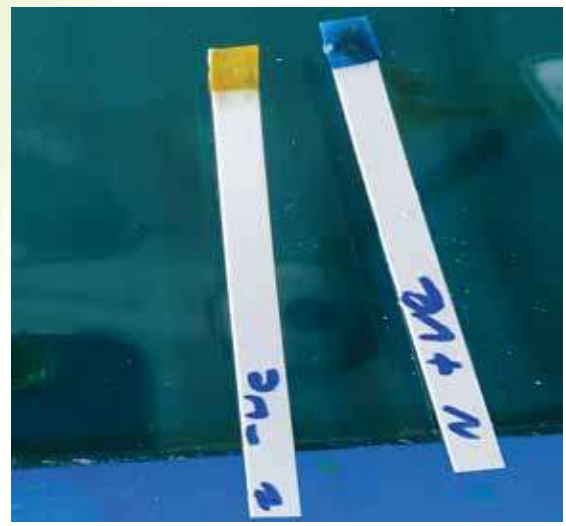
Preparation of serial dilutions for TVC determination in raw meatballs

Project 2: Development of Rapid Milk Testing Kit Exploiting Dry Chemistry for Detection of Common Adulterants in Market Milk

- Milk adulteration testing paper strips for neutralizers and starch detection were successfully developed.
- The minimum sensitivity level for these strips was found to be 0.1 %.



Strip for starch detection in milk tested at 0.1% level (left: positive control, right: negative control)



Strip for neutralizer detection in milk tested at 0.1% level (left: negative control, right: positive control)

LIVESTOCK RESEARCH STATION

The Livestock Research Station (LRS) was established in April, 1988 with an objective to improve, preserve and supply superior breeds of cattle and buffaloes to the progressive farmers.

Project 1: Nutritional Enrichment of Maize Stovers as Feed for Ruminants through Physio-Chemical Treatment and Ensilation (ALP)

- A feeding trial has been completed on cattle calves (n=16) for the comparative evaluation of various treated maize stovers/cobs on growth rate, nutrient utilization and economic efficiency.
- Four total mixed rations differing only in forage source but same concentrate to forage ratio at 1:1, on a total DM basis:
  - The TMR-1 consisted of Maize silage and concentrate,
  - The TMR-2 consisted of Urea-molasses treated maize stover and concentrate,
  - The TMR-3 consisted of Urea-molasses treated maize cobs and concentrate
  - The TMR-4 consisted of Urea-molasses treated paddy straw and concentrate.
- The results revealed that average daily weight gain was higher (0.81kg/day) in the calves fed on TMR-1 than the other fed TMRs.
- The feed cost per unit of weight gain of calves fed TMR-3 was lowest (Rs. 375.70) than the other fed TMRs.

Fattening of calves on nutritionally enriched maize stover based diets

Project 2: Establishment of Nucleus Herd of Sahiwal &Cholistsani (Cattle) and Nili Ravi (Buffaloes) (PARC Research and Development Fund)

- The project was executed for two years (2022-24). During the first year, Purchase of Sahiwal and Cholistani (cattle) and Nili Ravi Buffaloes (n=15) along-with their calves (n=12) was accomplished.
- The shed of the animals was repaired to house the newly purchased animals.
- A new submersible pump was installed for the drinking and other water requirements of animals at LRS.
- During the second year, a new 85-HP tractor was purchased for land preparation and fodder production activities of LRS.

AQUACULTURE AND FISHERIES PROGRAM

The mandate of Aquaculture and Fisheries Program (AFP) is to undertake research on inland aquaculture to increase per unit fish production by applying modern aquaculture practices, intensive fish culture and introduction of new and high value fish in culture system.

Project1: Validation and Establishment of Intensive Production Packages for High Value Fisheries

- Results indicated Carps and American Channel Catfish outperformed at stocking density 1,600 per acre (out of 1,600, 1,800 and 2,200 per acre) with three species combination (two Carps and one American Channel Catfish) instead of five species combination (four Carps and one American Channel Catfish).
- Best Crude protein level i.e., 25% was optimized out of 15, 20 and 25% level in artificial feed.

Farmer's day at JhanghiThuthian, District Attock

One day national seminar for technology transfer at NARC

Project 2: Introduction of a High Value Fish Channastriatus (Saul) in Aquaculture system of Pakistan

- Achieved better growth rates of indigenous C. striatus about 27g/month in earthen ponds with optimum stocking densities @5,000/acre.
- Developed brood stock of indigenous C. striatus and breeding carried out successfully in earthen ponds and artificial breeding in plastic drums.
- Achieved better growth performance of exotic C. striatus in earthen ponds i.e. 36g/month ascompared to raceways 27g/month.
- Successfully cultured Moina (zooplanktons) in aquariums for feeding initial fry.

Channa striatus acclimatization and measurement of growth performance

NATIONAL REFERENCE LABORATORY FOR POULTRY DISEASES

The National Reference Laboratory For Poultry Diseases(NRLPD) is an apex Laboratory for avian disease diagnosis and survillence. The NRLPD is designated as Regional Leading Diagnostic Laboratory (RLDL) for Highly Pathogenic Avian Influenza (HPAI) for SAARC countries by FAO. In 2014 the laboratory was accredited for ISO/IEC 17025:2017 by Pakistan National Accreditation Council (PNAC), Islamabad. This laboratory is also a reference laboratory for Anti-Microbial Resistance for poultry.

Project1: Surveillance of Anti-Microbial Resistance (AMR) in Poultry (Fleming Fund UK)

Technical Advisory Group (TAG) meeting was held on 25thJanuary, 2023. Post-activity TAG meetingwas held on 13thNovember, 2023.

National External Quality Assessment Scheme (NEQAS) round one:

- Proficiency Testing (PT)provision by NRLPD
- 14 labs were registered in NEQAS round one
- Samples were sent to 13 labs, 10 labs responded back
- Training regarding NEQAS was conducted for all labs

Participation in PT by NRLPD:

- Two rounds of EQAsia AMR-PT were received in 2023 in which laboratory results showed good performance for pathogen identification and AST analysis.
- EQAsia round 8 has been received in 2024 and after analysis, the results have been submitted in during June, 2024.

Installation of MALDI and BD Phoenix at NRLPD:

- Training session regarding use of MALDI-TOF was arranged in the first week of December 2023 by Bruker and AstoLife in coordination with FF-CG-1.
- Training session regarding BD-Phoenix was arranged in December, 2023 by AstoLife in coordination with FF-CG-1.

Poultry sample processing for AMR

3. EXTENSION, TRAININGS, PUBLICATIONS, SEMINARS, WORKSHOPS

- Animal Nutrition Program, NARC prepared 10,250 bags of livestock feeds, 1,400 kg milk booster and 18,000 urea-molasses blocks and sold to farmers, apart from experimental feeds for different programs of ASI.
- A total of 124 samples of feed, fodder, silage, grasses, dung and milk from farmers, students, research organisations and industry were analysed for nutrient composition and toxins.
- More than 2,400 chicks of different breeds were sold to poultry farmers.
- One-day National Training Workshop was conducted on Sperm Sex Sorting and Cryopreservation Techniques in Water Buffalo at ARGP under ALP project. The trainees (n=30) were from academia, livestock departments and research organizations from all over the country.
- One-day National Training Workshop was conducted on Laparoscopic Artificial Insemination in Goats at ARGP under ALP project. The trainees (n=20) were from academia, livestock departments and research organizations from all over the country.
- Three-day International Training Workshop on Modern Breeding Technologies in Cattle was conducted from March 26-28, 2024 under KOPIA project at ARGP. The trainees (n=15) were from academia, livestock departments and research organizations from all over the country.
- Thirty students along-with two faculty members from the Department of Biomedical Sciences, Pak-Austria Fachhochschule: Institute of Applied Sciences and Technology, Haripur, KP, visited ARGP laboratories. ARGP scientists demonstrated about the latest research facilities and projects on in-vitro embryo production and transfer and other assisted reproductive techniques.
- A total of 78 milk samples from general public were analysed for composition and chemical adulterants. It was observed that about 50% of the milk samples had total solids, fat or SNF (Solids-not-fat) below the minimum standard values, i.e. 12% total solids, 3.5% fat and 8.5% SNF, thus showing dilution with water. None of the samples was found adulterated with chemicals (urea, formalin, neutralizers, starch, etc.)
- Seed of American Channel catfish (12,000) was provided to local farmers.
- Ornamental fish (3,742) was sold to local farmers/households.
- A Fish Farmer Field Day was organized in JhanghiThuthian, District Attock, on May 9, 2024.
- A one-day seminar on "Validation and Establishment of Intensive Production Packages for High- Value Fisheries was organized on May 29, 2024.

The summary of research publications, MPhil/PhD students supervised, internees trained, visitors and training (imparted/obtained) both local and international are summarized below:

Publications		Post Graduate students		Internees	Visitors	Trainings	
Research papers	*Abstracts*	*M. Phil*	*PhD*			*Imparted*	*Obtained*
16	13	11	02	60	400	19	22

Social Science

SOCIAL SCIENCES DIVISION

Farmers Perception and Adoption of Chip Bud Sugarcane Technology in Central Khyber Pakhtunkhwa

Pakistan's sugarcane yields per hectare are significantly below the potential, necessitating improvements in productivity through innovative technologies. The Sugar Crops Research Institute in Khyber Pakhtunkhwa has introduced chip bud technology and associated production techniques promoted through agricultural extension department to local farmers. This research was conducted in Mardan and Charsadda districts of the province, aimed to document farmers' perceptions of chip bud technology, assess its costs and revenues compared to conventional methods, and to identify barriers in adoption of chip bud technology. In this regard, data were collected through structured interviews with both the adopters and non-adopters. The study findings indicated that adopter farmers hold 15.52 acres of operational land on average, with over half receiving information about chip technology from extension services. The benefit-cost ratios favored the nursery-raised seedlings (2.69), compared to direct sowing (1.25) and conventional methods (1.95). The principal component analysis (PCA) identified eleven components from 30 variables, collectively explaining 79.954% of the total variation. The first component, accounting for 19.454%, was linked to sugarcane chip bud technology. The second component, contributing 13.734%, was associated with traditional farming practices and support services, whiles the third, accounting for 8.736%, encompassed financial support and pest/disease risks. The other components highlighted various issues, including tenancy status, high input costs, knowledge gaps, labor intensity, technology adoption challenges, and institutional support. Logistic regression revealed that landholding and farm services center membership significantly influences the adoption of chip bud technology. Major constraints include lack of knowledge for both adopter and non-adopter farmers, labor intensity of chip bud technology, and water scarcity. Recommendations emphasized research on chip bud technology tailored to farmers' conditions, awareness campaigns, training, and government support to enhance adoption and optimize sugarcane production. To support farmers, the government should regulate input prices and provide subsidies, while research and extension departments should maintain close coordination for timely solutions to farmers' challenges.

Analyzing the Role of Public and Private Sectors in Wheat Seed System in Khyber Pakhtunkhwa-Pakistan

Improving Khyber Pakhtunkhwa's agricultural sector, particularly through the adoption of high-quality wheat seeds, is crucial for enhancing productivity and economic prosperity in the province. This study, conducted during 2023-24, analyzed wheat seed production system and agricultural practices of the farmers who are having Seed Multiplication Plots (SMP), and identified areas for improvement and sustainability. For this purpose, data were collected from provincial agriculture departments, the Federal Seed Certification and Registration Department (FSC&RD), and through interviews with different stakeholders involved in seed production. The research revealed that private companies cannot access newly developed varieties of public sector due to lack of coordination between public institutes and private seed companies. The province has devoted 2336 acres of land (collectively held by research institutes and agricultural farms) for seed production and multiplication. The provincial research system of Khyber Pakhtunkhwa has developed and released 70 wheat varieties since its

establishment. Currently, 8 varieties are being multiplied at SMPs out which two varieties are bio-fortified. Out of these eight varieties, six are developed by KP provincial research system, one variety (Akbar) is developed by Ayub Agricultural Research Institute (AARI) Faisalabad and one is developed by Arid Zone Research Centre of PARC at D.I. Khan. The Agriculture Extension Department is vital in transforming research into practical applications, supporting farmers with education and information. Despite SMP farmers achieving an average yield of 30.22 maunds per acre, below the average potential yield of 41.88 maunds. This reflect that the province's overall wheat yield is lagging behind the national average. The benefit cost ratio was 2.23, excluding the cost of irrigation water and land rent. As of 2023-24, Khyber Pakhtunkhwa produced 17,762.15 tonnes of wheat seed, with 70% of this amount supplied by the private sector. However, these private seed companies are also dealing with the financial challenges, exacerbated by the current price hikes and high mark-up rates that hindered their expansion in the business. Major wheat varieties grown in the province include Pirsabak-13, Gulzar-19 and Pirsabak-19 that together dominated both cultivated area and production. Four-fifths of the area and production of wheat seed from the pre-basic category were attributed to Agriculture Research Department while basic, certified and approved wheat seed were predominantly produced by the Agriculture Extension department. The wheat seed requirement for the province is 92,817 tonnes, highlighting a deficit of that necessitates an additional area of 18,354 hectares to meet the deficit. Key recommendations include fostering public-private collaboration, increasing research funding, enhancing extension services, and developing supportive policies to boost wheat productivity and profitability.

Trend Analysis of Area, Production and Yield of Major Food Crops in Khyber Pakhtunkhwa-Pakistan

Primary food crops grown in Khyber Pakhtunkhwa include wheat, maize, rice, and sugarcane. The government needs accurate data on key food crops to inform policy measures, utilizing growth and decline trends to assess agricultural performance. In this context, this was designed to carry out trend analysis of area, production and yield of major food crops in Khyber Pakhtunkhwa-Pakistan. An analysis of data from 2009-10 to 2021-22 indicated that wheat production and yield experienced modest growth, with rates of 1.11% and 1.10%, respectively. Major wheat production areas including Swat, Mansehra, Dera Ismail Khan, Mardan, Charsadda, Swabi, Peshawar and Buner districts of KP province are collectively contributing 57 percent of total wheat production in the province. Maize crop also experienced growth, with production and yield rising by 1.06% and 0.62% respectively. Major maize production areas including Swat, Mansehra, Mardan, Bunir, Swabi, Shangla and Kohistan districts of KP province are collectively contributing 61 percent of total maize production in the province. Factors such as water availability, which is influenced by rainfall patterns, impact the production of both wheat and maize. Area, production, and yield of rice witnessed notable increase during the study period (2.74%, 5.88%, and 3.05% growth respectively). Major rice producing areas of KP province include Dera Ismail Khan, Swat, Kurram, Dir Lower, Dir Upper and Malakand districts which together contribute to 70.41 percent of the total rice production in the province. Sugarcane production and yield increased at rates of 0.69% and 0.39%, supported by irrigation sources like the CRBC and Gomal Zam Dam. However, the region also faces complexities such as land conversions and reduction in cultivated areas. Major sugarcane production areas of KP include Mardan, Charsadda, Dera Ismail Khan, Malakand and Peshawar districts. Study pointed out that ensuring timely availability, accessibility, and affordability of inputs like seeds, fertilizers, and pesticides through subsidies

and effective distribution channels are crucial. Reductions in cultivated areas and conversions to other crops add complexity to sugarcane production dynamics in the region. Promoting improved crop management practices, implementing water management strategies, and enhancing irrigation systems are essential. Government support through policies, research, and development is necessary to address challenges and to ensure sustainable production.

Economic Analysis of Sweet Potato Cultivation in Punjab-Pakistan

Sweet potato is one of the world's most essential food crops because of its high yield and nutritive value. About 90 percent of global sweet potato production is coming from the developing countries. China is the leading producer of sweet potatoes having 72 percent share in global production. Sweet potato is a traditional vegetable crop of Pakistan. According to Pakistan Bureau of Statics (PBS), the area under sweet potato was 1637 hectares with the production of 14134 tonnes during the year 2021-22. This study was conducted in Sheikhupura, Nankana Sahib and Faisalabad districts of Punjab province. On average, total variable cost was Rs. 72108 per acre. Analysis indicated that the sweet potato farmers receive Rs. 205,679 per acre after meeting variable cost. Study identified there are three to five marketing channels out of which the most prevalent marketing channel is selling through commission agents operating in major wholesale markets. To facilitate the sweet potato growers, it is suggested to develop complete production technology package for this traditional vegetable.

Dwindling Sustainable Agricultural Food System in Pakistan: Current Challenges and Policy

The Sustainable Agricultural Food System (SAFS) is crucial for meeting basic human needs, including food security, nutritional security, food safety, health, decent livelihoods, equity, and a clean environment. Therefore, SAFS is in the center of debate in relation to Sustainable Development Goals, 2030 (SDGs). This present research was designed based on synthesis of pervious literature and key informant interviews. Study indicated that despite being agrarian economy; Agricultural Food System fails to deliver in Pakistan. As mentioned in World Bank report from January 2023 highlighted that six million people in Pakistan are experiencing acute food insecurity. Malnutrition and food safety issues are also widespread, while environmental conditions continue to deteriorate, posing significant challenges for both rural and urban populations. Research indicated that food system in Pakistan struggles to ensure food and nutritional security and cannot address the socio-economic and environmental challenges associated with food production, marketing, processing, distribution, and consumption. The existing food system is suffering from limited access to essential food items, high food inflation, and variable food quality which adversely affect the rights to adequate food and livelihood of masses. The study identified the key challenges to agri. food system including poor implementation of agricultural policies, high population growth, climate vulnerability, limited value-added products, and ongoing energy crises. To address the issues in agri. food sector and to ensure the diversity, competitiveness, and resilience, this research emphasized in urgent need of reforms. Study further pointed out that targeted investment is needed in modern agricultural technologies to ensure sustainable agri. food system such as crop diversity, improved agricultural production & marketing, and natural resource conservation.

Consumer Preferences Towards Edible Oil Purchasing Decisions in Faisalabad

In modern marketing, consumer satisfaction is a basic notion. In the present study, an attempt has been made to identify consumer awareness, satisfaction level and the factors influencing edible oil purchasing decisions. Data were collected through well-structured questionnaire from 200 respondents in Faisalabad. This study revealed that educated respondents are more aware of the prices, brands, net weight and expiry date of edible oil. In the study area, majority of the respondents (43%) preferred sunflower oil followed by kisan cooking oil (18 %), dalda cooking oil (15%), canola oil (12.5%), and mustard oil (12%). Most of the respondents were satisfied with the texture (53.5%), consistency (52.5%), and taste & aroma (49.5%) of edible oil they are purchasing. Exploratory Factor Analysis (EFA) indicated that good quality, hygienic products, chemical-free, appropriate packaging and effective advertisements are the factors that affect the consumers' purchase of edible oil. Study suggested that edible oil producers should ensure quality and focus on and chemical-free product to attract more customers.

Economic and Financial Analysis of Bamboo Production, Processing and Marketing in Selected Districts of Punjab

Bamboo, often referred as “the green gold of the forest,” offers a wide range of ecological, economic, social, and commercial benefits for both animals and humans. Its potential for alleviating poverty and boosting the economy is significant due to the growing demand for bamboo products in local and international markets. Bamboo development is promoted as a means to improve the livelihoods of rural communities in bamboo-growing regions. This study aimed to assess the economics of bamboo production and processing in Kasur and Sargdha districts of Punjab Province, to explore its market potential, and to conduct SWOT analysis. Findings indicated that bamboo is harvested after five years of its plantation with subsequent harvest of every three years. The analysis found that bamboo cultivation is profitable for owner-farmers, with a BCR of 2.12, NPV of Rs. 180,204, and IRR of 58% while tenant farmers faced negative returns, with a BCR of 0.90, NPV of Rs. -258,692, and an IRR of -7%. This finding suggested that tenant farmers should avoid entering the bamboo sector under prevailing market conditions and discount rate of 21%. This study found that bamboo cultivation is financially viable primarily for farmers who own land and can manage their bamboo farms strategically. There is substantial market potential for high-value bamboo products in local, regional, and internationally (Afghan market). Government support is needed in providing improved bamboo varieties and facilitation in bamboo exports, particularly through the Pakistan-Afghan border. This study also recommended research on consumer side to facilitate this sector in producing demand oriented products, to benefit farmers, processors, traders, and other stakeholders, and to enhance Pakistan's foreign exchange reserves.

Who Consume More Broken Rice Grain? Evidence from Rural and Urban Consumers

The present study in response to rising food prices was conceived to find quantitative differences, particularly in broken rice consumption concerning the geographic (urban/rural) location of the consumers. The study investigated broken rice consumption among urban and rural households in Faisalabad, Sheikhupura, Kasur, Lahore, Sargodha, Khanewal, and Toba Tek Singh districts of Punjab Province. Significant disparity in income distribution was noted in urban and rural divide (average monthly income Rs. 77,285 of rural household and Rs. 89,895 of urban households). The overall total rice consumption per household is 9.18

Kg/month out of which more than half (57%) is of broken rice (5.23 Kg/month). Interestingly, though rural households have lower incomes, their total rice consumption was slightly higher than that of urban households. This is mainly attributed to preference for rice and greater availability of milk for consumption alongside it. Moreover, rural households consume less wheat (38.46 kg/month) than urban households. The combined monthly consumption of rice and wheat (47 kg) highlights important policy implications for food security in the region. To address the rising demand for broken rice, this study recommended collecting comprehensive primary data on various broken rice types (including locally called pona, adhwaar, tota or mix type categories) to inform national policy.

Economics and Marketing of Rapeseed and Mustard in Punjab

The Punjab government has taken several steps to enhance the productivity of oilseed crops, especially rapeseed and mustard, by offering subsidies on certified seeds and fertilizers. The National Agricultural Research System (NARS) has released high-yielding and disease-resistant varieties of these crops. However, increasing costs of agricultural inputs and production have adversely affected profitability. Furthermore, the marketing conditions for rapeseed and mustard deteriorated in 2022-23 due to declining output prices. Therefore, this research work focused on the economics and marketing of rapeseed and mustard crops in selected areas of Bahawalpur and Faisalabad. Study indicated that the average landholding was 25.67 acres and land rent was Rs. 66158 per acre. Wheat was the predominant rabi crop, covering 62% of the land, while rapeseed and mustard occupied 28% of cultiavated land. The estimated gross revenue of rapeseed and mustard crop was Rs. 131,001 per acre and average cost of production was Rs. 77,517. Though the production cost was higher for small farms but mall farmers allocated a relatively higher percentage of their land to rapeseed and mustard compared to larger farms because of higher revenues. Higher revenues were due to higher yields stemming from better soil conditions mostly situated in Faisalabad district. Net returns, after incorporating land rent, were Rs. 20,406, with benefit-cost ratio (BCR) of 1.69:1.00. Without land rent, net returns were Rs. 53,485, and BCR was 2.95:1.00. This indicates that rapeseed and mustard cultivation is profitable in irrigated Punjab. On average, 131.44 maunds of rapeseed and mustard were produced per farm, with 97% marketed and 3% kept for home consumption. The commission agents are main market intermediaries (occupies 69% of market share) followed by local traders (29%). Farmers received better prices from local traders and oil expellers due to their negotiating power. The study concluded that, although rapeseed and mustard are profitable but farmers still prefer wheat due to its higher returns. This study recommended the efforts to be made to make certified seed and fertilizer available that are necessary to improve yield and to make rapeseed & mustard more profitable.

Mechanical Transplanting: A Viable Option to Enhance the Productivity of Rice Crop

In the era of agricultural research and development initiatives, majority of the farmers in rice-growing countries have shifted to mechanical rice transplanting due to labour shortage or rice productivity prospects. However, rice-growing farmers in Pakistan are still stuck or convinced with the conventional way of rice sowing. Anticipating a labor shortage in the agricultural sector and the potential for increased productivity, the management team of the Productivity Enhancement of Rice project (funded by PSDP) identified the adoption of mechanical rice transplanting on farmers' fields as a key intervention. Keeping this in view, current study was designed to assess impact of mechanical transplanting on rice

productivity, and to explore adoption prospects of the technology. Thirty farmers were interviewed in 2023 who benefited from subsidized mechanical transplanters and nursery machines. It was found that beneficiary farmers obtained 5.18 maund higher yield with mechanical transplanting than their normal practice. The productivity of the Super Basmati variety was higher for beneficiary farmers as compared to normal practice (increment of 3.63 maunds/acre). Similarly, productivity of other basmati varieties (viz. Kissan 1509, Kainat 1121, and PK 386) planted using mechanical transplanter the mechanically transplanted crops was also higher compared to normal practice (51.88 maunds/acre and 46.00 maunds/acre respectively). Moreover, farmers mentioned the ease of use of mechanical transplanter and also reported that technology may save labor and time. However, beneficiary farmers noted the high cost of machinery @ Rs. 1000-2000 per acre than the conventional method. Farmers also told that height of the saplings used in mechanical transplanter was less as compared to the height of saplings used in conventional method; therefore, nursery requires extra care during transplantation Farmers showed concerns regarding availability of mechanical transplanter and mandatory laser leveling which may hinder the adoption of mechanical transplanter. In addition to this, some of the farmers were reluctant to change traditional practices. Study suggested creating more awareness through farmer field days about the effectiveness of this technology. More public support in the form of subsidy was proposed for up scaling the adoption. It was also recommended to provide technical support for the repair and maintenance of the transplanters, along with the establishment of public sector facilitation centers to train machinery operators and workers involved in nursery raising and transplanting.

Effectiveness of Demonstration Plots to Improve Farmers' Learning and Enhance Rice Productivity

Despite improvements in crop productivity over the years, Pakistan's agricultural output of major crops remains below potential and lower than the world average. To address these issues, the public PSDP funded a project for rice productivity enhancement in the country. The main interventions made by the project include mechanical transplanting and line sowing, provision of certified seeds, and improved crop management. These interventions aimed to improve farmers' knowledge and yield through demonstration plots on farmers' field to showcase best crop management practices. This study assessed the effectiveness of these demonstration plots in the context of improvement in productivity and profitability of rice growers. The project was implemented in rice growing areas of Punjab. For this study, interviews were carried out with 72 farmers across four major rice-producing districts in Punjab: Gujranwala, Sheikhupura, Sialkot, and Hafizabad. Results revealed that yields and net returns were significantly higher on demonstration plots for various basmati varieties, with yields of 56.37 maunds per acre and net returns of 73,339 PKR, compared to 49.45 maunds and 54,619 PKR on conventionally managed fields. Similarly, productivity and profitability per acre were also higher for the super basmati (43.19 vs 37.08) maunds and (38858 vs 20339) PKR, respectively. Farmers identified factors such as increased plant density, quality seeds, balanced fertilizer use, proper pest management, and timely agronomic practices as crucial for enhancing rice yield. Host farmers expressed a commitment to applying what they learned at demonstration plots to 30-35% of their rice area in the 2024 crop year. Additionally, neighboring farmers showed interest in adopting these improved farm practices. This study found demonstration plots methodology effective for introducing new technologies, therefore, efforts to be made to organize these events frequently.

Dietary Diversity by Provinces and Administrative Divisions with Rural-Urban Divide in Pakistan

Diet is one of the biggest factors affecting human health. This study aimed at determining dietary diversity in Pakistan by provinces and administrative divisions with rural urban divide using data from Household Integrated Economic Survey (HIES) 2018-19 and PSLM 2013-14. Previous studies on food security and dietary diversity mainly focuse on women and children under the age of five while this study is an attempt to determine across provinces and administrative divisions of Pakistan. It was revealed that food consumption pattern of the people has changed to a substantial extent during the study period. This study found rise in per capita consumption of fruits and vegetables (43.3% and 14.8%, respectively) and milk & milk products (7.2%) and 4.5% in urban and rural areas respectively). Meat consumption has increased a little in urban areas (1.0%) while it decreased in rural areas (9.3%). Similarly, decrease was observed in consumption of eggs (30.3% and 24.6 % in urban and rural area respectively). Comparative analysis of food diversification across provinces indicated that food pattern in KP has diversified the most. Household dietary diversity improved the most in Quetta, Dera Ismail Khan, Dera Ghazi Khan, and Larkana divisions of Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh, respectively.

Exploring the Impact of Rural Transformation on Food Security in Pakistan

This study assessed food security across administrative divisions, provinces and at national level, while exploring household characteristics. This study utilized data from HIES (2013-14 and 2018-19) and employed logistic regression assess the impact of high-value crop production, non-farm employment, and farming household characteristics on rural food security. The study found an increase in nominal income and food availability in rural areas during report period, with a substantial rise in the food-secure population from 76.31% to 90.31%. The study further explained that Balochistan province exhibited noteworthy improvements, followed by Punjab and other provinces. In year 2018-19, Sibbi division of Baluchistan province was identified as the least food-secured, while Hazara division of Khyber Pakhtunkhwa province was the most food-secure. The results of logistic regression showed positive effect of the age of household head, monthly income, and household size per adult equivalent on rural food security. These findings offer valuable insights into the intricate dynamics of rural food security and contribute to a comprehensive understanding of regional factors at play.

Competitiveness of Selected Agricultural Commodities of Pakistan

This study estimated the competitiveness, comparative advantage, and extent of protection for pulses crops (chickpea, mung, mash and lentil) and vegetables (potato, onion, garlic and tomatoes). The results of Policy Analysis Matrix (PAM) at import parity prices revealed that Pakistan has a comparative advantage in producing pulses as substitution crop in Punjab. The result implies that production inside the country is more economical than imports from abroad. There is need to strengthen research and extension services for introduction of modern technologies for higher pulses crop productivity which ensures financial viability for growers. Analysis further revealed that Pakistan has been exporting potato; onion, tomatoes and garlic commodities in the glut period and imported these in shortage. This shows that Pakistan has potential of export in these commodities by increasing the competitiveness of these commodities. Pakistan is net importer in garlic, and tomato however in onion and potato Pakistan remained net exporter during 2021-22. The analysis revealed that production of all selected vegetables in the country to meet the local demand is economically more viable than import.

Analysis suggested implementing import substitution policies especially for pulses to promote local production in the country to save precious foreign exchange.

Comparative Agriculture: Pakistan, GCC and Selected Central Asian Republics

This study provides a comprehensive analysis of agriculture in Pakistan compared to the Gulf Cooperation Council (GCC) and Central Asia Republics (CARs). Both Pakistan and the GCC face unique challenges and adopt different agricultural strategies, but share the common goal of achieving food security and sustainability. The analysis, based on secondary data, highlighted that Pakistan is a net importer with a significant trade deficit of $39.1 billion globally whereas, trade with GCC is $11.5 billion as it exports $2.8 billion and imports $14.3 billion. Agriculture is the mainstay of Pakistan economy contributing 22.7% to its GDP, wherein agricultural contribution to GDP in GCC is less than 1%. Land ownership in Pakistan is fragmented, affecting economies of scale, while GCC countries have centralized, government-managed agricultural projects. Pakistan employs a mix of traditional and modern agricultural practices, whereas the GCC invests heavily in advanced technologies like desert farming and controlled environment agriculture. Pakistan has a revealed comparative advantage (RCA) in several agricultural products, such as dairy, edible vegetables and fruits, and cereals. It also has a regional RCA in commodities like meat, rice, mangoes, guavas and mangosteens, tangerines, mandarins, clementines, potatoes. However, trade volumes with the GCC are below potential. In contrast, Pakistan maintains a trade surplus of $41 million with CARs, with exports totaling $167 million and imports at $125 million in 2022. The RCA analysis for CARs indicates strengths in vegetables, fruits, dairy, and cereals. This study recommends to exploit the trade potential with CARs and GCCs by improving connectivity, infrastructure, and political stability.

Pakistan's Agricultural Terms of Trade: An empirical Analysis

The terms of trade for the crop sector are defined as the ratio of the indices of prices received by the crop sector and the prices paid by the sector. The overall objective of this study was to work out terms of trade for Pakistan's crop sector to reveal how the sector has performed over time in terms of profitability and to assess impact of price changes on living standard of the farmers in Pakistan. The results showed that there is an overall increasing trend in Producer Price Index (PPI) from 12.11 in 1991 to 306.58 in 2023. Notable increases are observed in recent years, particularly from 2019 to 2023. The index of prices paid by farmers (PFI) on consumer goods also showed an increasing trend, from 11.66 in 1991 to 291.16 in 2023. The rate of increase appears to accelerate after 2005. The Input Price Index (IPI) also showed an increasing trend from 14.28 in 1991 to 178.92 in 2022. The overall upward trends in PPI, PFI, and IPI reflect general inflation and increased costs within the agricultural sector. The ToT, calculated as the ratio of PPI and PFI, fluctuates but generally remains around 100, indicating a balanced terms of trade for much of the period. There are periods indicating unfavorable terms of trade for farmers. However, recent years (2018-2022) show an improving trend. The ToT calculated as the ratio of PPI and IPI revealed variability but has increased significantly in recent years, reaching a peak of 161.59 in 2020. PPI is increasing at a faster rate than the IPI in recent years, potentially indicating better profitability for farmers. The results of the study suggested implementing policies to stabilize both the PPI and PPF to reduce the volatility faced by farmers. Appropriate measures are needed to control price hike in seed, fertilizer, machinery, and other farm inputs to sustain favorable Terms of Trade.

Impact of Foreign Direct Investment (FDI) in Agriculture Growth: Low and Middle Income Countries

The capital flows are likely to have profound impacts on the agriculture sector in countries across the globe. However, there remains limited literature on the role of capital inflows in the agriculture sector in low- and middle-income countries. Therefore, the study was aimed to examine the role of foreign capital inflows in the growth of the agriculture, forestry, and fishing sectors in low-middle income countries by using the panel data analysis. The random and fixed effect econometric model has been applied for the analysis in fifteen countries from the year 1980 to 2022. The growth in agriculture sector was the outcome variable while Foreign Direct Investment (FDI), GDP growth rate, poverty, inflation, and logistic performance index were independent variables. The results indicated that FDI has a positive and significant effect on agriculture growth in low income countries. While, poverty and inflation rate has adverse effect on agriculture growth. Therefore, it is concluded that the government should be focused on the policies that bring the capital inflow to the country and pay attention to all the determinants, particularly for the reduction of poverty and inflation.

Forecasting Production of Essential Food Crops in Pakistan

This study investigated the production trends and forecasting for ten key essential food crops in Pakistan including wheat, rice, sugarcane, tomato, potato, onion, mung, mash, masoor, and gram. By examining historical production data and applying various forecasting models, the study identified production trends and predicted future production levels. Six forecasting models were used to determine the best fit for essential food crop production in Pakistan, including: Linear trend model, Quadratic trend model, Exponential growth model, S-curve model, Single exponential smoothing model and Double exponential smoothing model. The forecasting models were evaluated using three accuracy measures: mean absolute percentage error, mean absolute deviation, and mean squared deviation. Lower values of these measures indicate a more reliable model with fewer errors. The findings revealed significant variations in mean production levels across crops and highlighted the importance of understanding historical production trends to inform agricultural planning and resource allocation. The S Curve model was identified as the best-fitted model for wheat forecasting, while the Quadratic Trend model proved most suitable for rice and sugarcane. The Double Exponential Smoothing model was selected for tomato, onion, mung, and mash forecasting and, the Single Exponential Smoothing model for masoor and gram. Exponential growth model was the best-fitted model for potato production in Pakistan. Forecast results indicated an overall increasing trend in the production of wheat, rice, sugarcane, tomatoes, potatoes, onions, and mung. Wheat production is expected to rise from 28,529.3 to 28,825.9 thousand tons, while rice and sugarcane are forecasted to grow to 9,396.1 and 89,970 thousand tons respectively. Decrease was indicated for the production of gram while production of mash and masoor was predicted to remain stagnant highlighting potential challenges for these crops. Therefore, this study advocates targeted interventions for these crops and exploring advanced technologies such as precision farming to enhance the overall production of agricultural commodities. Additionally, this study underscores the importance of selecting suitable forecasting models and measuring their accuracy to enhance forecasting precision.

Virtual Nutrients Trade in Selected Agricultural Commodities of Pakistan

Virtual nutrient trade refers to the concept of transferring nutrients across regions or countries through the trade of agricultural products. When any region imports food,

they are effectively importing the nutrients that were used to produce that food, which can impact local nutrient cycles and agricultural practices. Nutrient flows are important economically as well as environmentally. This study estimated the amounts of N, P, K, Calcium, Sulfur and gypsum embodied in selected agricultural commodities. It was obtained by multiplying the nutrient content of each commodity by the corresponding production and consumption volumes of all the provinces of the country to determine the flow of virtual nutrients from one region to the other. Interprovincial transfer of virtual nutrients was calculated for five major agricultural commodities were selected based on the availability of the desired data for the year 2021-22. The research results indicated that Punjab province is the net exporter of nutrients (given values are in thousand tons) for major agricultural commodities (wheat 656680, sugarcane 190386, cotton 404069, maize 298033, and rice 2541198). The KPK province was found to be a net importer of virtual nutrients for wheat (-270553), sugarcane (-18596), cotton (-52554), and rice (21382). Sindh province was found to be importing virtual nutrients for wheat (-31534), and maize (-340529). Balochistan was found to be importing nutrients virtually for wheat (-11991), sugarcane (-19471), cotton (-3655), and maize (-79096). It is suggested to encourage the implementation of sustainable agricultural practices in nutrient-deficient regions to enhance production and reduce dependency on imports from other provinces. Production can be enhanced through improved soil fertility by improving crop rotation, practicing organic farming, and the use of bio-fertilizers. Programs should be developed to promote the recycling of nutrients, such as composting and use of animal manure, to help restore nutrient balance and minimize the negative impacts of nutrient outflows.

Comparative Analysis of Agricultural and Rural Development in Cholistan-Pakistan and Rajasthan-India

The Thar Desert has significantly influenced the dry and semi-arid climates of Cholistan-Pakistan, and Rajasthan-India. This review report aimed to compare agricultural and rural developments in the Rajasthan Desert with the Cholistan Desert to have an idea of potential development that can be made in Cholistan. The harsh weather, low rainfall, and recurrent droughts in these areas pose challenges to agriculture. Raising livestock is still a vital source of income in both the desert ecologies. Due to its harsh climate and lack of water, Cholistan has historically relied on nomadic pastoralism with little agricultural activity. With an effort to improve food security and livelihoods, Cholistan has recently focused on drought-resistant crops, better water management, and sustainable farming techniques. The review revealed that Rajasthan became a leader in adoption of cutting-edge technology (block chain, artificial intelligence, and automated irrigation systems) with significant support of government and research centers like CAZRI and IARI. There is now sufficient water available for agricultural production of crops like wheat, mustard, and cotton in the area through the Indira Gandhi Canal irrigation project. Conversely, Cholistan remained more dependent on conventional methods mixed with new technologies like solar power and livestock farming. There is a heavy emphasis on community-driven solutions and a widespread use of sustainable practices, such as conventional methods of water conservation and soil moisture management. Socioeconomic variables indicate that Cholistan still suffers issues with healthcare, education, and economic diversification compared to Rajasthan. In general, Rajasthan has seen significant growth in agriculture and rural development through better infrastructure and technology. In contrast, Cholistan relies more on traditional methods and has not adopted improved practices widely. This highlights the need for targeted support to boost farming productivity and resilience in Cholistan-Pakistan.

Pakistan Dietary Guidelines and Nutrients' Consumption: An Exploratory Analysis

Pakistan Dietary Guidelines (PDG) aimed to promote healthy eating, reduce malnutrition, and prevent diseases but despite that, a significant percentage of households in Pakistan face undernourishment with higher rates in urban areas. This study aimed to analyze nutrient consumption, to identify regional and socio-economic disparities in dietary habits, and to inform nutrition policy and programs. To meet these objectives, latest available dataset (HIES 2018-19) was used. Analysis indicated that cereals dominate food consumption in all regions, with significant variations between urban and rural areas. The inter-provincial comparison revealed that KP has higher cereal and meat consumption with lower milk and dairy consumption. While milk and dairy consumption was relatively higher in Punjab with lower fruit and vegetable consumption. Sindh shows higher fruit and vegetable while lower cereal consumption. The Baluchistan consumes more oil and ghee and less pulses. Furthermore, the results revealed that the average daily consumption of essential nutrients across four provinces in Pakistan is lower than the Recommended Daily Allowance (RDA). Significant variations were found in nutrient consumption across provinces and urban-rural areas, with many populations falling short of the recommended daily allowances for essential nutrients. Study further revealed that intake of Iron, Zinc Vitamin A and Iodine intake was below the recommended daily allowance (RDA) in all provinces. Protein consumption was higher in KPK and lowest in rural Balochistan. Beta-carotene consumption is highest in urban Punjab and lowest in rural Sindh. Calcium consumption is highest in urban KPK and lowest in rural Balochistan. These insights provide information for designing nutrition policy and programs to address specific provincial needs, ensuring equitable access to nutritious food.

Comparison of Retail Markets and Weekend Bazar for Fruits and Vegetables in Rawalpindi and Islamabad

In Pakistan, household expenditure on vegetables and fruits has increased over the years; however, consumers have diverse purchasing behaviors in selecting vegetable and fruit market. This study aimed to explore the factors influencing consumers' choices of specific markets for buying vegetables and to compare these factors across different market types, specifically retail markets and weekend markets. The findings indicated that retail markets capture a significant share of customers compared to weekend markets. The quality of vegetables & fruits and the distance to weekend market were the most critical factors driving consumer' choice of market. Furthermore, the consumers preferred the retail market due to availability of fresh fruits and vegetable and other daily necessities. Conversely, weekend markets were preferred by the consumers because of economical rates and to purchase in bulk due to large family size. Other notable factor was household income. Interestingly, access to organic and pesticide-free vegetables and fruits did not appear to be a significant concern for consumers in this context. The insights gained from this study have important implications for the marketing system and for entrepreneurs operating within retail markets, as they highlight the key factors that influence consumer behavior and preferences in vegetable and fruit purchasing.

Factors Contributing to Poultry Retail Price Hikes in Rawalpindi-Pakistan

Despite the growth, poultry sector of Pakistan faces numerous challenges, including fluctuating prices and rising production costs hindering its development. The present study was conducted to explore the factors influencing the price of poultry meat in Rawalpindi, Pakistan. By the analysis of primary data collected

through surveys of poultry farmers and poultry experts, it was found that the market is now witnessing a decline in open shed poultry farming, significantly impacted by the COVID-19 pandemic, which has led many small and medium-scale farmers to exit the industry due to substantial losses. Additionally, the price of feed has surged following the GMO soybean controversy, along with increased costs for day- old chicks and soaring electricity bills. The use of untrained labour further exacerbates production costs, ultimately driving up poultry meat prices. There is the need of proactive government regulations, continuous market monitoring, and strategic policies to support the poultry farmers and to protect consumers' purchasing power.

Cooperative Farming in the World: A Review

Special Investment Facilitation Council (SIFC) of Pakistan is taking tangible steps to promote agriculture in country. In this context, cooperative farming model is being considered ` boost agriculture growth in Pakistan. This study was aimed to provide a detailed literature review on cooperative farming globally and its impacts with a focus on relevance in Pakistan. The review highlighted positive effects of cooperatives on food security, production efficiency, and technology adoption in agriculture. This study pointed out the complexity of factors influencing cooperative success and emphasized the importance of cooperatives' member motivation, organizational ability, and entrepreneurship. Challenges such as opposition from various stakeholders, inadequate knowledge of constraints faced by farmers, and control by influential figures in rural areas were identified. The role of government support in providing public goods, policy interventions, and avoiding excessive regulation was highlighted. Effective leadership, sound management practices, supportive policies, and capacity building were identified as crucial factors for the success and sustainability of cooperative movements. Recommendations included establishing strong organizational structures of cooperatives, encouraging entrepreneurial spirit among members, and ensuring tailored support for cooperative development based on thorough assessments of farmers' needs. By following these recommendations, cooperative movements in agriculture and rural development can overcome challenges, achieve sustainable growth, and make positive impacts on their members and communities.

Impact Assessment of Zero Tillage Wheat Sowing Technology in the Rice-Wheat Farming System of Sindh Province

The study examined factors affecting zero tillage adoption among rice-wheat growers and compared the costs and yields of conventional and zero tillage methods using primary and secondary data. The findings revealed that zero tillage adopters had an average landholding of 12.05 acres and reported higher wheat yields (5.47 mounds per acre more than conventional practices) and higher net income as compared to non-adopters along with improved food security. Key benefits noted by adopters included reduced cultivation costs, time savings, and higher yields. However, challenges such as poor financial resources, availability of zero tillage machine at local level, soil texture (not everywhere but in the areas having hard soils), and lack of information hindered wider adoption. The study identified constraints faced by non-adopters, such as low landholdings and lack of awareness. Overall, the study suggests a positive outlook for zero tillage technology in the region, but highlights the need for addressing the above mentioned constraints to enhance adoption rates.

Relationship between Equity in Irrigation and Crop Productivity in Sindh, Pakistan

The study was aimed to find out the correlation between equity in irrigation and productivity levels among the farmers in Sindh, Pakistan. Data were gathered through survey with the purpose to establish relationship between distribution of irrigation water and crop productivity. The analysis revealed significant disparities in irrigation water access and productivity across locations. The result showed that the farmers located at downstream had lowest access to irrigation water, as indicated by all water accessibility indicators (reliability, equity, adequacy, and satisfaction) as compared to the farmers located at upstream and at middle. The results showed that there is significant difference in irrigation water usage by the farmers located at upstream compared to the farmers at middle. The study indicated no significant difference in wheat yield between farmers located at the middle and downstream. However, a considerable difference was found between wheat yield of the farmers located at downstream and the upstream. This indicated that farmers at downstream are at more disadvantaged position as compared to the farmers at middle. Farmers at downstream reported that crops are mainly stressed during periods of water scarcity, leading to low production and low profitability causing significant volatility and revenue instability in their farming.

Community-Based Approaches to Enhance Food Security in AJK: A Review Study

This review study critically evaluated the effectiveness of community-based interventions implemented to enhance food security in AJK. The objective of this study was to synthesize the most recent literature, case studies, and project assessments which have demonstrated success and to document constraints and lessons learned with the purpose to generate evidence-based suggestions for stakeholders dealing with food security in AJK and elsewhere. This review highlighted the diverse nature of community-based interventions including community gardens, farmer cooperatives, local food systems, participatory research, and nutrition initiatives. These efforts have not only improved food security, but also fostered rural development, sustainable livelihoods, and community resilience. However, there are still issues, including lack of resources, infrastructure, and training. Addressing these challenges requires a collaborative effort from policymakers, practitioners, and researchers to establish conductive settings for community-led initiatives. Future research should investigate deeper into the long-term effects of these interventions, consider scaling-up options, and examine the role of technology in assisting community-based food security initiatives. Finally, ensuring food security in AJK requires a comprehensive strategy that includes community empowerment, sustainable agriculture, and strong policy support.

DIRECTORATE OF SCIENTIFIC COMMUNICATIONS AND PUBLICATIONS

Directorate of Scientific Communications and Publications (DSC&P) progress report during 2023-24 is as under:

Media Activities

DSC&P provides scientific and functional media coverage, as well as photographic services, to PARC/NARC scientists and their subsidiaries. DSC&P developed YouTube channels titled "PARC Official" and "PARC Archive" with links available on the PARC website. There is also an official Facebook page. During 2023-24, the directorate developed and published 62 documentaries on YouTube and captured 37 key functions and events. The Directorate created two videos that documented PARC field research efforts and provided 33 audio facilities to various programmes. For field/lab experiments, 10624 pictures were taken, and 95 important events were covered.

PARC Website

PARC Website has been redesigned from Joomla 2.4 version to latest PHP technologies with cooperation of National Information Technology Board (NITB). New website is dynamic, interactive and user friendly. Day to day issues of the website are being resolved in consultation/coordination with NITB and NTC. Data is being uploaded in the relevant pages of website as and when received from PARC, NARC and different institutes/outstation centers working under PARC. Pictures, tenders, latest news, tickers, notifications/circulars/OMs and other data is being updated and uploaded on daily basis.

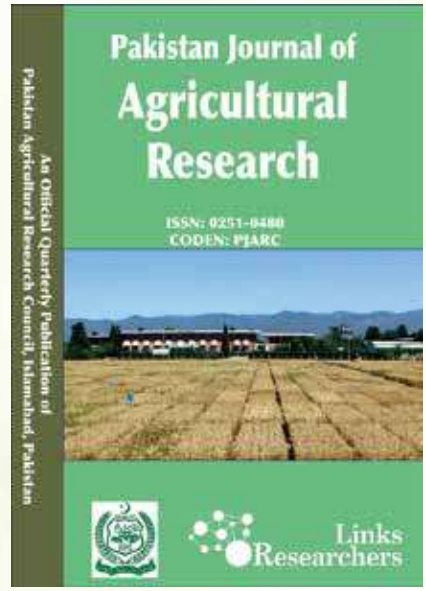
NARC Library

NARC library is the central information resource for scientists, researchers and students in the field of agriculture and allied subjects. Library users can find a wealth of knowledge, either in print or online. The library has collection of over 30,500 books covers a wide range of different agricultural subjects.

Resources of Higher Education Commission of Pakistan Digital Library and CABI information products are accessible at NARC Library and access is provided on PARC Local Area Network. During 2023-24 234 books were added to library collection and 29 reprints were supplied to foreign agencies/scientists and 97 to local scientists during the year.

Pakistan Journal of Agricultural Research

Pakistan Journal of Agricultural Research (PJAR) is a quarterly publication of Pakistan Agricultural Research Council in the field of Agriculture. It is an HEC recognized Journal and is being indexed in Scopus, AGRIS of FAO; CAB Abstracts; Pakistan Sciences Abstract of PASTIC. PJAR is availing services of British publisher partner Smith and Franklin for promotion as well as publishing assistance to get impact factor through wide indexing of the Journal. It is being published regularly and is also available online http://researcherslinks.com/journal/Pakistan-Jouranla-of-Agricualtural-Research/24. During the year 02 issues of Volume 36 (2023) and 02 issues of 37 (2024) were published and available online on PARC website.



Annual Report

PARC Annual Report is a regular activity of DSC&P published every year and uploaded on PARC website. It can be accessed and downloaded from the Link: http://www.parc.gov.pk.

PARC Newsletter

PARC Newsletter is being published quarterly, uploaded on PARC website and widely circulated to national as well as international partners. During the year 02 issues of Volume 35 (2023) and 02 issues of 36 (2024) were published and available online on PARC website.

AGRICULTURAL ENGINEERING

AGRICULTURAL ENGINEERING DIVISION

The key focus of Agricultural Engineering Division (AED) is to design, develop, adapt and promote demand based and precision agricultural machines/technologies in the country. The main thrust is to introduce needful agricultural mechanization and postharvest processing technologies for cereal, fruits, vegetables and other crops. AED is also playing an important role of coordination among the stakeholders related with the promotion of agricultural mechanization in the country. Furthermore, AED has also been providing the technical input for development of National Standards of agricultural machinery and tractors and establishment of a machinery test centre in the Punjab with the financial assistance of Asian Development Bank.

Agricultural Engineering Division has executed several research projects during the reported period on development, testing, commercialisation and promotion of agricultural machinery for local farmers. Some salient achievements of on-going research projects during the reported period are given below:

1. Rice residue management machinery for wheat sowing

Farm mechanization is essential for enhancing agricultural efficiency, with wheat being one of the most mechanized crops. In Pakistan, the rice-wheat cropping area spans 2.2 million hectares (mha), with 1.25 mha in Punjab. In Central Punjab, rice is mainly harvested using combine harvesters, but managing the leftover residue is a challenge. Farmers often burn this residue, causing environmental pollution and depleting soil nutrients.

Sowing of wheat in combine-harvested paddy fields is difficult due to difficulty in straw handling. To address this issue, Agricultural Engineering Institute (AEI) has developed a machine called as Pak Seeder or Combine Seeder, which allows direct wheat planting in the combine-harvested paddy fields. Furthermore, promotion of other straw management technologies was also the focus of this project, such as rice straw choppers/mulchers, rake machines, straw balers, etc. These technologies not only help in timely sowing of wheat crop in combine-harvested paddy fields, but also improve soil health, increase crop yields up to 10%, reduce nutrient loss and help combat smoke pollution, thus addressing the SMOG issue in the country. From 2020 to 2023, wheat planting trials using these technologies were conducted across rice growing districts of the Punjab including Gujranwala, Sheikhupura, Hafizabad, Mandi Bahauddin, Sialkot, Sargodha and Lahore districts. The yield results were compared with conventional wheat sowing methods and found a significant increase in yield using these technologies. Field seminars and demonstrations were also held to promote these innovations among farmers.

Field trials of Combine Seeder and demonstration to farmers.

Table 1. Wheat yield data (FY-2022-23)

S. No.	Location	Combine Seeder (mnd/a)	Pak Seeder (mnd/a)	Control (mnd/a)
1.	Lalupur, Gujranwala	47.45	44.82	42.7
2.	Kot Baray Khan, Gujranwala	48.2	46.66	41.35
3.	Sial Mor, Sargodha	44.4	41.6	41.25
4.	KSK, Sheikhupura 1	34.46	36.04	32.1
5.	KSK, Sheikhupura 2	47.12	43.89	41.56
6.	Mangowal, Gujrat	37.39	35.62	33.5
7.	Soianwala, Gujranwala	37.93	36.23	34.69
8.	AR Farm, Gujranwala	37.65	35.12	34.11
9.	Adaptive Farm, Gujranwala	44.77	43.12	34.95
10.	Raikay, Mandi Bahauddin	42.21	42.0	37.58
11.	NARC, Islamabad	36.4	33.2	36.3
	Average (Mnd/a)	**41.63**	**39.85**	**37.28**

2. Promotion of rice production machinery

Pakistan is the 10th largest rice producer globally, contributing over 8% to the world's rice trade. However, traditional manual transplanting methods result in a plant population of only 35,000-40,000 plants per acre, far below the recommended 80,000-85,000 plants per acre, leading to lower yields. To improve this, Agricultural Engineering Institute (AEI) at NARC supported farmers with rice nursery raising and mechanical transplanting. Demonstrations were held in Gujranwala, Sheikhupura, Sialkot and Hafizabad. New and reconditioned rice transplanters were tested, and performance data was collected to guide farmers in

choosing the best machinery for optimal yield.

Two field seminars on "Rice Planting and Harvesting Machinery" in Narowal and Hafizabad drew around 300 participants, including farmers, manufacturers, and policymakers. The Director General of the Agricultural Engineering Division, PARC, attended as Chief Guest and experts trained attendees on using rice-specific machinery to boost productivity and reduce losses.

Additionally, 250 farmers were trained on key aspects of operating rice machinery, such as monitoring grain losses during harvesting and adjusting combine harvester settings to minimize shattering losses.

Glimpses of field activities to promote rice mechanization.

Glimpses of field awareness seminars to promote rice mechanization.

3. Design, Development and Adaptation of an Olive Harvester

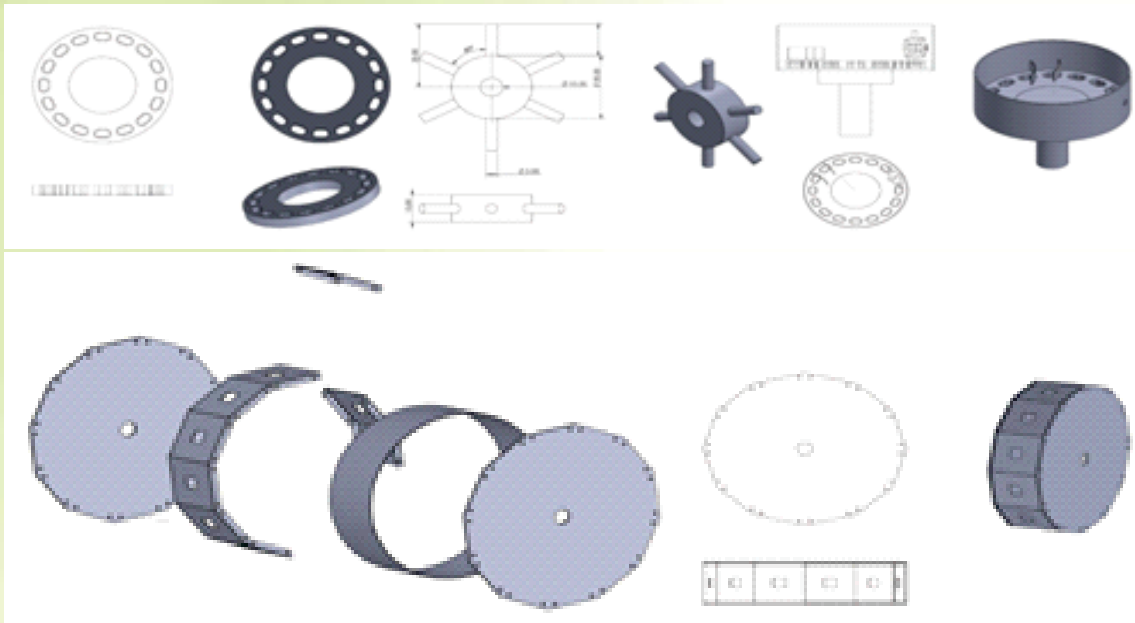
Olive (Olea europaea L.) is an evergreen tree that produces high-quality oil rich in monounsaturated fatty acids, beneficial for health. In Pakistan, olive cultivation is concentrated in arid and semi-arid regions like Chakwal, Fateh Jang, and various areas in Khyber Pakhtunkhwa and Baluchistan. Most olive harvesting in Punjab's Pothohar region is done manually, which is time-consuming, labour-intensive work and leads to delayed harvesting, reducing fruit quality and increasing costs. To address this challenge, Agricultural Engineering Institute (AEI) of PARC in collaboration with Pir Mehr Ali Shah University of Arid Agriculture, Rawalpindi developed a tractor-operated olive harvester. Tested on the Bari Zaitoon-I cultivar, the machine was evaluated at various PTO speeds, stroke lengths, and clamp positions. The optimal settings; 300 rpm PTO speed, 10 cm stroke length and 1-meter clamp position yielded 92.4% harvested fruit, 7.6% leftover, and a field capacity of 23.6 trees per hour. This machine offers a timely and economical alternative to manual harvesting, and further research is recommended to enhance the harvesting efficiency of the machine.

Design, fabrication and testing of indigenous olive harvester

4. Design and Development of a Groundnut Precision Planter

Groundnut (Arachis hypogaea L.), commonly known as peanut, is a crucial leguminous crop in Pakistan, valued for its protein-rich seeds and oil. It is predominantly cultivated in the arid and semi-arid regions, thriving in the warm climate and sandy soils. Groundnut farming plays a vital role in the local economy, supporting rural livelihoods and providing a significant source of income for farmers. However, the traditional manual sowing method is labour-intensive, time-consuming, and can lead to inconsistent planting depth and spacing, which negatively impacts crop yields and overall productivity.

To enhance sowing efficiency and improve yields, the Agricultural Engineering Institute (AEI) is working on developing precision seed metering units for a groundnut planter. Production drawings for these units were prepared using SolidWorks software, and both horizontal and vertical seed metering units were fabricated and lab-tested at AEI's workshop. The ongoing development and modification work aim to optimize these units for better performance. To further refine the precision planter, AEI representatives visited agricultural machinery manufacturers in Daska, Gujranwala, and Lahore. They engaged in detailed discussions with manufacturers regarding the fabrication of suitable seed metering units using advanced techniques like die-casting, injection moulding, and CNC machining. During these visits, the manufacturing facilities were inspected, and existing metering units designed for multi-crop use were evaluated. This collaborative effort aims to produce the most effective precision planter for groundnut cultivation, ultimately boosting productivity and profitability for farmers in Pakistan.



Production drawing of different seed metering units

5. On-farm mechanized postharvest processing and value addition technologies for fruits in Gilgit Baltistan and KPK

Fruits are vital to the agriculture and economy of Khyber Pakhtunkhwa (KPK) and Gilgit-Baltistan, where diverse climatic conditions support fruits like apples, pears, peaches, apricots, and plums. However, their perishable nature leads to high post-

harvest losses from spoilage and degradation.

To tackle this issue, desiccant-assisted solar dryers offer a promising solution. Unlike conventional methods, these dryers use solar energy and desiccant materials to create a controlled environment for efficient moisture removal, preserving fruit quality and extending shelf life. This technology is particularly beneficial in KPK and Gilgit-Baltistan, where traditional drying methods are inadequate due to variable climate.

Detailed design drawings for the solar dryer were created using SolidWorks, allowing for precise refinement of its components. Additionally, consultations with a private industry provided valuable technical input and opportunities for future collaboration, enhancing the project's feasibility. Implementing this technology could significantly reduce post-harvest losses, improve fruit quality, and boost profitability for local growers, contributing to the agricultural development in these regions.

Production drawing of solar dryer

Visit of private machinery manufacturing facility

List of Publications

1. Md-Tahir, H, Mahmood, H. S, Xia, J, Zhang, J, Khaliq, A, Ali, M. Advancing Agricultural Mechanization and Arable Land Management for Climate Resilient and Sustainable Agro-Food System. 2024. Proceedings of Emerging Scientist - Season III. Asian Council of Science Editors.
2. Khan, A.A., Haq.U.Z., Islam.A.M., Saad. A., Raza.M.S., Ali. I., Sheraz.K., Usman.M., Ali.M.M., Ali.M., 2023. Prospectus and Scope of Olive Mechanization: A Review. Zoo Botanica.01 (2) 79-93. ISSN 3007-2050 (E) 3007-2042 (P).
3. Munir, Z., Román, F., Niazi, B. M. K., Mahmood, N., Munir, A., & Hensel, O. (2023). Parametric analysis for exergetic optimisation of a solar shell-and-tube latent heat storage unit for agricultural applications. Applied Thermal Engineering, 233, 121029. https://doi.org/10.1016/j.applthermaleng.2023.121029.
4. Javaid, M.A., Haq, Z.U., Mahmood, H.S., Iqbal, T., Ansar, M., Mehmood, T., Yaseen, G., Asam, H.M., Husain, M., Islam, M.A. and Ali, I. 2023. Design, development and testing of different shapes of flails for Pak-Seeder. Pure and Applied Biology, 12 (4): 1587-1600.

PLANNING & DEVELOPMENT

PLANNING AND DEVELOPMENT DIVISION

Agricultural Linkages Program (ALP)

The Agricultural Linkages Program (ALP), established in the year 2000, receives funding from the Agricultural Research Endowment Fund (AREF). This endowment fund is a collaborative effort between the Government of Pakistan and the Government of the United States of America through an agreement signed in February 1999.

The primary purpose of this fund is to support and promote agricultural research and development activities in alignment with Pakistan's long-term development goals. Additionally, it aims to foster long-term scientific collaboration and cooperation between Pakistan and the United States within the agricultural sector.

The management of this fund falls under the purview of the Board of Directors (BOD) of the Agricultural Linkages Program (ALP). This board oversees the allocation and utilization of the funds in various agricultural research projects. The selection of projects to be funded is done on a competitive basis within the framework of the National Agricultural Research System (NARS). The Technical Advisory Committee (TAC) is responsible for recommending projects for funding, and the final approval for funding these projects rests with the Board of Directors of the ALP.
The key activities conducted during the fiscal year 2023-24 as part of the Agricultural Linkages Program (ALP) are outlined as follows:

- 84 projects were actively underway, benefitting from funding provided through the Agricultural Linkages Program (ALP).
- Geographical distribution data is illustrated in Figure 1, showcasing the allocation of projects across different regions.
- Figure 2 provides insight into projects' distribution across various disciplines.
- The combined approved budget for these projects amounted to Rs 759.02 million (Figure 3).

- During the fiscal year 2023-24, a total of 20 projects were brought to successful completion within the framework of the National Agricultural Research System.
- These projects were distributed across various disciplines: 10 in Plant Sciences, 04 in Animal Sciences, 03 in Agricultural Engineering, 02 in Natural Resources, and 01 in Social Sciences.
- The collective expenditure for these endeavors amounted to Rs. 135.486 million (Figure 4), drawn from the Agricultural Linkages Program (ALP).

- The ALP Secretariate ensured the seamless flow of funds by processing and releasing necessary funds in a timely manner.
- During year 2023-24, an on-site review of 11 ALP funded on-going projects was conducted: 4 in Plant Sciences, 5 in Animal Sciences, 02 in Natural Resources
- ALP Secretariat, P & D Division, PARC has invited the preliminary proposals to be funded under 10th batch of ALP through advertisement. Under 10th

batch of Agricultural Linkages Program, 1896 proposals were received. These proposals have been short listed by appraisal committee of each sector comprises of scientists/ experts representing provincial research system/ universities of each sector (Figure 5)

Directorate of Planning, Monitoring and Evaluation (PM&E)

Following activities have been carried out during 2023-24 in Directorate of Planning Monitoring and Evaluation.

On-Site Evaluation of PSDP Projects:

PM&E directorate evaluated the following two PSDP projects.

- Strengthening/Up-gradation of AZRI, Umerkot, Sindh
- Productivity Enhancement of Wheat

The M&E directorate conducted on-site Monitoring & Evaluation of PSDP Project titled, "Productivity Enhancement of Wheat" on 28th May-7th June, 2024. The detailed M&E report of the said project was prepared and submitted to concerned quarter.

The M&E directorate conducted on-site monitoring & Evaluation of PSDP Project titled, "Strengthening/Up-gradation of AZRI, Umerkot, Sindh" on 26th November-30th November, 2023. The detailed M&E report of the said project was prepared and submitted on 15th December, 2023, to concerned quarter.

Research Agreement (MoU type) Projects:

Overall, 20 research agreement projects (MoU type) were ongoing during 2023-24. The MoU section of PM&E has processed and revised administrative approval of 22 projects for revision / re-appropriation of budget breakup and extended the project duration of different MoU projects as desired by the NARC/PARC scientists for smooth implementation of projects. In which, some of the major contributing donors were Royal Botanical Garden (RBG) UK, International Atomic Energy Agency (IAEA), CIMMYT-PARC, Rural Development Administration (RDA) Republic of Korea through (KOPIA), South Asian Association for Regional Cooperation (SAARC), MGI Tech Singapore PTE.LTD, Joint Scientific Exchange Program of Pakistan Science Foundation (NSFC-PSF), Livestock & Dairy Development Board (L&DDB), Global Crop Diversity Trust (Germany), FAO, etc.

MoU type projects implemented in 2023-24

Plant Science	Animal Science	Natural Resources	Social Science	Total
11	02	05	02	20

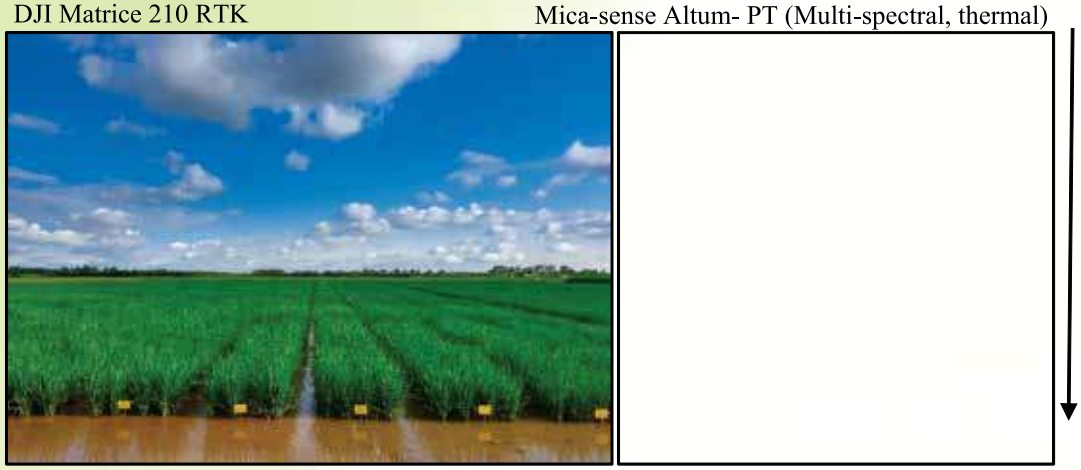
The MoU section has also processed more than 35 projects proposals and concept papers to different local and international donors like Korean International Cooperation Agency (KOPIA), NSLP (PSF), Turkish Cooperation and Coordination Agency (TIKA), Trade Development Authority of Pakistan European Union funding program, Technical corporation between Pakistan and Brazil, Malaysian Partner Institutes, competitive grant of UAE, Dutch entities, Pakistan Institute of Development Economics (PIDE) etc. As the council has privilege to compete for financial assistance from the local and international donors of the world. Some of the research agreements with international organization are underway for implementation in the future.

PSDP

The PSDP projects are the building blocks for any organization. Keeping in view the national and sectorial priorities, PSDP projects are being prepared. The Directorate of PSDP (P&DD) is responsible for the processing of new projects submitted by scientists of PARC. Presenting and defending the submitted projects for getting approval of respective PSDP forums including DDWP, CDWP and ECNEC. Preparation, presenting and defending budget demand for the forthcoming PSDP regarding ongoing and new projects. After final PSDP allocation to projects, the Cash/Work Plan for each development project is prepared as per approved budget. Revision and extension in duration of ongoing projects are also processed and get approved for competent authority/forum. The Directorate has been facilitating the PARC/NARC scientists in preparing and implementation process of PSDP projects through following activities in 2023-24:

DJI Matrice 210 RTK

Mica-sense Altum- PT (Multi-spectral, thermal)



Sino-Pak Agricultural Breeding Innovations Project for Rapid Yield Enhancement:
Drone System for High-Throughput Digital Data of Crops

I. Preparation, Scrutiny, and Processing of New and Modified Development Project:

Following nine (09) Project Concept Notes (PCNs) were submitted to M/o NFS&R for inclusion in PSDP for the FY 2023-24:

i. Pakistan-Korea Joint Program on Certified Seed Potato Production System
ii. Genetic Improvement of Livestock for Productivity Enhancement.
iii. Research and Development of High Value Horticulture Crops in various Ecologies of Pakistan.
iv. Development and Promotion of Urban and Peri-urban Agriculture Models for Improving Food Safety and Livelihood.
v. Establishment of Arid Zone Research Centre Bahawalpur to Support Food Security and Poverty Alleviation in the Desert Areas of Southern Punjab.
vi. Scaling up of Quality Honey Production Technologies Under Different Ecological Regions.
vii. Genetic improvement program for the cultureable fish species in Pakistan & Establishment of National Reference Lab for Control of Fish Diseases.
viii. Induction of high value date palm varieties and establish processing plant to revenue increase by export for Pakistan.
ix. Development of the high value camel milk powder to earn foreign exchange and improve livelihood of arid area of Pakistan.

Appraised and scrutinizes 32 project concept proposals and submitted under the "Emergency Food, Agricultural Supply and National Agricultural & Food System" by Islamic Development Bank forum for the F.Y 2023-24.

03 project concept proposals were submitted for consideration under Public-Private Partnership (PPP) Mode 2023-24.

S.No.	Name of Project	Project Cost (Rs. Million)	Duration (Months)
1.	Commercialization of Banana Tissue Culture Technology in Pakistan	365.480	60
2.	Development and Promotion of Novel interventions and post-harvest technologies for Fruits Crops (Dates, Banana, Mango and Citrus)	982.000	60
3.	Introduction of New Exotic High Yielding Cultivars Promotion and Expansion in Area under Dates Cultivation and Installation of Dates processing Plant for value addition at Turbat Balochistan	1517.300	60

II. The projects prioritized/recommended for budget allocation during F.Y. 2023-24 are as under:

A) On-Going Projects:

i. Commercialization of Potato Tissue Culture Technology in Pakistan.
ii. Productivity Enhancement of Rice.
iii. Productivity Enhancement of Sugarcane.
iv. Productivity Enhancement of Wheat.
v. Promoting Research for Productivity Enhancement of Pulses.
vi. Sino-Pak Agricultural Breeding Innovations Project for Rapid Yield

Sino-Pak Agricultural Breeding Innovations Project for Rapid Yield Enhancement: *NIGAB Field of 5 Varieties of Wheat with 7 Tons/Hac*

B) Principally Approved New Projects:

i. Prime Minister's Initiatives For Green Revolution 2.0
ii. Horticulture Support Program.

C) New Projects for FY 2024-25:

i. Research for Innovations in Agricultural Development (RIAD).
ii. Endowment for National Agricultural Research System - to support R&D with Long-Term Financial Stability (ENARS).
iii. Establishment of Animal Bio-Safety Level-III Facility for Vaccine Development and other allied research work).

D) Extension in the Execution Period of the following On-going PSDP Projects:

i. Sino-Pak Agricultural Breeding Innovations Project for Rapid Yield Enhancement.
ii. Productivity Enhancement of Wheat.
iii. Productivity Enhancement of Rice.
iv. Productivity Enhancement of Sugarcane.
v. Promoting Research for Productivity Enhancement in Pulses.

III) Preparation of Public Sector Development Program (PSDP)

- Prepared Public Sector Development Programme (PSDP) 2023-24 of 08 on-going projects for forth coming Standing Committee meeting of National Assembly at M/o NFS&R.
- Prepared Project Profiles of (08) On-Going PSDP Projects for submission to M/o NFS&R.
- Arranged and documentation for Quarterly, Mid Year and Annual Review of PSDP 2023-24 for submission to M/o NFS&R.
- Prepared PSDP 2023-24 and financial projection (2024-25, 2025-26, 2026-27) for the next three years of New unapproved projects for Senate Standing Committee (SSC) and National Assembly Standing Committee (NASC) and M/o NFS&R.
- Submitted Budgetary proposals relating to the Public Sector Development Programme (PSDP) of PARC to Standing Committee of National Assembly to make recommendations for next Financial Years.

IV) Revision of Ongoing PSDP Projects by CDWP/DDWP/ECNEC:

Submission of following 02 On-going revised development projects to the M/o NFS&R, the projects are considered by DDWP/CDWP.

i. Sino-Pak Agricultural Breeding Innovations Project for Rapid Yield Enhancement.
ii. Commercialization of Potato Tissue Culture Technology in Pakistan.

V) Review Meetings of PSDP Projects at PARC, M/o NFS&R and M/o PD&SI:

Conducted and coordinated more than 100 monthly, quarterly and annual review meetings and media briefings held at PARC, M/o NFS&R and M/o PD&SI to help update physical and financial progress of the On-going projects. Follow up on the

Pak- Korea Joint Program on Certified Seed Potato Production System: *Media briefing on Aerponic Technology for Potato Seed Production.*
On the stage L-R Dr. Ghulam Muhammad Ali (Chairman PARC) Dr. Kausar Abdullah Malik (Caretaker Federal Minister NFS&R), H.E. Park Ki Jun (Ambassador of Korea) and Dr. Cho Gyoungrae (Director KOPIA-Pakistan Center). Speaker: Dr. Aish Muhammad (Coordinator Projects KOPIA)

VI) Financial Outlay, Expenditure, Budget etc

S. No	Name of the Project	Approved Cost	Allocation 2023-24	Release 2023-24	Expenditure as on 30.06.2024
1.	Commercialization of Potato Tissue Culture Technology in Pakistan	218.746	25.380	25.320	25.128
2.	Productivity Enhancement of Rice	3,750.660	235.000	162.500	162.397
3.	Productivity Enhancement of Sugarcane	1,003.773	130.000	116.064	115.955
4.	Productivity Enhancement of Wheat	5,632.774	248.000	121.600	121.469
5.	Productivity Enhancement in Pulses	1,437.358	300.000	166.396	165.344
6.	Sino-Pak Agricultural Breeding innovations Project for Rapid Yield Enhancement	611.090	63.490	103.373	103.308
7.	Mainstreaming of Mountain Agricultural Research Centre (MARC) for the for the Promotion of High Value Agriculture in Gilgit - Baltistan	288.200	65.000	56.280	56.198
8.	Pak- Korea Joint Program on Certified Seed Potato Production System.	985.067	100.530	29.150	29.150
9.	Horticulture Support Program	1,000.000	50.000	-	-
10.	[illegible]	5,000.000	5,000.000	-	-
	Total	**19,927.668**	**6,217.400**	**780.683**	**778.947**

COORDINATION &MONITORING

COORDINATION AND MONITORING DIVISION

Coordination and Monitoring Division consists of two Directorates and one Institute namely; (i) Directorate of Coordination, (ii) Directorate of Human Resource Development and (iii) PARC Institute of Advanced Studies in Agriculture (PIASA), each having its own mandate and objectives. Recently, regional coordinating units were established in PARC outstation establishments at Quetta, Peshawar, Faisalabad, Tandojam, Muzaffarabad and Juglote-Gilgit to coordinate with all the Agriculture Universities and Livestock Departments of provinces, at regional level.

The functions of this Division mainly include; i) Coordination between PARC and national agricultural research systems of many countries (bilateral links), and UN/CGIAR/US based agricultural research agencies (international development partners), ii) Coordination and facilitation of research at national level, and iii) Assessment of training needs (local/foreign) for NARS and arrangement of pre-service and in service training along with budget & placement proposals. Furthermore, this Division is also involved in post-graduate education through PARC Institute of Advanced Studies (PIASA).

PROGRESS FOR THE YEAR 2023-24

1. Identification of areas/ proposals of cooperation

Provided proposals for cooperation, implementation of decisions for Joint Working Meetings, Joint Economic Cooperation meetings and Regional Cooperation meetings held under Ministry of National Food Security and Research, Economic Affairs Division, Ministry of Foreign Affairs and Board of Investment for China, Turkey, Belarus, Kazakhstan, Uzbekistan, Kingdom of Saudi Arabia, Kuwait, Qatar, Australia, USA and Russia.

2. Facilitation for International Projects

a) PARC and KOPIA, Korea

Facilitated for processing and approval of following projects:

I. Improving potato production machinery in Pakistan.
ii. Development of Italian Ryegrass variety and expansion of new oat variety to establish village base seed enterprise through Farmer's Participatory Approach.
iii. Efficient Artificial Insemination Services by using Korean Holstein Sexed Semen in Cattle.
iv. Establishment of Seed Potato Production and Supply Centre (SPPSC) at Pakistan Agricultural Research Council, Pakistan.
v. Establishment of a Smart Agricultural Farm for Vegetable Production at NARC, Islamabad.
vi. Establishment of Korean Holstein Breeding Stock and Development of a Composite Dairy Cattle Breed.

b) PARC and CABI

Facilitated in signing of Plantwiseplus Work and Funding Contract Between PARC and CABI

3. Facilitation in organizing international meetings

Facilitated in Holding following meetings with Foreign and National Delegates:

i. Pakistan – Turkmenistan Joint Working Group meeting
ii. Meeting of Federal Minister, NFS&R with Australian Ambassador
iii. Meeting of Federal Minister, NFS&R with UN Resident Coordinator

4. Holding of PARC's Membership in international organizations:

Renewed the membership of CABI and Centre for Sustainable Agricultural Mechanization (CSAM)

5. Visa Processing Facilitation:

PARC facilitated the visa processing of 18 foreign participants of Workshops/Seminars & Internationally Recruited Staff (IRS) of agricultural research organizations, posted in Pakistan.

6. MOUs/Agreements

Six (06) MOUs/ Agreements with international organizations and 08 national level MOUs/Agreements/LoIs have been signed with Universities/ Agri-tech companies/ NGOs/Public-Private Sectors and Public sector organizations for development and dissemination of research technologies. Following is the detail:

a) International Level:

1.	Plantwiseplus Work And Funding Contract Between Pakistan Agricultural Research Council (PARC) and Centre for Agriculture and Biosciences International (CABI)	27-07-2023
2.	Agreement between PARC and Global Crop Diversity Trust (GCDT) Bonn Germany	02-08-2023
3.	Letter of Agreement between Food and Agriculture Organization (FAO) of United Nation and PARC	13-12-2023
4.	Agreement between Pakistan Agricultural Research Council (PARC) and The Ministerial Standing Committee on Scientific and Technological Cooperation of the Organization of Islamic Cooperation (COMSTECH).	04-04-2024
5.	Letter of Exchanges for Juncao Cultivation Demonstration and Promotion Project	11-06-2024
6.	MoU between Pakistan Agricultural Research Council (PARC) and the Chinese Academy of Agricultural Sciences	14-06-2024

b) National Level:

S.No.	MoU between PARC & other farms	Commencing date
1.	LOI b/w PARC & WINROCK International Institute for Agriculture Development.	03-08-2023
2.	MOU b/w PARC & Association for Gender Awareness and Human Empowerment (AGAHE)	11-08-2023
3.	MOU b/w PARC & Center for Non-communicable Diseases (CNCD), Karachi	13-10-2023
4.	MOU b/w PARC & Pak One Health Alliance (POHA)	06-11-2023
5.	MOU b/w PARC &Riphah College of Veterinary Sciences (RVCetS) Lahore. RIPHAH	02-02-2024
6.	MoU between PARC & KAFALAH Foundation	26-02-2024
7.	MoU between PARC & Holstein Research Management Pvt ltd Pakistan (HRM)	07-03-2024
8.	MoU between PARC & Green Perfect Plant (GPP)	18-04-2024

1. Human Resource Development

Training	Program	No. of Nominees
Foreign long term	MS/ M.Phil/Diploma	0
	Ph.D	3
	Post Doc.	2
Local long term	MS/ M.Phil/Diploma	10
	Ph.D	7
Foreign short term		59
Visits		72
Local short term		23

2. Promotion of Higher Education Promotion in Agriculture

PARC Institute of Advanced Studies in Agriculture (PIASA)

In view to even increasing skills and expertise gap in the advanced agricultural sciences and to capitalize on its rich knowledge base and infrastructure, PARC established PARC Institute of Advance Studies in Agriculture (PIASA) in 2008, to embark upon a unique postgraduate academic program at the campus of NARC.

PIASA has been affiliated with University of Agriculture, Peshawar since 2010 to 2017 and since 2012, with Quaid-i-Azam University, Islamabad. As to ensure excellence in education as well as research in order to actively contribute towards human resource development in fields of agriculture, livestock and other allied disciplines for more than a decade. PIASA has been offering MPhil and Ph.D programs in the following disciplines:

i. Animal Genomics & Biotechnology (AGB)
ii. Applied Economic (AE)
iii. Plant & Environmental Protection (PEP)

iv. Plant Genomics & Biotechnology (PGB)
v. Natural Resource Management (NRM)

During the year, 3 Ph.D students of PIASA successfully completed their degree in their respective fields. Currently, 17 Ph.D students are enrolled and their relevant dealings are being catered through coordination with their host universities. As the admission process was halted due to HEC policy limitation, various meetings were held with Chairman HEC and Vice Chancellor QAU for resumption of academic process at PIASA. HEC has allowed PIASA to resume its academic programs with Quaid-i-Azam University Islamabad, which is in process.

FINANCE

Financial Resources & Budget of PARC

Highlights

As per Article-18 of PARC Ordinance-1981, the funds of the Council consist of the following:

- Grants made by the Federal government and the Provincial governments.
- Grants, donations, endowments, contributions, aid and assistance given by other organizations.
- Foreign aid and loans obtained or rose with the approval of the Federal Government.
- Receipts from other sources.

An Overview of the Budget:

(Rs. in million)

Budget Head/Funding Source	2022-23 Actuals	2023-24		
		Budget	Revised Budget	Actuals
A- Current Expenditure Budget	5,312.141	7,812,716*	6,690.245**	6,650.696**
B- Research Budget	187.000	0.000	0.000	0.000
Total (A+B):	**5,499.141**	**7,812.716**	**6,690.245**	**6,650.696**
Development Expenditure (PSDP)	1,068.412	6,217.400	780.683	778.947
Memorandum of Understanding (MOU's)	32.748	157.517	76.090	76.090
Agricultural Linkage Program (ALP)	211.836	435.059	435.059	216.841

I. Current Expenditure Budget

(Rs. in million)

Objects	2022-23 Actuals	2023-24		
		Budget	Revised Budget	Actuals
Employee Related Expenses (ERE)	2,917.401	4,862.400	3,660.584	3,621.101
General Expenses	446.789	1062.316*	1062.316**	1062.250**
Employee Related Benefits (ERB)	1,800.000	1,800.000	1,851.816	1,851.816
Total Grant-in-Aid	**5,164.190**	**7,724.716**	**6,574.716**	**6,535.167**
Add: Own Source	147.951	88.000	115.529	115.529
Total Current Expenditure Budget (A)	**5,312.141**	**7,812.716**	**6,690.245**	**6,650.696**
Research Budget (B)	187.000	0.000	0.000	0.000
Total (A+B):	**5,499.141**	**7,812.716**	**6,690.245**	**6,650.696**

* Rs.300.000 million has been allocated for Research purpose out of Rs.1062.316 million.
** Revised Budget & Actuals for the F.Y 2023-24 includes Rs.109.522 million on account of expenditure incurred for Research purpose.

II. Development Expenditure Budget

a) PSDP

Development Expenditure budget of Rs.6,217.400million was allocated for the following on-going PSDP Projects for the year 2023-24 which was subsequently revised to Rs.780.683 million surrendering Rs.5,436.717 million. Project wise detail is as under:

On-going Project:

(Rs. in million)

Title of the Projects	Approval Date/Forum	Total Cost	Actuals 2022-23	Budget 2023-24	Revised Budget 2023-24	Actuals 2023-24
Main Streaming of MARC for the promotion of High Value Agri. In G.B	DDWP 20-05-2021	288.200	32.054	65.000	56.280	56.198
Strengthening/Up-Gradation of Agriculture and Livestock Research System of (AZRI) Umerkot, Sindh	DDWP 03-05-2017	528.260	134.316	-	-	-
Productivity Enhancement of Wheat	ECNEC 28-08-2019	5632.774	254.054	248.000	121.600	121.469
Productivity Enhancement of Rice	ECNEC 28-08-2019	3750.660	199.912	235.000	162.500	162.397
Productivity Enhancement of Sugarcane	ECNEC 28-08-2019	1003.773	103.080	130.000	116.064	115.955
Pulses Project	ECNEC 29-11-2019	1437.358	216.686	300.000	166.396	165.344
Commercialization of Potato Tissue Culture Technology in Pakistan	DDWP/04-05-2020	158.830	43.343	25.380	25.320	25.128
Sino-Pak Agricultural Breeding Innovation Project for Rapid Yield Enhancement	DDWP/04-05-2020	433.936	72.701	63.490	103.373	103.308
Upgradation of Agro-Ecological Zones for Pakistan through Satellite and in-situ Data Mapping	DDWP/24-02-2020	60.450	12.266	-	-	-
Horticulture Support Programme		1000.000	0.000	50.000	-	-
Pakistan Koria Joint Program on Certified Seed Potato Production System			-	100.530	29.150	29.150
Prime Minister's Initiative for Green Revolution 2.0				5000.000	-	-
TOTAL			**1068.412**	**6,217.400**	**780.683**	**778.947**

b) Memorandum of Understanding (MoU)

13 Nos projects with total cost of Rs.157.517 million were approved under MOU's with different national and international organization for the year 2023-24. An over view of two years is as follows:

(Rs. in million)

Sr.#	Name of Project	Actuals 2022-23	Budget 2023-24	Revised Budget 2023-24	Actuals 2023-24
1	Conserving Pakistan Rare and Threatened Medicinal and Useful Trees and Shrubs	8.357	7.481	7.481	7.481
2	Self Sufficiency of Virus Free Potato Seed Multiplication by Aeroponic Technique (Potato Component Nigab)	3.550	12.522	10.972	10.972
3	Self Sufficiency of Virus Free Potato Seed Multiplication by Aeroponic Technique (GB)	1.240	1.830	1.830	1.830
4	Mitigation the effects of stripe rust on wheat Production in South Asis and EasternAfrica CDR, NARC	1.626	0.000	0.000	0.000
5	Genetic and Anti Genetic Characteriaztion of FMD Viruses for Development of mproved and Potent Vaccines	0.000	0.000	0.000	0.000
6	Chilli Production and Post-Harvest Management Technology Development In Pakistan (HRI Component)	1.015	2.215	2.215	2.215
7	Chilli Production and Post-Harvest Management Technology Development In Pakistan (AZRI Umerkot Component)	1.919	0.000	0.000	0.000
8	Establishment of Production Technology of Major Fodder Crops in Pakistan(Fooder & RRI Component)	5.732	8.612	8.324	8.324
9	Developing Competitive and Inclusive Value Chain Of Pulses in Pakistan	2.126	4.762	2.935	2.935
10	Breed Improvement through Efficient Artificial Insemination Services by using Korean Holstein sexed Semen in Cattle	0.000	24.612	19.816	19.816
11	Understanding the Drivers of Successful and Inclusive Rural Regional Transformation: Sharing Experiences and Policy Advice in Bangladesh, China, Indonesia & Pakistan	1.606	2.692	2.649	2.649
12	Accelerating Genetic Gains In Maize & Wheat For Improved Livelihood (AAG)	0.000	1.127	1.127	1.127
13	The Impact of Climate Change on Water Resources in the Indus River Basin and Adaption Strategy to copy with	0.000	1.800	1.562	1.562
14	BOLD WPI: Capacity and Resource Development of National Genebank of Pakistan	0.000	16.390	1.163	1.163
15	Strengthening Of Agro-Pastoralists in Sindh , Pakistan.	0.000	68.774	13.755	13.755
16	Towards Combined Use of MAT and SIT for Management of Bactrocera (Diptra: Tephritidae) Fruit Flies: Developing Methods of Delivering Methy Eugenol, Hormones and Diet Supplements	0.000	4.700	2.259	2.259
17	Increasing Productivity and Profitablility of Pulses Production in Cereal Based Cropping Systems in Pakistan	5.577	0.000	0.000	0.000
	Total	32.748	157.517	76.090	76.090

c) Agricultural Linkage Programme (ALP) Budget

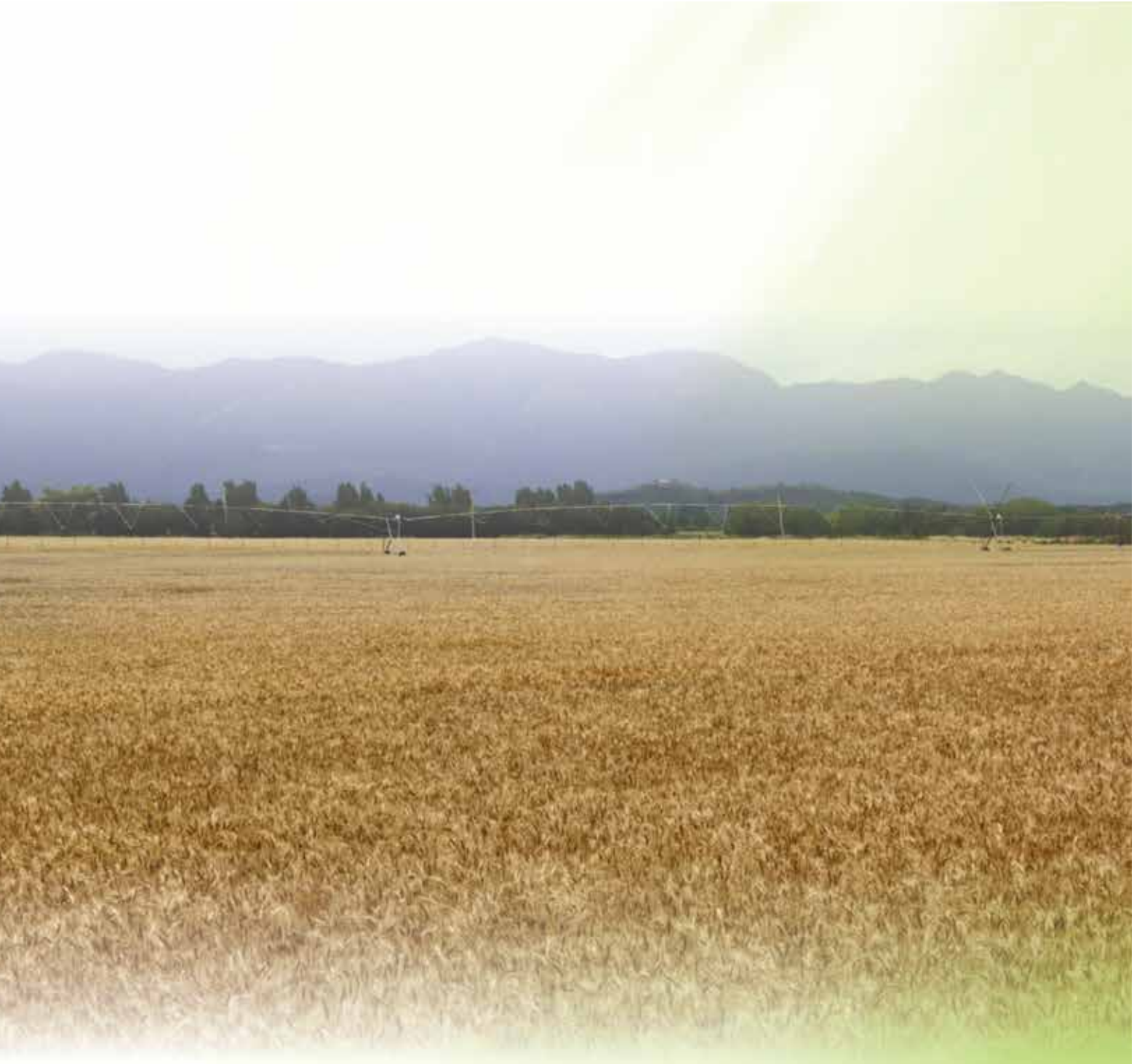
The Endowment fund of ALP is used for Research purpose with the collaboration of various Research organizations in the country. The fund position is as under:

(Rs. in million)

Sr. No.	Location	2022-23	2023-24			
		Actuals	Total Number of Project Executed	Budget	Revised Budget	Actuals
1	Federal	85.410	48	112.986	112.986	85.338
2	Punjab	40.439	33	50.278	50.278	28.458
3	KPK	27.283	15	28.086	28.086	20.174
4	Sindh	7.567	07	18.041	18.041	13.253
5	Balochistan	13.739	11	20.371	20.371	17.604
6	AJK	0.792	04	3.299	3.299	0.409
7	PARC, H.Qtr.	36.610	01	130.742	130.742	51.605
8	Budget Estimates for new Projects	-	-	71.256	71.256	-
	Total :-	**211.836**	**119**	**435.059**	**435.059**	**216.841**

Captain (R) Muhammad Asif, Federal Secretary for Ministry of National Food Security and Research alongwith Norwegian Ambassador to Pakistan, Dr. Ghulam Muhammad Ali, Chairman, PARC and Dr. Knut Ingolf Dragset, leading scientists from Geno Global, Norway during an international seminar on the "Genetic Potential and Economic Impact of Norwegian Red Dairy Cattle" at NARC

Honorable Federal Minister for the Ministry of National Food Security and Research, Dr. Kauser Abdulla Malik in a meeting with Dr. Ghulam Muhammad Ali, Chairman, PARC during his visit to PARC.



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