

ANNUAL REPORT

2019-2020



**Pakistan Agricultural
Research Council**

PARC

Annual Report

2019-20



PARC

<http://www.parc.gov.pk>

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FOREWORD FROM THE CHAIRMAN

Since a year is passed as a Chairman of Pakistan Agricultural Research Council, I am thankful to Allah Almighty, who gave us the strength to cope with the challenges successfully. Reaching all this way long, despite of prevailing COVID-19 pandemic and major locust attack, is a fortunate feeling. Although COVID-19 adversely effected the economy, yet by following SoP's our scientists, researchers, farmers, and officials carried out their responsibilities efficiently and now time has reached to put down a few thoughts in black and white as annual report for the 2019-2020.

Pakistan has an agrarian economic structure and as an agricultural economist I must say that the development in agriculture is directly proportional to social and economic growth. This year we have noticed major changes in our infrastructure, division expansions and an increase in revenue sources. These changes prove a positive motion which we continue to practice and achieve, particularly PARC persisted in its efforts to create a revenue stream via innovative research product marketing company, PATCO Display Centers. According to PARC performance reports PATCO- in its third phase of up scaling in PPP mode- recorded a significant boost in business growth of 463.6 million gross revenue in 2020 as compared to 95.6 million in 2019, which increased by approximately 15% from the previous year. I am pleased to say that we expect this revenue generation to be doubled in 2021.

Plant Science Division (PSD) of PARC is working for full-line smart farming solutions and sustainable improvement in productivity and quality of crops to reduce input costs and produce high yielding, disease resistant seed varieties that increase productivity. Significant activities which accomplished this year includes: a new variety of wheat 'Markaz-2019' and AZRC-Dera get approved from Punjab Seed Council for rainfed areas, groundnut variety 'NARC-2019' with yield potential of 4300 kg/ha got registered in Punjab Seed Council. Variety Evaluation Committee (VEC) recommended oats, millet and Sudan grass varieties for general cultivation in Pakistan. PARC acquired 552 Green Super Rice advance lined from Chinese Academy of Agricultural Science (CAAS), China for seed multiplication, evaluation and genomic selection. This year PARC first time participated in seed deposition ceremony at Global Seed Vault, Svalbard-Norway and deposited 310 accession of different crops. A new high yielding variety of garlic; NARC-HG1 was also introduced by our late scientist Mr. Humayoun Khan whose sad demise due to corona was great loss and an emblem of commitment to this council. More than 8000 local and exotic germplasm of wheat, rice maize, sorghum, millet, potato, soybean acquired, while 150 tones basic and certified seed is produced and distributed to relevant partners and progressive farmers for development of improved and climate resilient varieties.

PARC's interventions in paradoxical agriculture is also imperative for system of crop intensification, conservation agriculture and organic farming. Following the track of sustainable agriculture, food security and maintaining organic soil cover while enhancing agricultural productivity PARC promoted, Zero Tillage cropping technology in wheat. It has been found to bring down fuel, labor, and machinery costs, ad conserve soil moisture. In addition, reduction in natural erosion process provides significant environmental benefits.

The Natural Resource Division (NRD) has generated knowledge and developed technology like portable solar pumping system for small farmers, inventory of snow and glacier-fed irrigation system in upper Indus basin. Future water availability of glacierised Hunza Basin under the scenario of climate change, integrated nutrient management of wheat and citrus enhanced the production. Introduced automatic honey flow hive, developed Silvo-pastoral Model for sustainable land use and carbon sequestration. Promoted arid horticulture (olive, dates, grafted ber) in arid regions. Introduced successful cultivation and product development of moringa with brackish water in Thar area. Released climate resilient new crop varieties (Indus-2019, lentil-2019, wheat AZRC-Dera).

In livestock PARC wants to preserve the local breeds and make them productive in terms of milk, meat and dairy products through adopting modern technologies. We introduced Laparoscopic

Artificial Insemination techniques in small ruminants. Besides this, in aquaculture and fisheries, intensive farming of high value fish species carried out to hit the global market for fish export and established first ever public sector Hatchery for all Male Tilapia Seed production.

Moreover, PARC put special focus on technological transformation of agriculture in Pakistan. Development, demonstration, provision, evaluation, and maintenance of modern and reliable machinery took place under the head of Agricultural Engineering Division. In this respect farmer's trainings and demonstration were held to make them aware of new technologies and introduced them to modern machineries such as Groundnut Digger Inverter, Ispaghol Processing Machinery, Solar Dates dryer, and Onion Seed Planter etc.

Planning & Development Division (P&DD) is supporting National Agricultural Research System (NARS) by coordination, designing, processing, monitoring and evaluation of research and development activities/ projects funded under: Public Sector Development Program (PSDP), Agricultural Linkages Program (ALP) and Research Agreement Projects (MoU types) and announced ALP 9th Batch in February 2019.

PLANT SCIENCES DIVISION

Plant Sciences Division (PSD) is focusing on sustainable improvement in productivity and quality of crop commodities, following PARC's mandatory role of undertaking, aiding, and coordinating agricultural research in the country. Major activities towards achieving this goal includes development of improved varieties, provision of relevant germplasm from various domestic and overseas sources to relevant partners belonging to National Agricultural Research System (NARS). The presented report will highlight the outcome of significant in-house studies as well as coordinating activities performed during the report period.

COORDINATION ACTIVITIES

Germplasm Acquisition and Distribution

i. Following germplasm was acquired from various international sources for their evaluation and utilization in national breeding programs of various commodities.

Crop	Acquired	Distributed
Wheat	4000	4000
Rice	552	552
MSM	3700	3700
Pulses	337	337
Potato	27	27
Soybean	100	100
Linseed	100	100

Meetings/Seminars

ii. Meetings of Variety Evaluation Committee (VEC) on rice (Sept 02, 2019), garlic (July 10, 2018), were held in which potential candidate lines were evaluated and those found promising were recommended to be released for commercial cultivation.

iii. Annual Rice Planning meeting held on July 9-10, 2020 to discuss the yield increase with minimum greenhouse gas emission.

National Uniform Yield Trials (NUYT)

iv. NUYTs of following crops were conducted to find out the suitable entries and to move forward with their commercialization

Crops	Entries	Locations
Wheat	70	48
NUBYT (Wheat)	15	10
NUDYT (Wheat)	11	12
Rice (Hybrids / Coarse / Fine)	70/24/24 = 118	15
Maize	796	151
Sorghum	28	15
Sorghum (Fodder)	19	26
Millet	53	20
Millet (Fodder)	20	26
Sugarcane	11	6
Lentil	56	25
Chickpea	121	25
Rapeseed/Canola	21	17
Mustard	35	17

Taramira	06	17
Sunflower	18	11
Soybean	12	8
Groundnut (Short)	8	4
Groundnut (Normal)	10	9
Sesame	10	9

CROPSCIENCES INSTITUTE

Wheat

- i. A new wheat variety 'Markaz-2019' approved for rainfed area by Punjab Seed Council.
- ii. Evaluated 440 advance lines at national and regional level. Among them 06 advance bread wheat lines contributed for testing in the National Uniform Wheat Trials (NUWYT) under rainfed and irrigated conditions.
- iii. Characterized 1325 test entries acquired from exotic sources for yield potential, diseases resistance and zinc content.



wheat seed production block

- iv. Attempted 550 crosses, maintained 890 populations at different filial generations (F1-F6) and selected 650 desirable populations for advancement and yield testing.
- v. About 2088 F7 head rows planted and 150 genetically stable lines were selected for evaluation on the basis of diseases resistance, grain color and plant type etc.
- vi. Established 80 on-farm demonstration of improved wheat varieties with production technology, 09 Zero till wheat planting, 11 Ridge planting, 14 green manuring- wheat and 17 mung-wheat system in different wheat growing areas of Pakistan.
- vii. Produced about 115 tones Pre-basic, Basic and Certified seed of Pakistan 2013, Zincol- 2016, Borlaug-2016, and NARC-2011 and provided to more than 450 farmers, seed companies, Punjab Seed Corporation and NGO,s for further multiplication.

Pulses

- i. Contributed 02 mung bean, 03 mash bean, 01 chickpea and 06 lentil advanced lines in National Uniform Yield Trials. Mung bean line NCM-13 had higher yield (933 kg/ha) and ranked 1st in Pakistan.
- ii. Evaluated 545 lines of Chickpea, Lentil, Mung bean and Mash bean. Our breeders identified a total of 65 disease resistant lines that included 20 chickpea lines against Ascochyta Blight, 10 lentil line against stem rot, 20 mung bean and 15 mash bean lines against Mung bean yellow Virus. In addition,

- 15 lentil and 20 mash bean lines selected that are suitable for machine harvesting.
- iii. Identified safe desiccant (Thiourea) for the drying of mung bean to facilitate the mechanized harvesting.
 - iv. Modified the combine harvester setting for mung bean that helped to reduce grain losses from 12 to 7%.
 - v. Organized 06 Farmer days and one exhibition attended by 1000 stakeholders in different pulse growing areas of Pakistan.
 - vi. Produced 3.59 tons of quality seed that included Mung bean NM-11 (2.90 ton), Mash bean Arooj (0.44 ton) and Lentil Markaz-09 (0.25 ton) and provided to farmers.



Enhancement of pulses productivity

Oilseeds

- i. A new Groundnut variety 'NARC-2019' with yield potential of 4300 kg/h registered from Punjab Seed Council for rain fed area of the country.
- ii. Contributed a total of 17 advance lines for testing in NUYT trials (Rapeseed: 03, Mustard:01, Groundnut: 05 medium duration& 06 short duration, Soybean: 03 and Sesame: 03)



Oilseed field view

- iii. Organized 02 Farmer days in Swat and Skardu and 04 Soybean product trainings in Sakurdu, Rahimabad, Juglot and Ghizir. More than 750 stakeholders attended these events.
- iv. 11 BS students completed their internship

Maize, Sorghum and Millet (MS&M)

- i. Contributed one White Maize OPV genotype (CZP132001) in Kharif-2019 and 03 White Maize OPV genotypes (CZP132001, MSM OPV2, and MSM OPV3) in Spring-2020 National Uniform Maize Yield Trials.
- ii. During Kharif 2019, more than 550 maize accessions were evaluated and generation was advanced. In NUYT testing, 204 maize white and yellow hybrids along 4 maize OPVs were evaluated during Kharif-2019. In Spring-2020, 164 maize hybrids and 4 maize OPVs are being evaluated in field condition.
- iii. 02 tons quality seed of Maize, Sorghum and Millet was provided to 70 farmers.
- iv. Arranged 04 farmer days in Gilgit Baltistan, 200 farmers participated.
- v. 08 BS and MS students completed their research.

Fodder & Forage

- i. Variety Evaluation Committee (VEC) recommended two Oat genotypes (Islamabad Oat with yield potential 68 t/ha and Green Gold Oat with yield potential 70 t/ha) and one Millet genotype (NARC Bajra with yield potential 50 t/ha) for general cultivation in Pakistan.
- ii. Germplasm of Sorghum (139 lines), Millet (rley (30 lines) and vetch (14 lines) Sudan grass (21 lines), oats (400 lines) were evaluated.
- iii. An advance line of millet (Sel-21) performed better with yield of 37 t/ha and four lines of vetch contributed in national uniform yield trials.
- iv. In Preliminary yield trials, 02 advance lines of oats, 02 lines of millet, 01 advance line of vetch and 02 advance lines of sorghum selected for further testing.
- v. 07 BS, 02 MS and one PhD student completed their research.
- vi. Provided 5.60 ton of quality seed (Oats 5.13 tons and Mott grass 0.47 tons) to farmers.



Evaluation of Fodder in field

Plant Physiology

- i. 370 wheat germplasm were evaluated for heat, drought tolerance, salt and mineral (Zn, Fe) contents in lab, greenhouse and field.
- ii. 50 synthetic back-derived wheat lines selected as drought and heat tolerant. 20 wheat genotypes showed highest Zn and Fe contents in grain than normal range of (25 ppm).
- iii. 33 NUWYT lines, 08 advance lines and 07 commercial wheat varieties showed better drought and heat tolerance potential and moderate tolerance to salinity.
- iv. 05 BS and 06 MS students completed their research.

Rice

- i. Planted 52 lines including 18 coarse, 30 fine and 4 hybrids for morphological traits evaluation and seed increase
- ii. 02 Basmati genotypes mutated and subjected to generation advancement (M0-M1).
- iii. Attempted 82 cross combination involving 20 parents and 37 successful cross combinations were obtained for generation advancement and backcrossing.
- iv. 04 rice hybrids were evaluated under three irrigation regimes.
- v. 02 BS and 03 MS students completed their research.

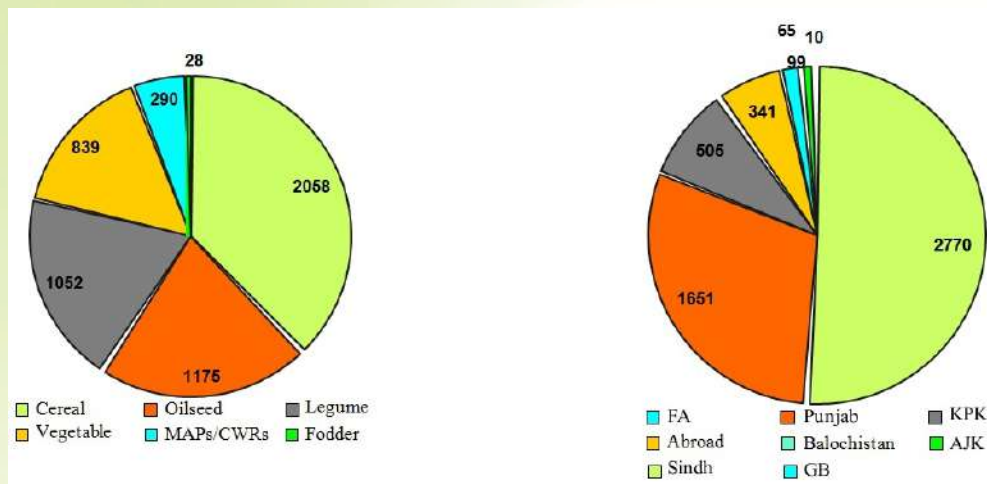


NARC rice research field area

BIORESOURCE CONSERVATION INSTITUTE

Plant Genetic Resources

- i. Genebank has acquired 261 entries including fruits & vegetables, MAPS, CWRs and cereals and banked 454 accessions after allotting accession numbers and now final germplasm inventory in the genebank reached to 41000 accessions.



Distribution of germplasm accessions to stakeholders by crop groups and province.

- ii. Received 158 seed requests from different institutions and provided 5442 accession's samples of diverse crops. The major crop groups requested were cereals (37.8%) followed by oilseeds (21.6%), legumes (19.3%) & vegetables (15.4%).
- iii. 448 accessions were tested for viability, including the 49 samples tested for PATCO.
- iv. PARC has participated for the first time in seed deposition ceremony at Global Seed Vault in

Svalbard-Norway on 25 February 2020 and deposited 310 accessions of different crops.

v. MoU project, Collection of Crop Wild Relatives (CWRs) collected 203 accessions representing 30 species from different parts of the country.

vi. Genetic diversity assessment and discrimination of carrot, radish, rice, wheat, maize, barely, lentils, and mungbean germplasm was carried out.

vii. Local and exotic plants that are being maintained in the home pharmacy area at NARC such as *Thymus vulgaris*, *Apium graveolus*, *Plectranthus* sp., *Aloe vera*, *Stevia* sp., *Coriandrum* sp., *Origanum vulgare*, *Artemisia annua*, *A. absinthium*, *Mentha arvensis* (China), Cool mint, *Mentha piperata* (Japan), Lavender (Syria) and *Ammaranthus* sp were multiplied and distributed to various stakeholders.

viii. Different combinations of herbs were evaluated and handed over to Institute of Agricultural Engineering (AEI), NARC for herbal tea processing.

Microbial Genetic Resources

i. 233 strains were collected and isolated from different ecological zones of the country and preserved in National Microbial Culture Collection of Pakistan (NCCP), NARC.

ii. 155 halotolerant strains were isolated from marine and mangroves forest soil and screened for NaCl tolerance for plant growth promoting activities.

iii. 52 multi-drug resistant bacteria isolated and identified from fecal ecology of neonatal calf diarrhea (NCD) animal having potential risk for zoonotic diseases.

iv. 26 pure bacterial strains were isolated and identified from yogurt and pickle samples for Probiotics traits evaluation.

National Herbarium

i. 16 strains were distributed to Scientific Community for R&D through SMTA.

ii. More than 600 specimens of medicinal/aromatic, wild edible and wild ornamental plants were collected from different areas of Pakistan, were accessioned.

iii. About 250 native plant species are being maintained in Botanical Conservatory at NARC.

iv. Provided plant identification services to visitors, scientists, MS and PhD students.

v. 29 BS, 08 MS and 7 PhD students trained in agro-morphological characterization/evaluation of crop germplasm under field and lab conditions.

vi. 594 visitors including high-level national and international delegates/dignitaries, researchers and university students paid visit to National Genebank and allied facilities.

vii. 05 seminars/ workshops were organized for awareness about importance and utilization of plant genetic resources in crop improvement programs.

viii. 13 research articles in national and international journals were published.

NATIONAL INSTITUTE FOR GENOMICS & ADVANCED BIOTECHNOLOGY

i. 27 seed samples received from various sectors have been tested for GM testing.

ii. Genetic transformation in chickpea for herbicide resistance: Highest transformation efficiency 0.9% was observed in Noor 2013 explant cotyledon with half cut embryo, whereas no transformation was observed in Bittle 2016.

iii. Improvement of rice blast resistance through CRISPR/Cas9-targeted knockout of the ERF transcription factor gene OsERF922 in rice.

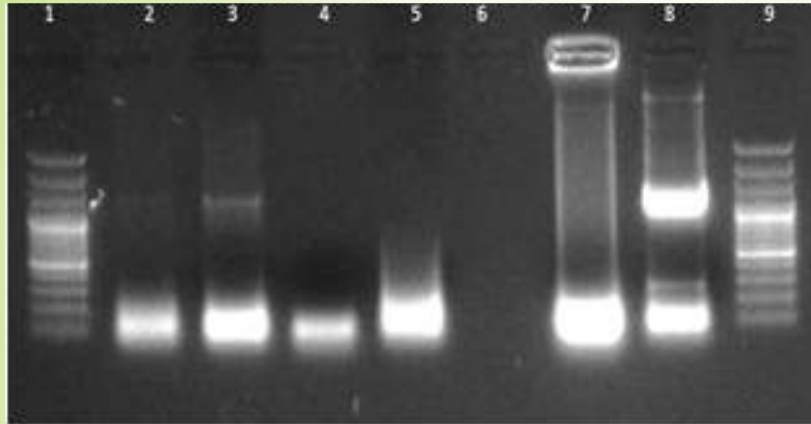
iv. EPSPS gene transformation has been carried out. PCR and ELISA has confirmed the presence of transgene in Bittle-16.

v. 13 cold tolerant tomato lines/Four transgenic events harboring DREB 1A have been advanced to T-7 generation. Field trial permission from NBC awaited.

vi. Bio-fortified tomato with precursor of Vitamin A: Development and confirmation of plant transformation construct of lycopene beta-cyclase. The construct was confirmed through PCR initially and then by Sequencing. The correct clone was transformed in *Agrobacterium tumefaciens* strain GV3101 and then confirmed through PCR.

v. Development of double haploid system in wheat: Three wheat (Borloug-16, Pakistan-13 and NARC-13) and three Maize varieties (Haq Nawaz Gold and Sargoda-2002, QPM-200) selected and study in progress.

vi. Acquired 552 Green Super Rice advance lines from CAAS China for seed multiplication,

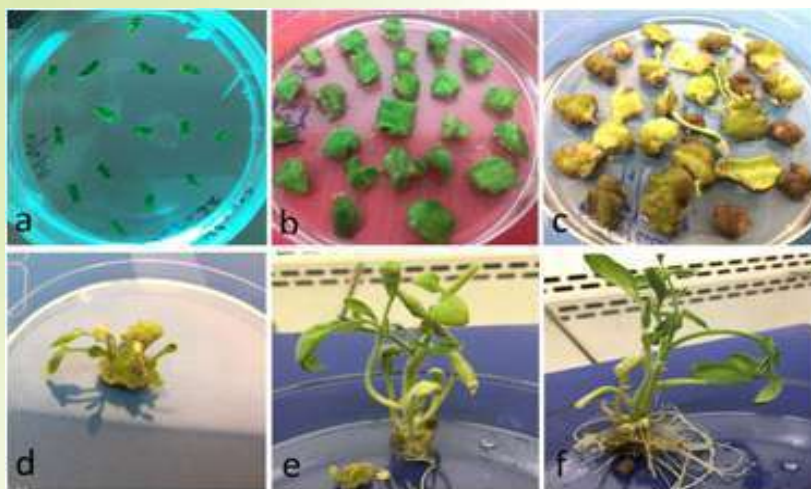


PCR Screening Results for EPSPS gene in Chickpea, Lane 1 and 9: 100bp ladder Lane, Lane 2 and 3: Positive Samples, Lane 5, 6 and 7: Negative samples, Lane 4: Negative Control, Lane 5: Positive Control

evaluation and genomic selection. DNA/RNA extraction and SNP genotyping using NGS for genome-based breeding by design strategy (GBBD). Selected 22 high yielding lines on the basis of yield parameters (> 10 tons/acre), short duration and grain length (8 to 8.6 mm).

vii. Probiotic characterization of the identified bacterial strains was done and 4 best bacterial strains ready to use for preparation of lab probiotic product preserved in glycerol and stored at -80oC.

viii. NGS-based identification of sugarcane varieties and hybrids: Collected phenotypic & genomic data, yield and sugar recovery of 28 sugarcane varieties. Extracted genomic DNA/RNA from 10



a, Cotyledonary leaves on MS media; b, Cotyledonary leaves on Shoot induction media; c,d,e, Shoot induction; f, Rooting from shoots

sugarcane cultivars. RNAs of 24 samples extracted and sent to MacroGen for RNA sequencing.

ix. State of the art bioinformatics analyses for molecular, biochemical and morphological data analyses facility established.

x. Designed, developed and maintaining NIGAB website (<http://nigab.parc.gov.pk>)

xi. Collected banana samples (14 cultivars) for diversity analysis of bananas grown in Pakistan. DNA

- vii. 100 internees received training. 20 students BS/MS/PhD completed their research and lectures were given to 280 people at API.
- viii. 10 Research Papers were published in HEC recognized Journals.

INSTITUTE OF PLANT AND ENVIRONMENTAL PROTECTION

Ecotoxicology

- i. Water samples from Rawal Dam and Chakwal pond were analyzed via scanning/screening by DRS.M method on GC-MS Analyzer to explore multi pesticide residues. Chakwal pond water samples was found contaminated with The obromine.
- ii. Sixty Citrus samples were analyzed for assessment of multi-class pesticides. The method optimized and validated on LC-MS/MS for 40 pesticides and fulfilled the EU's criteria i.e. recovery 70-120%, RSD < 20%, matrix effects $\pm 30\%$. For analyzing pesticide residue in citrus orchard soils, the QuEChERS extraction procedure was applied. The method was found fit for the purpose with recoveries ranging from 56-133%.



Steering Committee Meeting



Installation of GC-MS/MS

- iii. Six onion samples received from Quetta for analysis of Chlorpyrifos. The samples extracted and analyzed on GC-uECD and GC-MSD/ Pesticides analyzer. Traces of cyromazine pesticide found in 33% samples.
- iv. A study was designed to develop a multi pesticides residues method for rice. LC amenable pesticides were extracted and were analyzed on LC-MS/MS.
- v. Pesticide residues method was optimized and validated for black tea on LC-MS/MS.
- vi. Extraction & analytical method developed & optimized for chili on GC-uECD and LC-MS/MS.
- vii. Initial drafts of technical and quality procedures were prepared to get the ISO-17025:2017 accreditation of Pesticides Residues Testing Laboratory at NARC.
- viii. 02 research article published and 04 MPhil students completed their research.

Insect Pest Management

- i. Maize hybrids 143 entries evaluated against maize stem borer, 51 entries moderately resistant and 92 resistant according to leaf injury score. 60 wheat entries also evaluated against aphids.
- ii. Study on mass rearing technique & life table parameters of *H. dimidiata* completed.
- iii. Genetic sexing strain of Oriental fruit fly Hawaiian *Bactrocera dorsalis* was imported for evaluation and releasing their sterile males for population suppression of *B. dorsalis* and three species of fruit flies are reared on a artificial diet. *B. zonata* males were less responsive to methyl eugenol as compared to *B. dorsalis* males.
- iv. Plant based organic insecticides prepared both in EC and ULV formulation against wheat aphid. The EC formulation exhibited 100% mortality of aphids at 5%w/v under laboratory and field conditions.
- v. 4 PhD, 6 MS and 6 BS students completed their research. Also trained AOs and FAs on IPM and Biocontrol.

National Insect Museum

- i. Curation and maintenance of Historical Pusa and new insect collection is regular activity of the museum. More than 15000 specimens under order Odonata, Hymenoptera, Diptera and Coleoptera were inspected and curated.
- ii. Four insect collection surveys carried out in sugarcane and wheat fields in Punjab and Sindh, where 3970 insects collected, among them 45 were natural enemies and 15 pollinators.
- iii. 120 specimens were identified (70 as insect pests, 30 natural enemies, 05, pollinators and 15 water quality indicators).
- iv. 07 research articles published and 02 PhD, 04 MPhil and 02 BS students completed their research.



Insect collection surveys

Vertebrate Pest Management

- i. Research on new zinc phosphide paste bait for wild boar control initiated. Zinc phosphide @ 2%, 4% & 6% concentration in peanut butter/animal fat (bait base) was used and after 24 hours no phosphine gas was released in 2% & 4% concentration, hence 4% concentration in peanut butter gave significant results for controlling wild boar population.
- ii. Five successful wild boar control operations were conducted by using acute and chronic poisons.
- iii. Overall 85-90% reduction in rodent burrow activity was achieved based on pre and post-treatment number of burrows, covering a total area of 927.47 acres.
- iv. Successful rodent control operations were carried out at NAB, PTA and SUPARCO Islamabad.



Wild boar control operation

CROP DISEASES RESEARCH INSTITUTE

Wheat

583 advance lines were evaluated against leaf, stripe, stem rust, powdery mildew, spot blotch, Fusarium head blight and other seed and soil borne diseases at 15 locations of Pakistan. Only 10 lines found resistant and 19 highly resistant to all three rusts under NWDSN and 02 resistant and 03 highly resistant under NUWYT.

- i. Monitoring of wheat rust through trap nurseries planted at 23 location of Pakistan. Strip rust resistant gene Yr5, Yr10, Yr15 and YrSP were found effective. Sindh and Southern Punjab was badly effected by stripe rust due to the conducive environment and susceptible varieties i.e. TD-1, Kirin-95, TJ-83, Galaxy-13 and Faisalabad 2008. It is dire need susceptible should be replaced with disease resistant high yielding varieties.
- ii. 02 farmer field days at WRI Sakrand (28-02-2020) and QAARI Sukkur (03-03-2020) where 450 stakeholders trained in identification of wheat diseases and their management.
- iii. Mitigating the effects of stripe rust under MoU Project (ACIAR): Evaluated the mapping populations (2350) and core set lines (250) against stripe rust.
- iv. 250 yellow rust disease samples analyzed at Sub-station Murree and identified.

Rice

116 Rice fields in Punjab surveyed for Bacterial Blight (BB) and different fungal diseases. Incidence of BB was highest (50%) in Narowal and brown leaf spot varied from 15% to 50%; false smut less than 1%, sheet blight 5% to 20% and Fusarium head blight 1% to 10%.

- i. In screening of rice lines against BB, out of 24 fine rice lines 16 showed susceptible response and 8 showed resistant response. Out of 24 course lines 15 resistant. Out of 70 hybrids 52 were resistant and 18 were susceptible.
- ii. BB race identification on near isogenic lines and molecular studies are under process.

Legumes

38 Mungbean and 19 mashbean germplasm were evaluated for resistance against Cercospora leaf spot disease. 22 sorghum and 32 millet germplasm lines were evaluated for resistance against charcoal rot disease.

Biological Control

- i. Identification and exploration of bio-control potential of myco-viruses: First ever mycovirus 'Hadaka virus 1 (HadV1)' from Fusarium oxysporum characterized Pakistan.
- ii. Identification of mycoviruses from Maize and Groundnut fields: 232 fungi were isolated from Maize and groundnut field soil samples. All purified fungi identified morphologically. The samples were grown in PDB and screened for the presence of dsRNA by using small scale extraction protocol. Five dsRNA viruses were detected.
- iii. An atoxigenic strain identified already from Aspergillus flavus (Maize fields) is being tested for its potential in replacing aflatoxin. Strain multiplied and six batches of spores harvested and provided to Rafhan Maize for preparing product (AflaPak).
- iv. Established Aflatoxin Biological Control Laboratory in collaboration with collaboration.

USAID, USDA and CABI.

Sugarcane

- i. Surveyed sugarcane growing areas across 22 districts of Punjab, Sindh and KP where 1260 leaf samples were collected on symptom basis. 08 to 59 % Mosaic incidence was confirmed through DAS-ELISA.
- ii. 02 Workshops organized and trained 37 Field Staff in promotion of disease free seed-cane.

Testing Service

i. Analyzed 1637 samples of citrus for CTV and 32 for citrus greening of a progressive farmer of Punjab. Also analyzed 05 chilies, 02 cotton, 09 Maize, 01 Banana and 01 Coconut samples from Department of Plant Protection (DPP) and submitted the report. As per agreement with Pepsi cola, CDRI analyzed 6248 Potato samples for PVY, PVX, PLRV, PVA, PVM, PVS, 66 for Purple Top Roll Phytoplasma.

ii. 18 articles published and 04 BS Students completed their research.



Fig. (A) Rice field infected with bacterial blight of rice in Punjab. (B) Rice leaves infected with bacterial blight. (C) *Xanthomonas oryzae* pv. *oryzae* on Wakimoto agar medium. (D) Symptoms of brown leaf of rice in field. (E) False smut of rice. (F) Conidia of *Bipolaris* sp. (Brown leaf spot) (G) *Cochliobolus lunatus* (Brown leaf spot) (H) *Fusarium* sp. (Fusarium head blight) (I) *Rhizoctonia solani* (Sheath blight).



CDRI team demonstrating ongoing scientific work

HORTICULTURE RESEARCH INSTITUTE

Fruits

i. Fruit load optimization in early maturing peach cultivars: Four varieties tested i.e. Early Grand, Florida King, Spring Crest and Flame Crest. First two are early maturing, bear in 3rd year and also escape fruit fly attack while later two bear in 4th year, so Early Grand & Florida King are suitable for

Potohar.

ii. Evaluated exotic grape germplasm under Potohar Region. Superior seedless and Razaki identified as early maturing and seedless. Large sized berries, heavy bunch weight noted for Superior Seedless. NARC Black along with Early Round was identified high yielder and disease tolerant but seeded in nature.



High Density Pear



Grapes germplasm

iii. High Density Plantation of Pear: Data revealed that planting density at 10 feet is better than 3 feet planting density in all attributes, it gave maximum plant height plant spread, stem grith and yield.

iv. Nursery plants production through sexual means (2000 Peach Rootstock, 10000 Guava, 6000 Citrus Rootstock, 250 Loquat, 1250 Avocado and 400 Jaman and through asexual means (500 Fig, 5000 Grapes, 10000 Peach, 9000 Mexican Lime, 3000 Sweet Lime, 2500 Avocado, 1200 Citrus, 1000 Apricot and 2200 Pear).

285 stakeholders trained in orchard management and nursery production. 07 BS students completed their internship. 02 Radio Talks, 07 Seminar/Workshop and 03 research Papers and 04 abstracts published.

Vegetables

i. Effect of different weedicides on yield of garlic variety 'NARC-G1': The weedicide "Oxyfine" gave 100 % survival, maximum bulb size (231.7g), minimum numbers of weeds & maximum fresh bulb yield (23.5 t/ha) followed by "Dual gold".

ii. 02 onion strains (NARC Onion-1 and NARC Onion-2) along with cv. 'Phulkara' as check planted during October, 2019 for seed yield. Seed yield per plant (14.4 g) was highest in NARC Onion-1 among two new strain tested.

iii. Development of source population and pure lines in indeterminate tomatoes using double hybrids: 21 single plant selections and 22 bulk population selections were done. Seed was harvested manually,



Source population Tomato plant



Beef tomatoes

dried and packed with its label. Selections were done on the basis of fruit shape, plant stature, leaf shape and yield per plant.

iv. Harvested Seed of Garlic, Peas, Radish, Turnip, Spinach, Fenugreek & Coriander. 3000 Seed kits & 1 million Seedlings of summer and winter vegetables were provided to Kitchen Gardeners.

v. 15 BS students completed their research 07 research papers published.

Potato

i. 34 disease resistant potato clones received from CIP Lima, Peru multiplied through tissue culture for micro tuber production. 27 clones were selected and 800 kg basic seed produced.

ii. 1200 kg mini tubers of 51 local crosses produced for further multiplication. NARC Potato-I, NARC Potato-II and NARC Potato III have been multiplied in ample quantity which will be sent for DUS and NUYT trial in Autumn 2019 and spring 2020.

iii. 17 varieties tested for adaptability trial and maximum yield 33.8 t/ha observed in Effera followed by Donastar (29.9 t/ha).

iv. 27 clones were evaluated for dry matter among them 6 clones having high dry matter traits selected for Crisp and 11 clone having dry matter from 18.2 – 20.2 selected for French Fries.

v. Seed multiplication of four clones i.e. NARC Potato II (2000 kg), NARC Potato III (1220 kg), NARC Potato I (100 kg) and 2005-1 (240 kg) seed produced.

vi. 08 BS students completed their internship.



Evaluation of potato clones in field and tunnel.

Floriculture

i. Different species of exotic flower and ornamental plants established. More Mother blocks of amaryllis, chrysanthemum and Dutch Iris also established. About 20,000 plant species are available for R&D activities.

ii. Influence of Boric acid and Iron Sulphate on Vegetative, Floral and Bulbous Growth of White Dutch Iris: The study revealed maximum plant height ($75.11a \pm 0.19\text{cm}$) and rachis length ($40.66a \pm 0.67\text{cm}$) was observed.



Blooming stage of White Dutch



Gladiolus flower spikes



Flowers on Vermicompost

- iii. Gladiolus crop can be planted throughout the year except the harsh months of June-July and Dec.-January. This offseason planted crop gives a bit low yield but proved more profitable as compare to traditional planting time.
- iv. Growth responses of different potting media on annual flowers: It was concluded from the data analyzed that any type of media plays an important role in growth (vegetative and reproductive). Vermi compost and its combination with silt or both silt and compost have very good effect on the plant vegetative and reproductive growth and quality of flowers. Best treatments recorded were Silt + Compost + Vermicompost which gave maximum number of flowers, plant height, root length and other parameters as well.
- v. 04 research papers and two abstracts published in reputed journals.

PARC-SOUTHERN-ZONE AGRICULTURAL RESEARCH CENTER (P-SARC) KARACHI

CROP DISEASES RESEARCH INSTITUTE (CDRI)

- i. Screened wheat germplasm against Stem, Leaf and Yellow rust.
- ii. Management of Panama Wilt in Banana: NPK 15-15-30-TE an interval of 15 days and drenching with 10% Neem cake extracts an interval of 30 days reduce wilt severity and increased all growth parameters and yield in G9, W11 and B10 banana plants.
- iii. Management of Leaf spot and Blight in Bitter gourd: Quality fruit with 40% more yield received from bitter gourds treated with 10% Neem extracts as soil drenching and spray with low dose of NPK 15-15-30-TE.

Germplasm Resistance Against	NWDSN (583 lines/entries)	NUWYT (66 lines/entries)
Stem Rust	R=9; S=52; MR=94; RMS=184; MS=15; MSS=205	R=1; S=2; MR=4; RMS=16; MSS=32
Leaf Rust	R=240; S=80; MS=1; MSS=254	R=18; S=4; MSS=38
Yellow Rust	R=166; S=62; MR=80; MRMS=118; MS=12; MSS=93	R=20; S=2; MR=12; MRMS=11; MS=2; MSS=9
NWDSN=National Wheat Diseases Screening Nursery; NUWYT=National Uniform Wheat Yield Trial R=Resistant; S=Susceptible; MR=Moderately Resistant; MRMS= Moderately Resistant to Moderately Susceptible; MS=Moderately Susceptible; MSS=Moderately Susceptible to Susceptible.		

FOOD QUALITY & SAFETY RESEARCH INSTITUTE (FQSRI)

- i. Molecular characterization of chilli leaf curl virus and BBTV by PCR analysis, for quality control of chillies and banana tissue culture was carried out.
- ii. An eco-friendly method developed and optimized for the synthesis of silver nano-particles using Saraca asoca plant leaves. Characterization using FT-IR, SEM, EDX and XRD confirm the formation of spherical nanoparticle with an average particle size of 45 ± 08 nm. As prepared nanoparticle were checked against some common food borne pathogens i.e. E. coli, Bacillus and S. aureus.
- iii. Laboratories Quality management system updated to the latest version of ISO 17025.
- iv. 10 Research publications in Reputable journals.

INSTITUTE OF PLANT INTRODUCTION (IPI)

- I. Coconut Clonal Repository with 110 Srilankan and Malaysian varieties on 1.5 acre has been developed under AIP funded project.
- ii. 50 seedling of coconut (Cocos nucifera), 100 plants of dragon fruit (Hylocereus undatus), 50 plants of Karonda, 50 plants of Jungle Jalebi (Pithecello biumdulce), 16 plants of Sisal (Agave sisalana), 100 Tamarind (Tamarindus indica) of sweet brown 100 and 50 red, 100 neem plant (Azadirachta indica), 80 kherol, 15 Chiku (Manikara zapota), 40 Mulberry and 200 of Ixora coccinea cuttings

planted at IPI, Karachi.

iii. 54 Tamarind trees (sweet, sour and red varieties) have been maintained. The third variety of Tamarind red has also been introduced at Institute. The tamarind plants have also been provided to AZRI Umerkot and NSTHRI, Thatta.

iv. 188 Ber trees (gola and sufi varieties) have been maintained. Beside this one-acre Ber were also planted under drip irrigation on gravity flow.

v. 02 research papers published and 7 accepted in reputed journals.

VERTEBRATE PEST CONTROL INSTITUTE (VPCI)

i. A total of 244 rats & shrews (pests) as well as probable hosts of zoonotically important parasites were trapped from different areas and 44.67% rats found infected with Helminth parasites.

ii. A new species of trematode parasite *Brachylecithum heckmanni* sp.n. recovered from Cattle egret.

iii. Out of 153 fishes belonging to 13 different species were examined for helminth parasites. The percentage of infected fishes was 14.37%.

iv. A total of 63 birds, from Agricultural Farms, District Matiari, Sindh were autopsied, viscera were examined.

v. Two research papers are published and 7 accepted for publication.

PEST MANAGEMENT RESEARCH INSTITUTE (PMRI)

Monitoring of fruit fly on Ber: Methyl Eugenol in 06 traps per acre hanged at the height of about six feet and 50 meter away from each other Highest number of fruit flies 1870 per trap were recorded during the month of September 2019 while lowest numbers of fruit flies 122 per trap during the month of December 2019.

ii. Tested *Acacia nilotica* leaf extract in ethanol and leaf powder against store grain pest Khapra Beetle (*Trogoderma granarium*) as biopesticide. Preliminary findings indicates that 30 to 40% mortality was recorded at 5% concentration of leaf extract of *Acacia nilotica* in ethanol and leaf powder.

iii. One research papers are published and 7 accepted for publication.

PARC-NATIONAL SUGAR & TROPICAL HORTICULTURE RESEARCH INSTITUTE (P-NSTHRI), THATTA

i. A new sugarcane variety 'YT-55-Thatta' with high cane and sugar yield was approved by Sindh Seed Council for commercial cultivation.

ii. The promising genotype 'YTTh-1705' on account of its better performance in terms of cane yield and sugar recovery was selected for further study in NUVYT.

iii. 189 local and exotic sugarcane varieties/genotypes were maintained in germplasm for flowering study and only 32 sugarcane genotypes flowered up to end of December 2019.

iv. 700 poly cross fuzzi of different sugarcane varieties/genotypes were collected from coastal areas of Sindh. The collected fuzzi was dried, kept in plastic bags and stored in deep freezer.

iv. 4774 sugarcane seedlings were developed from local collected poly cross and bi-parental cross fuzzi.

v. In different variety evaluation trials, a total of 1330, 522, 204, 92, 14, 5, 3, 8 and 15 sugarcane clones/genotypes were maintained in single plant trial, 1st cycle, 2nd cycle, 3rd cycle, 4th cycle, preliminary yield trial, advanced varietal trial, NUVYT first and second plant crop, respectively. In each variety evaluation trial, selection and rejection of clones/genotypes was made on the basis of certain desirable characters.

vi. 17 sugarcane genotypes/varieties were planted for seed increase purpose.

vii. 12 promising sugarcane cultivars screened against whip smut, 02 genotypes i.e. YTTh-1707 and Th-1631 found very highly resistant (VHR) and 05 genotypes showed immunity.

Banana tissue culture activities: in vitro propagation of four banana varieties i.e. NIGAB-1 (W- 11),

NIGAB-2 (B-10), NIGAB-3 (Pisang) and G-9 was done. 538 healthy ex-plants were initiated to develop banana shoots. A total of 55736 banana shoots were developed/maintained in 6967 glass jars. 6402 rooted plants were developed and 3000 rooted plants were got hardened in net-house.

Sugarcane tissue culture activities: 20 ex-plants from 06 sugarcane varieties i.e. Thatta-10, Thatta-2109, Thatta-326, Thatta-300, Thatta-910 and YT-55 were cultured for callus formation. A total 83 cultures were successfully developed in calli. The calli were transferred for regeneration. 124 somaclones were tested in field under 1st cycle and 20 promoted to 2nd cycle on the basis of better crop stand.



Banana Tissue culture activities at NSTHRI-PARC, Thatta

PARC-NATIONAL TEA AND HIGH VALUE CROPS RESEARCH INSTITUTE (P-NTHRI) SHINKIARI

- i. Managed 30 acres tea garden regarding their plucking, pruning, soil nutrients management, irrigation, weeding etc.
- ii. Processed 1200 kg black tea and 5000 kg green tea from fresh tea leaves.
- iii. Raised 12000 tea cuttings nursery plants of different tea clones.
- iv. Established fruit nurseries and provided/sold 4000 true-to-type fruit plants i.e. Apricot, Peach, Plum, Almond, Cherry, Walnut, Fig, Persimmon and Pomegranate to growers.



Mother Fruits Orchard at NTHRI



Training of the growers in kiwi plantation



Training of the growers in olive plantation

- v. Budded 5300 peach rootstock plants with promising cultivars of peach, plum and apricot.
- vi. Grafted 600 cherry cultivars on rootstock Hanang.
- vii. Sown 5 kg of wild persimmon (*Diospyros lotus*) seeds for the propagation of persimmon (*Diospyros kaki*) cultivars.
- viii. Managed the Mother Fruit Orchard (comprising of 15 fruit species of promising cultivars) at NTHRI, Shinkhari regarding its nutritional requirements, weeding, irrigation and protection against insect, pests and diseases for proper plants growth and productivity and obtaining bud wood/graft wood of selected fruits cultivars for their propagation.

- ix. Produced 2500 kiwi seedling root stock from kiwi seeds.
- x. Grafted 1500 seedling rootstocks with different kiwifruit cultivars.
- xi. Produced 600 kiwi plants of 7 different kiwifruit genotypes by grafting method for plantation in kiwifruit testing plots in different districts of Hazara Division.
- xii. Produced 800 true-to-type kiwi seedlings of Hayward variety by kiwi shoot cuttings.
- xiii. About 1 kg kiwi seed was sown in PARC-NTHRI nursery during March 2020.
- xiv. Produced 1200 kg seeds of various economically important vegetables.
- xv. Collected 44000 olive cuttings of different varieties from farmers' orchards located at Ghazi and Hassan Abdal and planted in olive nursery at NTHRI.
- xvi. Planted tea on 2.5 acres area on the farmers' field in Baffa, Mansehra.
- xvii. Planted Olive on 77 acres on farmers' fields in different locations of Hazara Division.
- xviii. Provided 5000 olive plants to Forest Department for plantation on CPEC route.
- xix. 15 BS and MS students completed their research studies on tea and high value crops.
- xx. 15 research articles published in reputable journals.



Grafted kiwi plants produced at PARC-NTHRI Kiwi plant bearing fruit at PARC-NHRI

PARC-RESEARCH & TRAINING STATION (PRTS) MULTAN

- i. Trichogramma eggs cards (12995 in number) were prepared and 9573 cards were distributed to the farmers of local area and the students of BZU Multan. 4915 number of Chrysoperla carnea egg sheet cards were produced and 3520 number of eggs sheet cards was given to farmers of local area and students BZU Multan.
- ii. Maize (25), Millet and Cotton germplasm (10) were tested for yield, insect pest and diseases.
- iii. The fruit fly traps were installed at 9 acres for fruit fly management.
- iv. 91 farmers trained, 09 students got internship and 312 students were given lectures.
- v. 07 research articles published in PJAR.



Rearing of Sitotroga cerealella moths in glass jars



Rearing of Chrysoperla carnea on artificial diet

NATURAL RESOURCES DIVISION

Management of Natural Resources is vital for food security and ecosystem. The major challenge in terms of resources degradation is poor soil health, land degradation, desertification, climate change, ground water depletion and rapid withdrawal of water resources. The major thrust of NRD research and development agenda is focused on proper utilization and management of land, water, rangeland, agroforestry and honeybee in the country. During 2019-20 major emphasis was given to enhance the resilience of vulnerable farming communities through climate smart natural resource management practices, land and water resources management, arid horticulture, range management and mountainous agriculture.

CLIMATE CHANGE, ALTERNATE ENERGY AND WATER RESOURCES RESEARCH INSTITUTE

Portable Solar Pumping System (PSPS) - Climate Smart Solution for Supplementary Irrigation

PARC has developed and demonstrated a Portable Solar Pumping System (PSPS) - an economically feasible and socially acceptable innovative intervention to enhance per-acre crop output for farmers of large but scatter land holdings with multiple water resources especially in Pothowar and Thal regions. PSPS is a tractor mounted mobile pumping unit fixed with solar panels, which can operate in diverse terrains for multiple water sources (surface and groundwater etc.) Aside from providing



PSPS in operation

irrigation water, it can be used as an on-farm solar electrification unit that can support domestic energy requirements for farming communities, fodder chopping, grain milling, crops threshing, refrigeration and other household purposes etc. After this successful fabrication and customization of PSPS technology, PARC trained local manufacturers and service providers. Now local manufacturers especially in Thal area have started developing these systems and provision to farmers and service providers.

Dug-well Solar Pumping System for Small Farmers

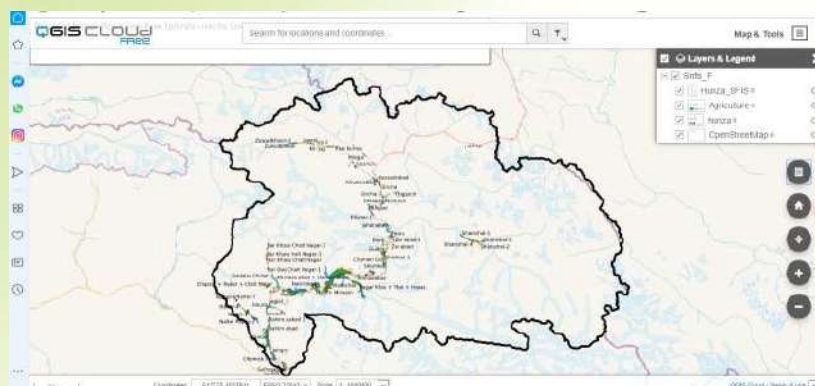
Dug wells have been the only source of water and livelihood for many farming communities in the Pothowar region for ages. Though still operational at a few places, mostly these systems are abandoned being old-fashioned, outdated options and uneconomical. The irrigation through dug wells is labor-intensive, animal-driven, and time-consuming. PARC developed and tested a cost-effective and climate smart solution - Solar Powered Pump Integrated with an efficient irrigation system to grow off-season crops (greenhouse tunnels). This is an economical solution for small and vulnerable farmers to efficiently utilize scarce water resources for high value crops with solar pump and HEIS. Results showed 3-4 times increases in cultivated area and production with total investment 0.20-0.30 million rupees. This intervention will boost livelihood of thousands of farmers especially in Pothowar and Hazara regions.



Dugwell solar pumping integration model with HEIS

Inventory of Snow and Glacier-fed Irrigation Systems in Upper Indus Basin Irrigation

Glacier and snow melt-water are the primary water sources for irrigation and agricultural production in Upper Indus Basin. Small-scale irrigated agriculture remains the main component of livelihood and food security for mountain dwellers despite an increase in the diversity of household strategies. These systems provide the lifeline to the local communities; however, their database does not exist. PARC has developed an inventory and database of snow fed irrigation channels, which provide complete database with original lay out, its length, irrigated area, valley etc. A web-based interface embedded with satellite imagery is developed to provide quick and accurate view the database for planning and maintenance purposes. Link is provided https://qgiscloud.com/bilal_iqbal86/Snfis_F/ for online visualization as well.

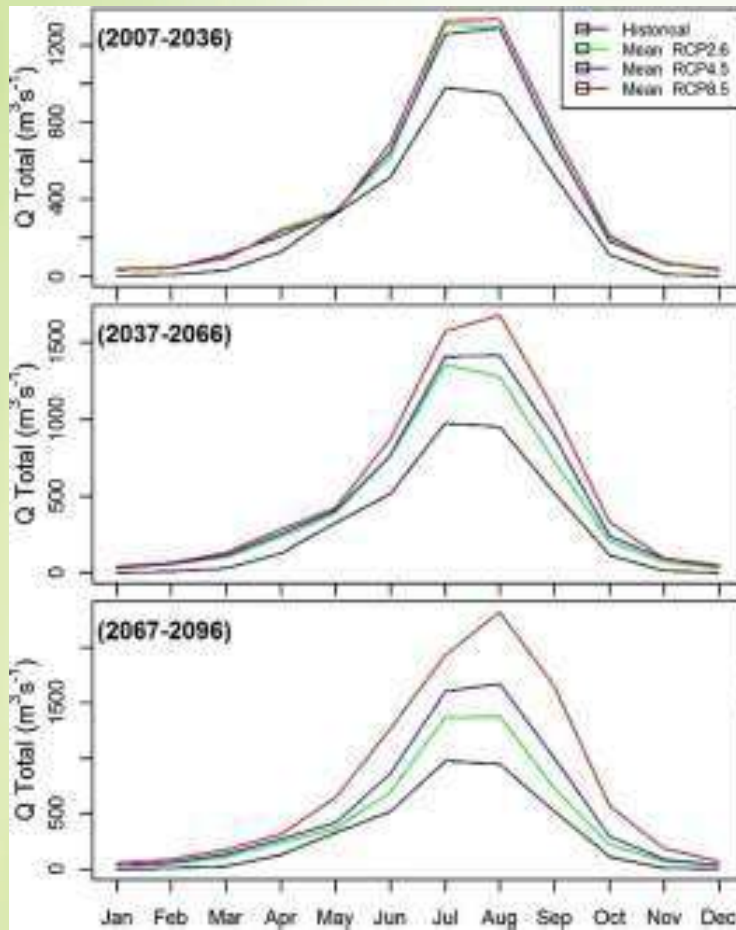


Glacial irrigation system inventory of Hunza Basin

Future Water Availability from the Western Karakoram under Representative Concentration Pathways as simulated by CORDEX South Asia

Future water availability of a glacierized Hunza basin has been assessed under plausible scenarios of climate change characterized by three representative concentration pathways (RCPs). A fully distributed hydrological model of (SPHY: Spatial Processes in Hydrology). The SPHY model projects a substantial increase in the ensemble mean discharges throughout the 21st century under all RCP scenarios. Such an increase is dominated by the enhanced glacier melt contribution under the high warming scenario of RCP8.5. Besides featuring a declining trend, snowmelt contribution will also remain higher than that of the historical period throughout the 21st century and under all RCPs. The analysis of flow duration curves suggests that high and median flows are projected to increase

while low flows are projected to decrease in the future. Hence, hydrological extremes of floods and droughts are anticipated to intensify.



Inter-model ensemble means of the discharge annual cycles

Solar Water Pumping System from Hunza River in Sust

Farmers along rivers in Upper Indus Basin cannot utilize the river flows for their orchards due to significantly lower levels of river water surface than the land surface and non-availability of viable pumping systems. PARC customized, tested and demonstrated solar operated system to pump water



Solar water pumping from Hunza river

from Hunza River near Sust, Khujerab. The system irrigates 03 acres of orchard on drip irrigation system and 15 acres of field crops. Infiltration galley was trenched to filter silt for clean water. To protect from corrosion and damage, an irrigation pump was installed in the gallery to pump clean water. This intervention showed huge potential for high value agriculture along riversides in Upper Indus Basin, Hazara, AJK, Kohistan etc.

Cropping Pattern Zonation of Pakistan

PARC-CEWRI in collaboration with CIMMYT-Pakistan prepared cropping pattern of Pakistan showing 25 major and minor crops grown during 2014-2018, as an invaluable tool to address opportunities, challenges, and risks for farm productivity and profitability in the country. Cotton- Wheat was identified as a major sequence in the southern districts of Punjab and Khyber Pakhtunkhwa, central districts of Sindh, and western districts of Balochistan province. The Rice-Wheat sequence was found prevailing in the northeastern districts of Punjab, northwestern and southern districts of Sindh.



Cropping pattern of Pakistan (2014-2018)

Rooftop Rainwater Harvesting for Kitchen Gardening

PARC successfully tested kitchen gardening through rooftop rainwater harvesting at NARC. Water was channelized and collected into tank and supplied through drip irrigation for vegetables production. Rooftop rainwater harvesting has shown significant potential to improve water availability for drinking and kitchen gardening at average household level in a study using 30 years weather data of Rawal watershed. Temporal rainwater harvesting potential has been linked with the optimum size of storage tank and crop water requirement of different vegetables (garlic, cucumber, tomato, onion), which may be instrumental in improving house hold food security.



Rooftop water harvesting for kitchen gardening piloted at NARC

Agriculture Info Dashboard-A Decision Support Application

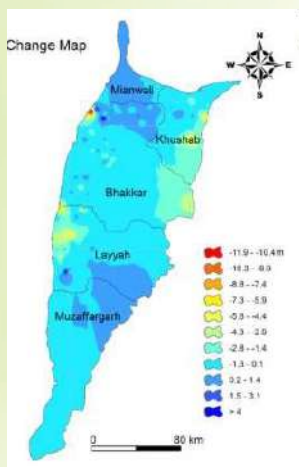
Pakistan's economy heavily depends on agriculture and natural resource base, which require reliable information for assessment of resources availability. To make quick access, effective display, easy visualization, and precise decision-making, PARC has developed an Android Application- Agriculture Info Dashboard that provides temporal and spatial crops information at single click on mobile phones anytime and anywhere. This tool can be used for resource planning and decision making to address opportunities, challenges, and risks for farm productivity and profitability in the country.



Web outlook of Agri Info dashboard

Groundwater Response to Climate Change in Thal Doab

Spatio-temporal (2005-2010 & 2011-2015) analysis of water table depth (WTD) was performed to study groundwater response to outside factors in the Thal doab area, Indus plan. The positive change in WTD was pronounced in parts of Thal area along the Indus and Jhelum Rivers. The groundwater levels indicated gradual rise in most of the upper Thal districts, i.e., Bhakkar, Layyah and Khushab, which can be effectively used for crop production. The increase in monsoon rainfall and river water is the main contributing factor to this groundwater recharge.

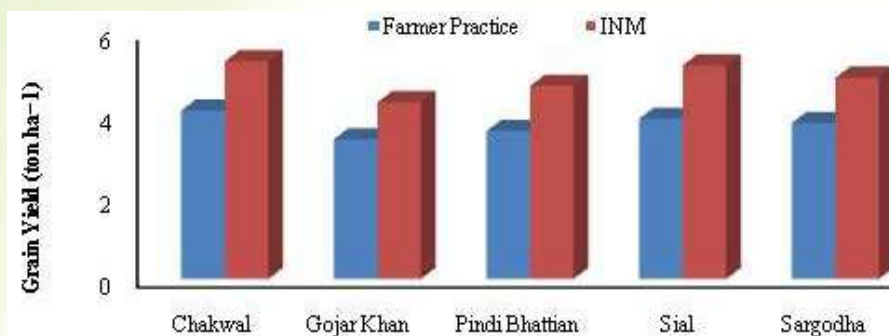


Variations in water table depth in Thal doab during 2005-2015.

LAND RESOURCES RESEARCH INSTITUTE

Productivity Enhancement of Wheat by Integrated Nutrient Management

Field experiments/ demonstrations were conducted to evaluate the productivity enhancement of wheat by Integrated Nutrient Management (INM) on yield and ionic concentrations of wheat varieties (Chakwal 50, Barani 17, Faisalabad 2008 and Borlaug 2016) directly sown in rainfed, salt affected and irrigated areas of Chakwal, Gujjar Khan, Pindi Bhattian, Sial and Sargodha during winter 2019.

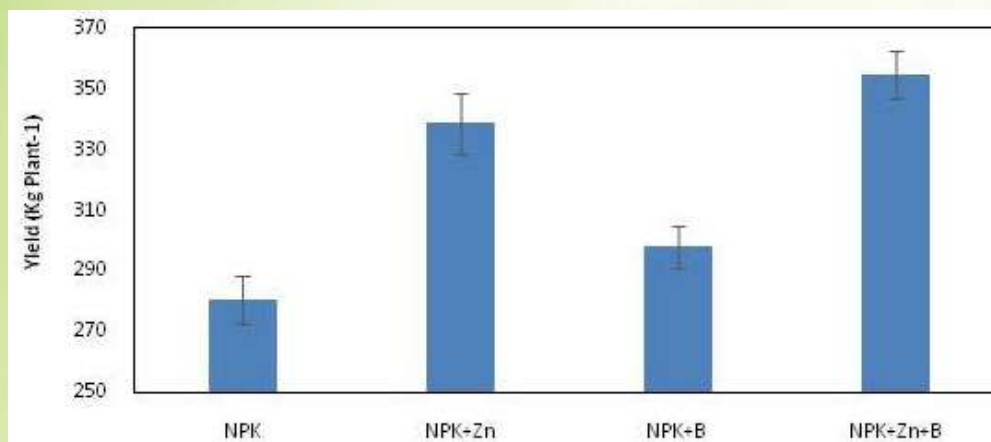


Productivity enhancement of wheat by INM in different ecologies

Wheat grain yield was 25-30% higher (5.3, 4.3, 4.7, 5.2 and 4.9 ton ha⁻¹, respectively) at Chakwal, Gujar Khan, Pindi Bhattian, Sial and Sargodha, with INM (120, 90, 60, 5, 1, and 2 kg ha⁻¹ of N, P, K, Zn, B, and Biofertilizer) as compared to farmers' practice (one bag of urea and half bag of DAP).

Mineral Nutrient Status and its Management for Enhancing Citrus Productivity and Fruit Quality

A field survey was carried out for indexing nutrients (N, P, K, Ca, Mg, S, Zn, Cu, Fe and Mn), using GIS and Geo-statistics as diagnostic norms, in soils of the citrus producing region of Sargodha, Pakistan. Digital maps indicated that 100, 78 and 76 percent of the surveyed orchards were deficient in plant available NO₃-N, P and Zn contents, respectively. Afterwards, a field trial was conducted in



Impact of Micronutrient Management on Citrus Yield

six citrus orchards to observe the effect of Zn @ 20g plant⁻¹ and B @ 5g plant⁻¹ (alone and in combination) in addition to farmers' practice of N, P and K application on citrus yield. Although B application resulted in significantly higher citrus yield as compared to NPK only, but Zn application had a greater effect while combined application of Zn and B in addition to NPK resulted in the highest citrus yield. Citrus fruit quality in terms of total sugar content, pH, peel thickness also improved significantly.

Influence of Siderophore Producing Rhizobacteria from Groundnut (*Arachis hypogaea* L.) on Iron Release in Soil

Iron is indispensable for growth and metabolism of all living organisms but its availability in soil is limited due to very low solubility of dominant ferric iron (Fe₃₊). Many PGPRs have the ability to synthesize low molecular weight siderophores having a high affinity for iron. Out of 120 isolates of groundnut, twenty bacterial isolates produced siderophore in the range of 11-73%, three siderophore producing bacterial isolates (MGS-11, MGS-14 & MGS-91) which produced maximum siderophore units (>60%) and quantitatively showed an increase in iron release of 82, 71 and 69% over control. These efficient bacterial isolates were identified as *Bacillus subtilis*, *Bacillus halotolerans*, and *Bacillus*.

Potential Rhizobacteria for Biofertilizer Production of Chilli and Okra

Chilli and okra rhizosphere soil and root sample were collected from Khanewal, Shorkot and Islamabad area and rhizobacteria were isolated from three regions, i.e. rhizosphere, rhizoplane, endosphere. Eighty-one potential rhizobacteria (Chilli: 22, Okra: 59) were added in the gene bank from 92 isolated bacterial strains of chilli and 104 of okra on the basis of best morphological and biochemical attributes. Nine potential bacterial isolates (3 Phosphate Solubilizing Bacteria (PSB), 3 Indole Acetic Acid (IAA) producer, 3 PGPR) of okra were tested in greenhouse to screen the promising strains. PSB strain ORSS1e followed by PGPR strain ORPS1c showed better results related to different growth parameters, chemical analysis and nutrient uptake. For chilli consortia of PSB and Extracellular Polymeric Substance (EPS) shown better response on growth.

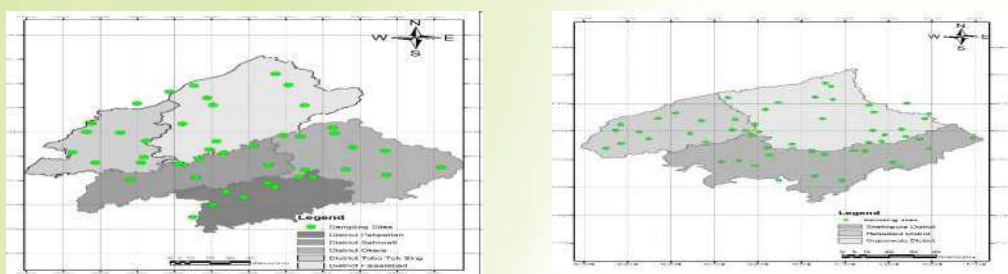
Efficacy of PGPR Isolates for Drought Tolerance in Mung Bean (*Vigna radiata* L.) under variable Moisture Regimes

Rhizosphere samples were collected from different areas of district Layyah and Bhakkar of the Punjab Province. Bacterial strains were isolated and characterized for Rhizobium, IAAproducer and PSB. Five bacterial isolates were inoculated. Two isolates belonged to PSB, two IAAproducers and one Rhizobium. Potential bacterial strains were tested for drought stress tolerance in mung bean at three different moisture levels, i.e. 80 %, 60 % and 40 % of field capacity. Inoculation significantly increased root length, shoot length, number of pods per plant, no of flowers per plant, dry and fresh weights of plants, total biomass, 1000 grain weight, N- and P-uptake as compared to control (without PGPR inoculation). Consortia of Rhizobium + Phosphate-1 + IAA-1 produced the highest 1000 grain weight (57.7 g) followed by Rhizobium + Phosphate-1 + IAA-2 (56.4 g) at 80% field capacity.

Assessment of Organic Carbon Status of Benchmark Soils under Different Cropping Systems

Rice-Wheat cropping System: The soil series of Rice-Wheat cropping system (Sheikhupura, Hafizabad, and Gujranwala districts) are non-saline and alkaline and coarse to fine in texture. Highest soil bulk density at 15-30 cm depth indicates the formation of plough-pan, prominent in light to medium textured soils. The mean Total Organic Carbon (TOC) in surface (0-15 cm) soil of all the series ranged from 0.37 to 0.55 %. In the lower depths, the TOC contents decreased substantially, i.e. 75 % and 80 % were less in 30-60 cm and 60-100 cm, respectively.

Mix Cropping System: Eight Benchmark soils from mix cropping systems (Faisalabad, Toba Tek Singh, Sahiwal, Pakpattan, and Okara districts) were non-saline (0.84 to 0.90 dS m^{-1}) and alkaline (7.8 and 8.5 pH). The texture of all the soils was loam to silty clay. Maximum bulk density (1.49 to 1.68 Mg m^{-3}) between 15-30 cm depth indicating the presence of plough-pan but the intensity and frequency



Geo positioning of sampling location in mix cropping system

was less than that of Rice-Wheat cropping system. The mean TOC in surface (0-15 cm) soil of all the series ranged from 0.51 to 0.81 % with mean value of 0.71 % and was higher than that of Rice-Wheat cropping system. As expected, TOC decreased substantially in the lower depth, i.e. 36 % (15-30 cm) 80 % (30-60 cm) and 85 % (60-100 cm) less than surface soil.

Quantification of Organic Carbon Pools in the Benchmark Soils of Pakistan

Different forms of carbon, i.e. very labile, labile, less labile and non-labile, representing different carbon pools, Pool-1, Pool-2, Pool-3 and Pool-4, respectively, were measured from 13 benchmark soil series (Shahdara, Miranpur, Pacca, Gajiana, Satghara, Bhalwal, Pindorian, Gujranwala, Kotli, Eminabad, Wazirabad, Hafizabad and Rasulpur) collected from Sheikhupura, Hafizabad and Gujranwala districts under Rice-Wheat cropping system. Pool-1 was found relatively larger fraction of the TOC contents followed by Pool-4, Pool-2 and Pool-3. Similarly, the carbon pools were also measured from 8 benchmark soil series (Bagh, Hafizabad, Lyallpur, Pacca, Satghara, Shahdara, Shahpur and Sultanpur) collected from Faisalabad, Toba Tek Singh, Sahiwal, Pakpattan and Okara districts under mix cropping system. Contrary to Rice-Wheat cropping system, Pool-4 relatively represented the larger portion (39 %) of the TOC contents of surface soil, followed by Pool-1 (28 %), Pool-2 (19 %) and Pool-3 (14 %). Actual carbon-pool of benchmark series of soils of Pakistan was determined. All the soil series falling in the cropping system of rice-wheat, rice cropping and rainfed are found different in TOC content then the standard TOC content of 75%. Very liable (easily decomposable carbon), liable and less liable (associated with the minimum composition of the soil),

non-labile (resistant to decomposition). Pool 4 found minimum in the soil series of mix-cropping system, while the pool-1 was found in rice-wheat cropping system.

Irrigation Water Quality of Peri-Urban Areas of Gujranwala

The industrial effluent used for irrigation is highly contaminated with chromium (Cr), lead (Pb), cadmium (Cd) and nickel (Ni) in peri-urban area of Gujranwala. Almost 73 % of the wastewater samples showed Cr content above the permissible limit of irrigation. 55 % of the samples collected had higher Pb content than permissible limits. However, tube well (250 ft depth) water results showed that all the heavy metals remained below permissible limits. Almost similar results were recorded for canal water, but heavy metal contents were more than that of tube well waters.

Performance Evaluation of Fixed Dome Biogas Plant Installed at NARC

The fixed dome biodigester with loading rate of slurry at 80 kg per day with 1:1 ratio of water to livestock dung showed gradual decrease in volume and pressure of biogas produced from July to November. Average temperature for the month of July was 35 °C and for November 22 °C. The maximum volume of biogas production (2.2 m³) was in the month of July 2019 whereas minimum volume of biogas production (0.75 m³) was in the month of November 2019. Similarly, the maximum pressure of produced biogas (120 mbar) was in the month of July 2019 whereas minimum pressure of produced biogas (50 mbar) was in the month of November 2019. Biogas production in fix dome showed temperature dependence. More biogas was produced in summer months than in winter months.

Biogas Production Enhancement from Cattle Dung/Slurry Through Inoculation of Bacterial Strains

A lab scale study was carried out to examine the performance of pre-isolated and tested cellulose degrading bacteria for biogas production. A consortium of pre-isolated bacterial strains (AH8, AH10, AS1 and ABI) labeled as NARC inoculum (N-inoculum) was tested in comparison with Chinese inoculum (Ch-inoculum) and digested inoculum (D-inoculum) taken from already installed biodigesters at LRS, NARC. Bioreactors (19 L) were kept at 30 °C in the incubator for 40 days using cow dung as substrate. Methane collected in storage bags was measured by syringe method and analyzed on gas analyzer. The results of cumulative biogas production for 40 days revealed that N-inoculum treatment produced maximum biogas (35.35 L), followed by Ch-inoculum (32.55 L) and D-inoculum (24.85 L). Biogas production by control was only 2.7 L in 40 days. Results regarding methane percentage in biogas revealed that in 40 days, maximum rise in methane percentage (65 %) was observed by Ch-inoculum and N-inoculum than in control (45 %). Result of the study revealed that quantity and quality of biogas production can be enhanced by using microbial inoculum.

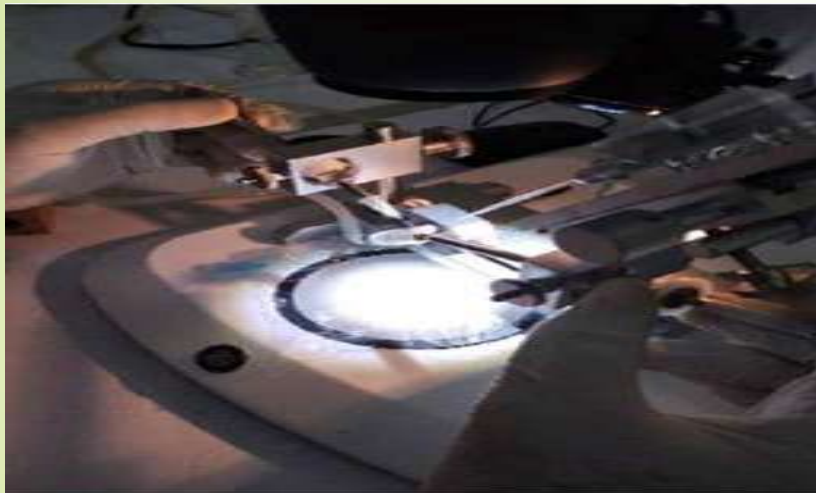


Methane production by N-inoculum vs control

HONEYBEE RESEARCH INSTITUTE

Superior Quality Honeybee Queens production through Non-Traditional Techniques

In order to produce the prolific quality queens HBRI developed the first quality queens production Laboratory well equipped with modern gadgets like Artificial Insemination Apparatus, Nicot kits produced 220 Superior quality queens from the selected breeder colonies with High colony performance indicator (CPI). The colonies headed by queens produced through artificial queen insemination technique, and selective cup grafting technique showed good results of honey production in current Margalla honey season enhancing honey production up to 3 kg to 4.5 kg compared to the colonies having queens produced from swarming cells or supercedure cells. Quality queens were also provided to Beekeepers from different ecologies of country like, Kashmir, Faisalabad, Karachi and Chitral and promising results obtained according to the feedback received from beekeepers. The technology was also disseminated to provincial beekeeping units and beekeepers in order to enhance their capacity for stock improvement in their apiaries by using this technique.



Artificial queen insemination

Introduction of Automatic Honey Flow Hive

Chairman PARC Inaugurated the PARC Honey Flow Hive at Margallah Hills Islamabad. Fifteen Kilograms of Honey was extracted from this flow hive in current Margalla season. Flow Hive is designed to allow honey to be extracted simply by turning a lever: the hive does not have to be opened and the bees are not disturbed as in normal extraction. This flow hive does not require much labor, no heavy lifting, and no expensive processing equipment and thus remains cost effective despite being expensive.



PARC automatic Flow Hive

Four hundred and ten (410) beekeepers were trained

Analyzed 798 honey samples received from beekeepers, honey traders and exporters. Four different pollen substitute diets for *Apis mellifera* colonies and their efforts on breed development and honey production were evaluated. Diet (30 g soya bean flour + 15 g yeast + 5 g honey + 20 g powdered sugar + 9.5 g powder of Fenugreek + turmeric and 20 ml of orange juice + 0.5 g A, D and E vitamins + 150 ml sugar syrup) was found highly useful for attaining maximum bee strength and honey production. Highest honey yield (9.2 kg per colony) was extracted from the colonies fed on this diet compared to (4.3 kg / colony) honey yield from the control group. Different experiments were conducted for ecto parasitic mite varroa destructor in *Apis mellifera* colonies. Oxalic acid 3.2% alone and in combination with breed removal and queen caging was found effective in lowering the ecto-parasitic mite population. Effectiveness of locally made Asian hornet trap was evaluated. Five hornet species *Vespa velutina*, v. *orientalis*, were captured. This device was helped in attracting and entrapping hornet species *Vespa veas* compared to other hornet species.

RANGE LAND AND AGROFORESTRY

Genotypic efficiency of Exotic Cactus species to survive under salt stress:

Three exotic cactus accessions namely *Opuntia stricta* haw, *Nopalea cochenillifera* and *Opuntia ficus indica* were evaluated at different salinity levels at Rangeland Research Institute, NARC. Pot experiments were conducted in three replications under Randomized Complete Block Design



Exotic Cactus species grown under salt stress at NARC

(RCBD). Cactus accessions were grown under three salinity stress levels low, medium and higher i.e. 0, 50mM (28.08gm), 75mM (42.12gm), and 100mM (56.16gm). Exotic Genotype (variety) *Nopalea cochenillifera* performed better under saline condition in survival emergence of new pads, length of pads with a survival rate of 91.66 % and *Opuntia ficus indica* with 83.33% and *Opuntia stricta* haw with 66.66%.

Effects of Biochar application on soil fertility and the growth of Rangeland Grasses

Biomass production of promising grasses *Cenchrus ciliaris* and *Panicum maximum* was investigated with application of corn straw biochar. Different concentrations of biochars i.e. control, 100gm, 150gm, 200gm, and 250gm. were applied to pot experiments. Results indicated positive effect of biochar on both germination (83.33% and 80%) and biomass (201.2gm and 180.1gm) at 200gm and 250 gm treatments in *Panicum maximum* but *Cenchrus ciliaris* showed just biomass production (192.8gm and 205.3gm) at 200gm and 250gm treatments. Result suggested that biochar can be a potential amendment to increase growth of grasses, higher productivity and soil carbon sequestration.



Grasses at seeding stage in biochar application

Development of Silvo-Pastoral System Model for sustainable land use and carbon sequestration in Potohar

Two experimental sites each of one acre were selected in Tehsil Fathejung and Pindi Gheb for the development of silvo-pastoral model during 2019-20. The progress of the work done and achievement made during the reporting period as follow:

Experimental Site at Domianl village, Pindi Gheb: After necessary preparation of experimental field lay out was carried out to plant the grass tufts. Three thousand tufts of Rhodes grass (*Chloris gayana*) were planted at 30x40 cm spacing in triangular shape to harvest rain water in order to maximize germination and growth of grasses. Biomass production was estimated using 1m² quadrat along the transect line. Utilizing the biomass data, carrying capacity and carbon sequestration potential were calculated. The forage production was estimated as 1344.85 kg ha⁻¹, 416.90 kg ha⁻¹ and 96.90 kg ha⁻¹ in summer, spring and winter respectively.

Experimental Site at Nawa Gerah village, Fathejang: Two thousand *Leucaena leucocephala* (ipil ipil) seedlings were planted at a spacing of 30 cm apart from each other. Additionally, three thousands tufts of Rhodes grass (*Chloris gayana*) were planted at 30x40 cm spacing. During summer, spring and winter the forage production was recorded as 1545 kg ha⁻¹, 416 kg ha⁻¹ and 147.80 kg ha⁻¹ respectively.

Agronomic performance of different varieties of Rhodes grass under rain fed conditions of Potohar

Rhodes grass is useful forage for pasture and hay, drought-resistant and very productive, of high quality forage. Tufts of five varieties of Rhodes grass (*Chloris gayana*) namely, Katambora, Tolgar, Sabre, Fine Cut, Toro were planted with four replications in a Randomized Complete Block Design at Rangeland Research Institute experiment filed at National Agricultural Research Center Islamabad. The results found that katambora produced highest fresh forage yield of 8.9 t ha⁻¹ and dry biomass of 3.98t ha⁻¹ of followed by fine cut variety that yielded 7.8 t ha⁻¹ and dry biomass of 2.5t ha⁻¹. The result suggested that katambora variety could be a potential for large scale planting to meet the forage shortage in Potohar and other suitable ecologies of Pakistan.



Rhodes grass experiment at RRI Field, NARC

PARC-BALUCHISTAN AGRICULTURE RESEARCH AND DEVELOPMENT CENTER, BALUCHISTAN

Dry land Crop Improvement and Promotion of Arid Horticulture in Arid Areas

BARDC Quetta multiplied seed of Shalkot-14, Ujala-15, Ass 2011, Johar-2016, Faisalabad-2008, Anaaj-2017 and Tijaban-2010, wheat varieties on farmer's field in 10 different districts of Baluchistan and produced 70 tons of wheat seeds. Drought tolerant barley variety Sanober-96 was planted on 15 acres on farmer's field in Kuchlak areas and produced 12000 kg of seeds for further

scaling up of cultivation. Different chickpea varieties (Indus 2019, DG-98, Bittle-2016, Niab-2016, CM-08 and Noor-2013) were cultivated on an area of five acres at farmer's field of JhalMagsi and Nasirabad. Sown agronomic varietal trial of Chick pea on three locations of JhalMagsi and Nasirabad districts..Sown 03 acres of lentil (Punjab Masoor) at farmer's field District Surab & Khuzdar (01 acre at Surab& 02 acres at Khuzdar). Sown Chickpea (Noor-2013) ½ acre at farmer's field in Khuzdar.



Lentil at JhalMagsi and chickpea varieties Fakhar-e-thal and Bittle at ARI Jaffarabad varieties



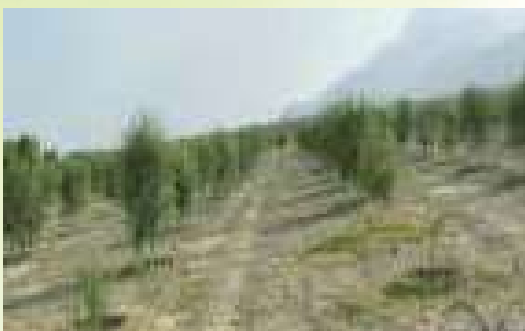
Wheat and barley trials at Farmers' field in Khuzdar

Introduced 3 varieties of chickpea (Fakhar-e-thal, Bittle-16 and Lalri) on 10 acres and 3 varieties of lentil (Punjab masoor, Niab Masoor and local) on 5 acres by selecting 15 farmers in Jaffarabad. Yield obtained 5000, 4500 and 3500 kg acre⁻¹ of Bittle-16, Fakhar-e-thal and local chick pea (Lalri) seeds. Where as yield obtained from lentils are 500, 200 and 100 kg/acre from Punjab Masoor, NIAB Masoor and local lentil seeds respectively.



Local masoor at Farmer's field Jaffarabad

Fifty thousands (50000) olive plants (Varieties: Arbiquina, Coratina and Gemlik) distributed in 10 districts (Quetta, KillaSaifullah, Zhob, Khuzdar, Kalat, Noshki, Washuk, Musa Khel, Bolan and Punjgoor under Olive (PSDP) project. Expanded and established a progeny orchard of Olives(varieties: Arbiquina, ArbosonaCoratina and Gemlik) on 15 acre on high efficiency irrigation (Drip) system at BARDC, farm, Quetta. Two hundred and thirty (230) acres of High Efficiency Irrigation (Drip) System was installed on olive orchards in Baluchistan including 15 acres at BARDC, Quetta, and 10 acres (varieties: Arbiquina, Arbosona Coratina and Leccino) in PARC- Tomagh station Ziarat. Harvested 2500 kg olive fruit form BARDC and Tomagh station and 350 kg of oil was extracted.



Olive farm at Bizenjo Farm, Khuzdar Baghbana



Olive mother orchard at PARC BARDC, Quetta

Expanded and managed Saffron on one acre at BARDC medicinal herb garden. Produced 20000 saffron bulbs, 14000 bulbs were replanted and the remaining bulbs were sold out through PATCO. Produced 205.57 gm. of saffron (Stigma) out of 54000 flowers collected.



Saffron plantation at PARC BARDC Quetta

PARC-ARID ZONE RESEARCH INSTITUTE, BAHAWALPUR, PUNJAB Arid Horticultural Plants

High Density True-to-Type Mother Orchard of Arid Horticultural Plants at AZRI: The True to type high density mother orchard of arid horticultural crops including Ber, Guava, Fig, Pomegranate, Date palm and falsa has been established at Arid Zone Research Institute, Bahawalpur to raise the quality nursery plants for the farmers of the area. The institute has established the fruit orchard of thirteen high yielding and good quality genotypes of grafted ber i.e.; Kerala, soofan, kalidas, sherin, dehliwhite, hyderabad gola, waqar-1 and ajooba on highly saline soil patch. The production potential of Kerala (90 kg ha^{-1}), soofan (135 kg ha^{-1}), kalidas (120 kg ha^{-1}), sherin (125 kg ha^{-1}), dehliwhite (140 kg ha^{-1}), hyderabad gola (130 kg ha^{-1}), waqar-1 (160 kg ha^{-1}) and ajooba (140 kg ha^{-1}) on highly saline soil.



Fruiting and fruit grading of promising genotypes of grafted ber at AZRI, Bahawalpur

Establishment of True-to-Type Mother Orchard of High Density Fig Plantation Trials

The high density true to type mother orchard of fig has been established at experimental area of AZRI, Bahawalpur for first time in hot climatic conditions. To raise the disease free seedlings for



Fruiting performance field conditions and natural drying of fig at Bahawalpur

multiplication of this new crop in the area, 3500 nursery plants have been produced through cutting from this mother orchard. The data on plant growth and yield potential have been recorded. Another intervention have been to train the field staff to raise the plants through air layering techniques and a technical training followed by practical has been given to the field staff. The nursery plants will be raised through air layering in the coming season. The institute is leading towards its product development. The different combination of its fruit drying has been recently tested i.e. natural drying in direct sunlight, under shade condition and under room conditions. The institute has requested for shifting of solar dryer from NARC to AZRI, Bahawalpur for proper drying process of fig and its product development.

Clean Nursery of Fruit Plants

A good quality , clean and high yielding fruit nursery plants have produced at AZRI, Bahawalpur including grafted ber, pomegranate, falsa, fig, jaman and guava to multiply at farmer fields in Cholistan desert, focusing on disease-free true to type and use of rootstocks suited to varied soil and climatic conditions to the farmers of the area. The institute has produced nursery plants of Pomegranate 1000, Guava 200, Jaman 200, Ber 1500, fig 3500 and moringa 3000 plants. The main objective of this research activity is to produce good quality nursery plants for future research needs and to meet the requirements of farmers and other researchers.

Genetic Improvement of Crops

CIMMYT Yield Trial: 27th Semi-Arid Wheat Yield Trial- 2019-20: The collaborative experiment comprising of fifty (50) genotypes of wheat was conducted at AZRI, Bahawalpur during Rabi-2019-20 in collaboration with CIMMYT to test & evaluate their yield potential under arid climatic conditions. The data on seed yield and other yield components have been recorded at various critical growth stages. The genotype (415) produced the highest seed yield of 5243.7kg ha⁻¹, which was followed by the genotype (429) with the seed yield of 4379.3 kg ha⁻¹ while the lowest seed yield 2361.8 kg ha⁻¹ was obtained from genotypes (455). The check variety Faisalabad 2008 produced seed yield of 3562.4kg ha⁻¹.

Response of growth and yield of different Advance lines of wheat of AZRI for drought tolerance (screened out of CIMMYT Yield Trial): Six genotypes of wheat (screened out of CIMMYT germplasm) were selected from previous screening trials on the basis of yield and other attributes. These genotypes have been further tested to verify the results and were compared during Rabi-2019-20 at AZRI, Bahawalpur. The data on seed yield and other yield components was recorded at various critical growth stages. The genotype AZ-W-8 produced the seed yield of 5732.9 kg/ha, which was followed by genotype AZ-W-4 with the seed yield of 4281.4 kg/ha, while the lowest seed yield 2192.5 kg/ha was obtained from AZ-W-2. The local check variety Johar 2016 produced seed yield of 3562.4 kg/ha.

Comparison of different advance lines of Mungbean for their yield potential, screened out at AZRI, Bahawalpur: The adaptability study comprising of four (04) advance lines/ genotypes of mungbean have been screened out on the basis of yield potential under drought



Mungbean advance lines at experimental farm of AZRI, Bahawalpur

conditions at AZRI Bahawalpur. The Advance line of AZRI Bahawalpur AZ-MH-1 produced the highest seed yield of 1953.9 kg ha⁻¹ which was followed by AZ-MY-6 with the seed yield of 1631.7 kg ha⁻¹, while AZ-MH-4 produced the lowest seed yield of 1384.9 kg ha⁻¹, The seed yield of 1595.8 kg ha⁻¹ was obtained in check variety NM-2016.

Efficient Soil Nutrition Management

Response of NPK foliar fertilizer on growth and yield of promising wheat genotypes:

Five (5) different levels of NPK foliar (0, 0.25, 0.50, 0.75 and 1.0 liter ha⁻¹) were compared on Johar-2016 wheat variety. The maximum seed yield of 4935.4 kg ha⁻¹ was obtained from the plots where NPK foliar was applied @ 0.5 liters ha⁻¹. While the seed yield of 3486.4 in case of 0.25 liters ha⁻¹ NPK applied. Whereas, the seed yield of lowest seed yield (1969.3 kg ha⁻¹) was resulted from the plots where no NPK foliar was applied.

Response of different concentration of Zinc on the growth & yield of Mungbean crop:

The study was carried out to test six different levels (0, 1, 2, 3, 4 & 5 kg ha⁻¹ of Zinc Sulphate (G) on mungbean. The 3 kg ha⁻¹ of Zinc Sulphate gave the highest seed yield of 1735.4 kg ha⁻¹ which was followed by the concentration level of 2 kg ha⁻¹ of Zinc Sulphate, with the seed yield of 1475.3 kg ha⁻¹ while the lowest seed yield of 1349.7 kg ha⁻¹ was obtained from control (where no Zn has been applied). The tested variety was NM-2011. The role of micronutrients particularly the Zinc Sulphate has been identified that has responded in the enhancement of the yield of Mungbean.

Integrated Pest Management

Efficacy of new chemistry insecticides for control of fruit fly with the use of methyl eugenol as male attractant in ber orchard:

Five different treatments, Trichlorphon @110 g/ 100 lit of water+ protein hydrolysate 50 ml/ 100 liter of water, Lambda cyhalothrin @250 ml / 100 lit of water+ protein hydrolysate 70 ml/ 100 liter of water, Trichlorphon @170 g/ 100 lit of water+ protein hydrolysate 90 ml/ 100 liter of water, Lambda cyhalothrin @220 ml / 100 lit of water+ protein hydrolysate 110 ml/ 100 liter of water and control were tested for percentage fruit fly damage and yield/plant. Damage percentage and yield/plant varied with the use of different concentrations Trichlorphon @110 g/ 100 lit of water+ protein hydrolysate 50 ml/ 100 liter of water + Lambda cyhalothrin @250 ml / 100 lit of water showed excellent results with yield potential of 45 and 79.5 kg plant⁻¹ with minimum damage of 11% and 8% respectively. The lowest yield (26 kg plant⁻¹) and the highest damage (28.5%) were recorded in plants where no treatment was applied.

Desert Grasses: The following are the findings of different field studies of range grasses, shrubs and trees which have been conducted at Cholistan Farm of AZRI, Bahawalpur, under typical desert condition. The results have shown that Panicum maximum (Ginea grass) produced the highest green fodder yield of 46.3t ha⁻¹ followed by Panicum antidotale (Blue panic), Panicum antidotale (Gatton panic) Cenchrus ciliaris, (local Dhaman) and Cenchrus ciliaris (Nun bank) produced green fodder yield of 40.2, 31.9, 28.10 and 27.6t ha⁻¹ respectively. While the lowest green fodder yield of 10.9 t ha⁻¹ was obtained from Chloris gayana (Rhodes grass).



Establishment of Range grasses on high sand dunes under typical arid conditions at Thar

PARC-ARID ZONE RESEARCH INSTITUTE, UMERKOT, SINDH

PARC has initiated mega project in Sindh on “Strengthening/Up-gradation of Agri. and Livestock Research System of Arid Zone Res. Institute, Umerkot, Sindh” to expand the scope of the existing Institute to meet the demands of poor farming communities spread over hyper arid zone of Thar desert. The project strives improvements in agricultural and livestock productivity and poverty reduction. So far under the project; Boundary wall is constructed around 211 acres of land, Orchards developed on 32 acres, 5 Units of solar pumps for irrigation system completed, Drip irrigation system is installed on 40 acres of land. Furthermore Construction of office building, hostel, roads, animal and implement sheds, underground, overhead water tanks, grain store, and vehicle parking shed is in progress.



Drip Irrigation system



Date palm

Promotion of Arid Horticulture in Arid Areas: Established 17 acres of Grafted Ber (Soofi-Dehli Gola) orchard on saline underground water with 3500 ppm irrigated through drip irrigation system using solar energy for pumping. Established 12 acres Date palm with 25 national and international varieties (Ajwa, Allien, Aseel, Barhee, Bert Moda, Begum Jangi, Dhaki, Daidhe, Daido, Faslee, Gajjar, Gulistan, Karblain, Kashowari, Khalas, Khurmo. Kupro, Lullu, Madjol, Mithri, Muzavati, Nabutsaif, Nawadar, Nakulkurh and shakri) on saline underground water with 3500 ppm irrigated through drip irrigation system using solar energy for pumping. Twenty four acres orchard (eight acres Grafted ber, three acres lemon and Chiku each, two acres Guava and eight acres date palm) have been planted on drip irrigation system. More than 15,000 plants of grated ber developed and provided to farmers and research Institutes.

Dryland Crops: Fifty one genotypes of cluster bean were evaluated against biotic and abiotic stresses. Four high yielding genotypes (GGP-04, GGP-27, GGP-03, GGP-38) selected for further



Mung Bean



Ground Nut national uniform yield trial

testing. Further, 17 advanced genotypes were planted for seed multiplication. Total 2800 kg seed was produced and also provided to Thar farming community. Mungbeen national uniform trial (16 genotypes), mash been national uniform field trial (10 genotypes), mustered varietal trial (10 genotypes), groundnut national uniform field trials (9 genotypes) were evaluated under the prevailing

stresses of Umerkot. Promising high yields and disease free genotypes were selected for further advanced trials. Mung bean seed multiplication/demonstration were conducted on 70 acres farm field. Improved Mungbean varieties (NIAB and AZRI Bhakar) were provided to farmers.

Range and Agro forestry in Thar Desert: Planted six acres forest block of Salvo pasturing for food, fodder and fire sticks on saline water. Introduced three new trees varieties in Thar ecology (Moringa, Imlu and Jungle julibi). These are fast growing trees and can provide food, fodder and can help in desertification control. 3300 tree plants (Moringa, Jungle julibi, Rohiro and Neem) have been planted around boundary wall and field area of PARC-AZRI. Four thousands one thundred (4100) tree sapling were handed over to Local Government, DC Office (Umerkot & Tharparkar), SP Office Umerkot, Government Schools Umerkot, NGOs, and local farmers. Perennial grasses already under evaluation are showing encouraging results and these grasses may play a major role in the desertification control and enhancing livestock productivity. 2500 large & 5000 small ruminants were vaccinated and drenched in the Thar area.



Panic grass field



Trees/shrubs/grasses field

Biodiversity conservation: live arboratum species of trees/shrubs/grasses are maintained for seed production and further multiplication of local desert species.

Nursery of native & exotic plants: Institute developed two nurseries namely Umer & Marvi. In these nurseries along with native plants, plantlets of exotic plants like Moringa, Jungle jilaibe, Conocarpus, Sisal, etc. have been developed. More than 30,000 native & exotic plants, more than 3000 plants of Moringa and 30,000 plants of Conocarpus were developed. About 10,000 plants of Conocarpus and 10,000 plants of Moringa and other plants were distributed among Pak Army, NGOs, farmers and even planted at farm of institute and at farmer's fields.



Nursery of native & exotic plants

Introduction of Moringa: Moringa as a miracle tree was successfully introduced in Umerkot for multiple uses. Besides fodder production, moringa leaf powder is properly collected, dried, grinded and forwarded as a Umerkot moringa powder at



Book on Moringa production technology

PATCO PARC.AZRI Umerkot published Moringa book on production technology, uses and importance of different plant parts and recepies.

PARC-ARID ZONE RESEARCH CENTRE, D.I.KHAN, KP

PARC has initiated mega PSDP project in Khyber Pakhtunkhwa on “Up-gradation of Arid Zone Research Institute (AZRI) to the level of Arid Zone Research Center (AZRC) DI Khan”. The overall objective of the project is to upgrade research infrastructure of the institute and expend its scope to cover the less developed recently merged districts of the southern western Khyber Pukhtun khawa province. The center aims to conduct research and development activities in specific agro-ecologies of the region for improving agricultural productivity and prosperity of rural communities. Construction of Green House, Installation of Tube-well, Storage & Implement sheds and construction of Screen Houses completed at AZRC, D.I.Khan, whereas Constructions of office / hostel building, Residential colony, Installation of Tube-well, Storage & Implement sheds along with Screen House completed at ARDI Tank and Matora Lakki Marwat while the work is under way at ARDI Wana and Miransha.



Chief Minister Khyber Pukhtunkhwa & Federal Minister Visit to AZRC D.I.Khan

Release of New Drought Tolerant Varieties

Arid Zone Research Center, D.I. Khan released new improved varieties of Indus-2019 (Desi Chickpea), Lentil-2019, Wheat variety (AZRC-Dera) at AZRC DIKhan as approved by Provincial Seed Council, KP. Two local varieties Karak-1 and PB- 2000 were used for current varietal development at ICARDA during Kharif 2018. Wider adaptability studies tested at various locations in the country including Indus-19 which gave better yield over check varieties in NUYT (2015-2017) performed well; got 3rd position among 26 candidate lines and 1st position among 5 candidate lines



Chickpea variety “Indus-2019”



Lentil 2019 at AZRC DIKhan

from KPK. DUS data was recorded and confirmed jointly with Federal Seed Certification Officer, FSC&RD, DIKhan during 2015-16 and 2016-17. Finally Indus- 19 was approved by the Provincial Seed Council as a pre-basic variety in 2019 for general cultivation in KP. Accordingly, Indus-19 was

sown on an area of 38.5 acres with the production of 23 tonnes (600 kg/acre) in Rabi 2019-2020. Indus-2019 is bold seeded, stiff stem, high yield potential along with better disease resistance as compared to the earlier varieties. Chickpea variety “Indus-2019” developed from hybridization; a cross between Karak-1 and Punjab-2000 with a yield potential of 2100 to 2500 kg per hectare.

Lentil-2019 is high yielding, small seeded, spotted seed coat, and bushy branches with medium size pods. It is resistant to wilt disease. Its yield at different locations ranged from 1888 kg ha⁻¹ to 1972 kg ha⁻¹). However it has potential of 2750-2850 kg ha⁻¹. These varieties can play a vital role in fulfilling



Wheat variety AZRC-Dera



Officials from Provincial Seed Council, Khyber Pukhtunkhwa for seed certification

the future demands of increasing pulses production in the country. About 2.5 ton pre-basic seed of these varieties was produced at AZRC farm.

Most recently AZRC DI Khan has developed new high yielding, diseases and drought tolerant wheat variety “AZRC DERA” Third variety was approved in 39th meeting of Provincial Seed Council held on 23rd April, 2020 under the chairmanship of Minister for Agricultural Khyber Pukhtunkhwa. Newly released variety AZRC DERA has high yield potential with resistant against yellow and leaf rust diseases. It is highly suitable for rainfed conditions with additional potentials character of heat and drought tolerance. Its yield potential is higher than 80 monds in irrigated and 36 monds in rainfed conditions. The AZRC-2011 was registered by the Provincial Seed Council, KP in March 2020 as AZRC-Dera. It was cultivated on an area of 250 acres including 50 acres at AZRC Farm and 200 acres at farmers field. Total 40 tones seeds of this variety was produced and out of this, 10 tons seeds was provided to Khyber Pukhtunkhawa agriculture department on their demand for further scaling up in the province.

Water Resources Development

Efficient Utilization of Spate Irrigation water in specific ecology. Monitored flood and crop yields. Advisory service to Farming Community in project target area. Developed Water Harvesting Model for demonstration. Gomal Zam Command area surveyed and cropping pattern observed with respect to available water.

Soil Sciences

Carried out crop residual management (mulching, composting) in Chickpea, Wheat for improvement of crop yield. Integrated Nutrient Management by Identification of PGPR for wheat & chickpea. Gibberellic Acid and potassium enhanced yield of wheat 9% (7212 kg ha⁻¹), Chickpea 8% (1232) kg ha⁻¹, Moong bean 11% (1822 kg ha⁻¹) and Cotton 13% (3127kg ha⁻¹).

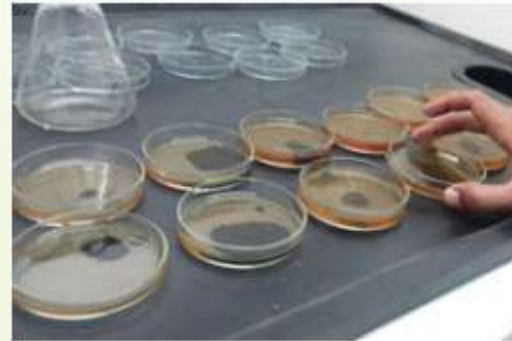


Chickpea field



Wheat field

Soil & Water testing Lab, AZRC, D.I.Khan: Established Soil & Water testing Laboratory at AZRC Office. Analyzed more than 100 soil samples for EC, pH, phosphorus, potassium, sodium, bulk density, porosity, water retention and organic matter and operationalized the GIS lab for satellite mapping of the soils in KP.



Soil and water analysis at AZRC, D.I. Khan

MOUNTAIN AGRICULTURAL RESEARCH CENTER-GILGIT

Fruit section

Two thousands (2000) crown gall resistant rootstock of Cherry (Mahlab & Maxima-60), Three thousands (3000) rootstock of Apple (MM111), one thousands (1000) rootstock each of almond (Katha) and pear (Quince) budded /grafted. Ten thousands (10000) true to type plants of (Apricot, cherry, almond, pear, peach, grapes, fig and apple) were provided to farmers, NGOs, Government organization. Surveyed and selected ten sites in Gilgit-Baltistan for the establishment of olive orchards for adaptability trials of new olive varieties. Kiwi variety (Hayward), Black berry (Boysen and strawberry varieties (Sea Scape & Tribute) showing good performance and these varieties will further be propagated for up scaling in Gilgit Baltistan.



Kiwi var. Hayward



Black Berry



Strawberry

Vegetables Section

Evaluated 3 varieties of Tomato i.e. Roma, Riogrande & SAARC line (the yield was 24.48, 26.30 and 29.19 t ha⁻¹ respectively), 4 varieties of Brinjal namely Nirala, Padagoda, Dilnasheen & Local (The yield was 34.31, 25.24, 21.06 & 26.84 t ha⁻¹ respectively), 3 varieties of hot chilies i.e China long,



Tomato (SAARC line)



Radish (China Red)

Kathmandu & local (Yield was 2.28, 2.19 & 1.81 t ha⁻¹ respectively), and 3 varieties of Radish namely China red, Mino early & green neck (Yield obtained was 39.99, 12.66, & 23.82 t ha⁻¹ respectively) for selection of high yielding varieties. Tomato variety SAARC line, Brinjal variety Nirala, Chili variety China long and Radish variety China red were recommended based on their higher yield. Produced and issued 240 kg seed of china cabbage to 240 Farmers of MARC Gilgit.

Cereal Section

Distributed 960 and 1000 kg seed of Maize variety (Azam and Pahari) to farmers at MARC Gilgit. Provided wheat seed NARC-11 (152 kg), MARC-1 (223kg), Pak-13 (540 kg), Zincol (173 kg) and Borlog-16 (75 kg) seeds to Farmers of Gilgit Baltistan. Collected/tested twelve (12) varieties of Soybean and three varieties (NARC-16, NARC-11 & Rawal -1) were selected on the basis of high yielding (1380 kg, 1050 kg & 1030 kg ha⁻¹ respectively) in agro-ecological condition of GB. Total 1200 kg soybean seeds was produced. Promoted high yielding buckwheat variety (Mancan) on farmer fields and maintained pure seed at MARS Skardu research field. 2200 kg Seeds were produced at farmer's fields and 70 kg at research station. The mean yield obtained was 2 tons per hectare.



Soybean field at MARC, Gilgit

Agro Forestry Section

Introduced Ryegrass as winter fodder in Gilgit Baltistan. Ryegrass variety Vertex was tested at MARC and at farmers field at two different locations for biomass and seed increase. Total fresh biomass from three cuttings i.e. 1st, 2nd and 3rd cutting was 25 tons, 20 tones and 15 tons per hectare respectively. Five kg Seed was also collected for further multiplication.



Ryegrass field at MARC Juglote

WATER & AGRICULTURAL WASTE MANAGEMENT INSTITUTE, TANDOJAM

Banana Productivity Enhancement and Tissue Culture

This research trial was undertaken at the field of Agriculture Research Institute Tandojam to examine and compare the yield and fruit quality of Tissue Culture Banana varieties compared to locally cultivated Basrai (dwarf Cavendish). The NIGAB-I Banana variety gave the maximum yield of 46.00 t ha⁻¹ as compared to 42.2 t ha⁻¹ by NIGAB-II, and 33.2 t ha⁻¹ by Basrai (control). About 45.4 % of irrigation water was saved under Drip irrigation as compared to traditional flood irrigation. Banana bio-compost was prepared and applied at the grower's field of Banana. The growth response of the plantation is better than the control.

ANIMAL SCIENCES DIVISION

The objective of this ASD is to set priorities of research according to the needs of the Provinces and monitor research activities being conducted at the Federal and Provincial level and eventually finding solutions of the burning issues confronting livestock sector. The researchable areas under ASD are Animal Health, Animal Feeds and Nutrition, Animal Reproduction and Genetics, Dairy Technology and Inland Aquaculture and Fisheries.

Aim

To improve production potential of food animals.

Objectives

- i. To set the priorities of research according to the need of provinces and relevant stakeholders.
- ii. To develop, monitor and evaluate research projects being conducted at Federal and Provincial level.
- iii. To find solutions to burning issues confronting livestock, poultry and inland fisheries sector in country.
- iv. To undertake, aid, promote and coordinate livestock, poultry and fisheries research and other activities as per all PARC-mandated functions.

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. Following are the salient outputs:

S. No	Funding sources	Completed	On-going	Total
1	Agricultural Linkages Program	7	21	28
2	Public Sector Development Program	2	3	5
3	International Cooperation	1	2	3
Total		10	26	36

RESEARCH ACHIEVEMENTS

Animal Health Program

The Animal Health Program (AHP) is focusing on studying the pathogenesis and epidemiology of emerging and newly introduced animal diseases, which has national, regional or international significance like FMD, PPR, warble fly and zoonotic diseases under One Health slogan. The facilities available at AHP are:

- i. Isolation and identification of bacteria (*P. multocida* and Brucella).
- ii. PCR for diagnosis of PPR and FMD.
- iii. ELISA for diagnosis of PPR, FMD and Brucella.
- iv. Diagnostic facilities for various external and internal parasites.
- v. Cell culture facility for virus isolation.

The major R&D based achievements of AHP are as follows

Live heterotypic Haemorrhagic Septicaemia Vaccine: The haemorrhagic septicemia (HS) caused by *Pasteurella multocida* is an acute, fatal, septicaemic disease of cattle and buffaloes in Pakistan and other South Asian countries. Safety of the HS vaccine prepared with 15% trehalose as stabilizer was tested in cattle and buffalo calves of age more than six months. The animals remained normal and no undesirable signs and symptoms were observed.

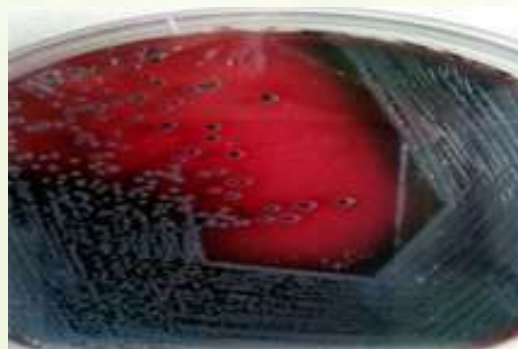
Molecular Epidemiology of Extended Spectrum β -lactamase E. coli (ESBL-Ec) from Slaughtered Animals: Extensive use of antibiotics in food animals has always been criticized as it has been linked to increased prevalence of Anti-Microbial Resistance (AMR) of organisms such as Extended Spectrum β -lactamase E. coli (ESBL-Ec), Salmonella and Campylobacter. Recto-anal Mucosal Swabs (RAMS) collected (n = 200) from cattle and buffaloes slaughtered in slaughter houses of Islamabad were analysed for ESBL-Ec. The overall prevalence of ESBL-Ec was 32.5%.

Prevalence and Antimicrobial Resistance of Salmonella: Salmonella is considered an

important foodborne pathogen of zoonotic and economic significance in animals and humans. A total of 168/350 recto anal mucosal swabs collected from six different abattoirs of the country (Islamabad, Lahore, Peshawar, Quetta, Hyderabad and Muzaffarabad) were found positive for Salmonella using PCR. The AMR ranging from 13.1% to 100% (Penicillin, lincomycin, neomycin, streptomycin and cephadrine) was observed in Salmonella isolates against various antibiotics.



Collection of Recto-anal mucosal swabs from sheep at slaughterhouse



Typical black colonies of Salmonella observed on

Development of Diagnostic Capacity for Detection of Crimean Congo Haemorrhagic Fever (CCHF): Tick Borne Diseases (TBDs) are major production limiting factor of the livestock industry. An overall prevalence of these diseases 18.75% was observed in animals at district Abbottabad and Mansehra, which was an indication of the virus activity in this area. While 31.4% was observed at slaughtered animals of Pakistan. The overall prevalence of CCHF was 41.7% in small ruminants (sheep and goat) and 21.1% in large ruminants (cattle and buffaloes).

Animal Nutrition Program

Animal Nutrition Program focuses research 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. The facilities available at ANP are:

- i. Analysis of animal feed composition.
- ii. Analysis of aflatoxins in animal feed stuff.
- iii. Production of animal feeds, urea molasses blocks, mineral mixture etc.
- iv. Experiment on different animal feeds for digestibility and fattening.

The major R&D based achievements of ANP are as follows

Effect of replacing cottonseed cake with palm kernel cake on growth performance and nutrient digestibility in growing buffalo calves: Traditionally in Pakistan, livestock farmers use cottonseed cakes for feeding to their livestock. Its prolonged use can affect the fertility of animals. Moreover, due to its limited supply, the cost of cottonseed cake has gone high. Adulterations in cakes with other inferior ingredients and contamination with pesticides are other major problems. It is experimentally observed that, dry matter intake and weight gain was lowest when 100% cottonseed cake was replaced with PKC. Nutrient digestibility and economic of the trial were almost similar when cottonseed cake was replaced with PKC.

Characterizing *Aspergillus flavus* from cotton fields to improve environmental, feed, and food safety (NAS-USAID project): Aflatoxins are carcinogenic mycotoxins, which commonly contaminate food and feed resources in Southeast Asia. These mycotoxins are transferred to the milk and eggs of the animals consuming the mycotoxin-contaminated feed, posing health risks to the consumers of such products. Over 200 isolates of *Aspergillus flavus* were obtained from cottonseed cake and soil samples from Sindh and Punjab; examined morphologically, and subjected to aspergillitic acid and aflatoxin production tests. Three isolates were found to be not producing detectible aflatoxins levels.

Improving productive performance of backyard poultry through propagation of superior hybrid poultry birds (PSDP Project): Poultry production in Pakistan is very low i.e. 70 to 80 eggs per year and adult body weight of 1.5 to 2kg. The need is to improve our indigenous poultry breed because it have the advantage of being well adapted to local environmental conditions and can live as a scavenger bird at a low rearing cost. More than 100 birds of different breeds as parent flocks have been procured and are being reared at poultry farm. Chicks produced from parent stocks are being reared up to 3 months of age. About 25 sets (5 hens + 1 cockerel per set) of 3 month age have been distributed among farmers on subsidized rate. Approximately the farmers received 50% increase in egg production and also low mortality due to higher adoptability rate than already reared indigenous poultry.

Development of Lactobacilli based probiotic for poultry: Probiotics supplementation in animal feed is necessary to get maximum nutrients from the available feed. So far imported probiotic products are used in livestock and poultry industry which are costly and increase cost of production. Media were standardised for initial isolation of Lactobacilli from gastro-intestinal tract of chickens. 20 isolates were obtained which are currently being characterized for suitability as probiotic use.

Animal Reproduction and Genetics Program

The main focus of the program is to improve reproductive efficiency of cow, buffalo and goat through modern Assisted Reproductive Techniques (ART). The facilities available at AR&GP are:

- I. Major reproductive tools i.e. artificial insemination, estrus synchronization and semen cryopreservation.
- ii. Experimental animals and laboratory.

The major R&D based achievements of AR&GP are as follows:

In-vitro Toxicity Effects of Zinc, Cerium, Silver and Magnesium Oxide Nano-particles (ZnO NPs) on Beetal Buck Spermatozoa: Semen obtained from bucks (n=5) was pooled and divided into six aliquots. Each aliquot was extended with tris-citric extender (Tris 2.64 g/100mL; Bio World, Ohio (OH) USA, Citric Acid 1.36 g/100mL) containing various concentrations of nano-particles (0.01 mg/ml, 0.5mg/ml, 1mg/ml, 2mg/ml, 4mg/ml) and control group. The results at lower concentration i.e., 0.01mg showed higher sperm motility, velocity and plasma membrane integrity followed by lower concentration. While Silver Oxide Nanoparticles were highly toxic for spermatozoa. Even lowest dose i.e. 0.01 mg/mL was found to be lethal for spermatozoa upon treatment.

Effect of Cerium and Zinc oxide nanoparticles on the quality of frozen Nili-Ravi Buffalo semen: This study was designed to assess the cryo-survival rate of Nili-Ravi semen with cerium and zinc oxide nanoparticles in freezing extender. Semen from five mature bulls was collected



Automatic Yogurt Cup Filling/Sealing Machine



PARC Yogurt

and initially evaluated. In the post-thaw evaluation the sperm treated with 75µg/ml of cerium oxide, nanoparticles were found to be better in terms of improving progressive motility. In the post-thaw evaluation, the sperm treated with 1mg/ml of zinc oxide nanoparticles were found to be better in terms of improving total and progressive motility.

Animal Product Improvement Program

Animal Products Improvement Program (APIP) is working 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. The facilities available at APIP are:

- i. Automatic Yogurt Production Unit.
- ii. Laboratory for experiment on animal products evaluation.

The major R&D based achievements of APIP are as follows

Utilization of natural preservative natamycin to extend shelf life of yogurt: Experimental trials were conducted to study the effect of natural antifungal agent natamycin on the shelf life of yogurt at 4°C. The results indicates that after 28 days the titratable acidity of control, 10ppm and 20ppm yogurt increased from 0.6% to 1.0%, 0.6% to 0.74% and 0.6% to 0.77%, respectively. However, there was a sharp rise in the titratable acidity of control as compared to the samples added with 10 and 20ppm natamycin, which indicate the efficacy of natamycin treatment.

Yogurt production and commercialization: The automatic yogurt production facility has been made functional with financial assistance from PATCO. The automatic cup filling and sealing machine (capable of filling and sealing 1200 cups/hour) has been installed along with an incubator cum refrigeration cabinet (having capacity of holding 350 cups of 400g capacity) and a milk pasteurizer. The quality of the yogurt and the facility has been highly appreciated. Keeping in view the high acceptability by the general public, the yogurt has been now branded with the name of PARC yogurt, and is available for sale at various retail shops in Islamabad.

Livestock Research Station

Livestock Research Station (LRS) is maintaining a herd of buffaloes, cattle and calves along with an angora rabbitry. The station not only serves as a demonstration site but also provides support to the research activities of the Animal Sciences Institute. The facilities available at LRS are:

- i. Maintained around 150 experimental animals (Cattle and buffalo).
- ii. Angora Rabbitry for experiment & demonstration.
- iii. Demonstration of animal feeding/fattening experiments.
- iv. Silage making for demonstration.

The major R&D based achievements of LRS are as follows

Effect of substituting wheat straw with maize stovers (MS) or maize cobs (MC) in complete ration as maintenance rations for cattle (ALP funding): A growth performance trial for 90 days on 12 buffalo calves (3 per treatment) was conducted at LRS. Daily feed intake and fortnightly body weights were recorded. The salient findings showed that calves fed ration containing MC20% gained weight 750g/d while the calves fed rations having MC40% and wheat straw (WS) 30% gained weight 700g/d. In economic terms, feed cost per unit of weight gain of calves fed ration MC30% and MC40% was lowest (i.e. Rs. 123/-) compared to rations with MC20% (Rs. 129/-) and WS30% (Rs. 151/-).

Sub-project of PM initiative Calf Feedlot Fattening in Pakistan under Livestock Dairy Development Board: The sub-project of PM initiative calf feedlot fattening in Pakistan under LDDDB was awarded. The fattening trial on buffalo calves (n=12) is underway. The adaptability period of the calves has been completed and the experimental rations are being fed. Data collection on feed offered, feed refused, feed intake, body measurement (girth) and weight gain to assess the growth rate were being undertaken.

Remodeling of Angora Rabbitry: Remodeling of Angora rabbitry was performed in collaboration with PATCO. Facilities were upgraded and expanded for rapid increase in

the production of rabbits. Multiplication of Angora rabbits through breeding was performed to increase the number of rabbits. The inauguration of the Remodeled Angora Rabbitry at LRS was done by Chairman, PARC on March 04, 2020.

National Reference Laboratory for Poultry Diseases

The NRLPD is an apex Lab for Avian Disease Diagnosis also designated as Regional Leading Diagnostic Laboratory (RLDL) for Highly Pathogenic Avian Influenza (HPAI) for SAARC countries by FAO of United Nations. In 2014 the laboratory was internationally accredited for ISO/IEC 17025:2005 by Pakistan National Accreditation Council (PNAC), Islamabad. The facilities available at NRLPD are:

- i. The NRLPD is extending referral diagnostics and strategic surveillance for avian diseases at national level.
- ii. The NRLPD is equipped with the latest state-of-the-art equipment, highly qualified and trained manpower and strong national and international collaborations in the field of avian disease diagnosis and research.

The major R&D based achievements of LRS are as follows

Extension of diagnostics to the referral samples received from the field: A total of 15,043 samples were received and analyzed for referral diagnostics for Avian Pathogens and for surveillance of Avian Influenza and Newcastle Disease Viruses.

Biological and molecular characterization of avian pathogens: A total of 269 isolated pathogens AIV-H9, NDV, E. coli, and Salmonella were propagated/cultured and added in the NRLPD repository. A total of 198 bacterial pathogens were characterized for AMR including E.coli and Salmonella.

Sustaining international Accreditation ISO/IEC-17025: 2017 and maintenance of quality assurance system: Coordinated 1st annual surveillance audit of NRLPD by PNAC for ISO-17025:2017. Successful Upgradation of NRLPD to transition ISO-17025/IEC-2017 by PNAC.

Aquaculture and Fisheries Program

Aquaculture and Fisheries Program (AFP) was set up with the vision to develop inland aquaculture on modern lines to meet national and international requirements. The mandate of program was to undertake strategic research on inland aquaculture to increase per unit fish production. The facilities available at AFP are as follows:

- I. Experimental fish pounds (nursery, cemented pounds and production).
- ii. Experimental Lab (Fish nutrition, water quality and fish diseases).
- iii. Fish hatcheries (Tilapia and Cat fish).
- iv. Cemented raceways.
- v. Circular tanks.
- vi. Small fish feed unit.

The major R&D based achievements of A&FP are as follows

Monosex(All male Tilapia) Seed Production and Culture in Pakistan (PSDP Funded):

In order to increase per unit area fish production there is need to introduce new species and tilapia seems to be the best alternate for culture in the local condition. Following achievement were made under this project:

- i. For breeding and sex reversal of tilapia, a modern tilapia hatchery was developed including all accessories i.e. raceways, cemented ponds, incubation system etc.
- ii. The seed of Genetically Improved Farm Tilapia (GIFT) was imported from Thailand, successfully acclimatized in local environment and brood stock for further breeding.
- iii. Artificial feed for seed growth out and brooders was developed.
- iv. Breeding and sex reversal of tilapia was successfully done and further trials are under process.
- v. Technology package is ready for dissemination among local beneficiary community.

Genetics improvement and mass seed production of American channel catfish (Ictalurus punctatus): The aquaculture system of Pakistan is mainly extensive and in some areas

are semi- intensive. It is a need of the time to move towards intensive aquaculture at high stocking densities by introducing high value fish species with high growth potential in aquaculture. American channel catfish is a high value fish having high consumer preference due to less spines (bones) and good quality of meat. Following are the achievements:

- i. The quality brooders of American Channel Catfish having good growth potential were developed by selection and feeding on artificial diet.
- ii. Artificial breeding were successfully done from the mature brooders and nursing of seed is under process.



Brooders of American Channel catfish



Eggs of American Channel catfish

iii. Fourth brood stock development one thousands (1000) fingerlings of American channel catfish were stocked in earthen ponds. The fish were fed on artificial feeding of 35% crude protein level @ 4 % fish body weight daily. The highest performance was recorded in African Catfish with a stocking density of 20,000 fish/acre and this continuously reduced with decrease in stocking density. Farmers can achieve high net yield and financial returns by stocking African catfish at 20,000 fish/acre.

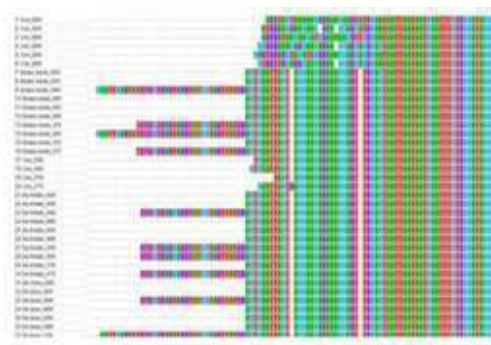
Animal Biotechnology Program (ABP)

Genetic architecture of production traits of indigenous livestock breeds has not been studied in detail yet, and there is a need to explore milk production potential at the molecular level. So potential focus of this program to establish research facilities in the area of genomics/functional genomics to characterize economically important candidate genes/genome of livestock for productivity enhancement like milk production, disease resistance, DNA profiles and identification of molecular markers along with development of improved /gene-based therapeutics & diagnostics for food animals and public health. The facilities available at ABP:

- i. Animal Biotechnology lab with accessories.

The major R&D based achievements of ABP are as follows

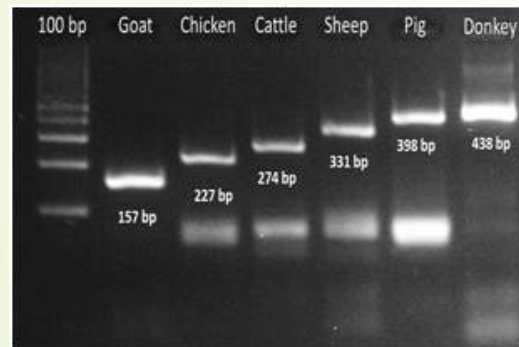
Genotyping of milk production genes in Nili-Ravi Buffaloes & Sahiwal cattle: In Nili-RaviBuffalo only BB genotype was found for Kappa-casein gene while in Sahiwal cattle genotypes AA & AB were observed. Sequence based analysis of amplified Kappa-casein (κ -CN) gene in Nili-Ravi buffaloes has been carried out. The results accurately revealed that the SNP based genotypes GG and AA with p-values 2.471×10^{-08} and 1.309×10^{-06} , AIC 4 and 13.9, respectively. This has also led



Genomic analysis of bovine Kappa-casein gene (milk protein) in Nili-Ravi buffalo

us to differentiate significantly between Nili-Ravi individuals from other respective breeds. However detailed work is required /under process in this regard.

DNA Based Identification of Meat animal species: This study was designed to standardize the best protocol for effective identification of specie specific meat. Samples comprising of six different types of meat were identified individually and also in meat mixture. The different size of species-specific amplicons, viz. 398 bp, 331 bp, 274bp, 227bp, 157bp and 439bp which were specific to pig, sheep, cattle, chicken, goat and horse/donkey respectively, separated by 3% ultrapure molecular grade agarose gel electrophoresis, which allowed clear species identification. Up till now established DNA testing (Specie specific & Multiplex PCRs) for meat specie (pig, sheep, cattle, chicken, goat and horse/donkey) identification using raw meat samples.



Specie specific PCR for Meat animal species identification

Extension, Trainings, Publications, Seminars, Workshops etc

- i. Animal Nutrition Program, NARC prepared 12,000 livestock feeds, 1,800 kg milk booster and 2,500 urea-molasses blocks and sold to farmers, apart from experimental feeds for different programs of ASI.
- ii. 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				Trainings	
Research Papers	Abstracts	M.Phil	PhD	Internees	Visitors	Imparted	Obtained
16	1	5	6	80	1,442	8	1

SOCIAL SCIENCES DIVISION

Agricultural Social Sciences research plays vital role in assessing the economic and social impacts of the adoption of new technologies, measuring impacts of investments in farming and agricultural R&D - livelihood, economic and social implications of various policy and non-policy measures taken by the government and generating updates on estimates pertaining to crop, livestock, forestry and fisheries sectors. The Social Sciences Division (SSD) of PARC works closely with its sister Divisions at PARC and provincial and federal researchers in crop, livestock, natural resources and system-based research teams through its network of Social Sciences Research Institutes located at provincial Agricultural Research Institutes and at NARC. The main objective of these institutes is to carry out research on socio-economic aspects at grass root level in Pakistan. SSD Research Agenda revolves around 12 Research Themes. During 2019-20, a number of studies and assignments were conducted by SSD researchers at the Headquarters and the SSRIs. The knowledge generated through these has been shared in the form of research reports, journal articles, briefs for the MNFS&R and presentations at numerous forums. Some of the studies are finalized while other are at various stages of their execution because these are project funded by ALP-PARC and the international donors like ACIAR and ADB-CABI Biosciences, etc. In the following paragraphs, some of the completed studies are briefly described.

A Study on Value Chain System of Major Cut-Flowers in Faisalabad City of Punjab

Historically, floriculture industry began growing in the late 19th century in England, while commercial purpose floriculture was emerged in Greece in 1940, whereas its sale in open markets began in 1950s. Today, it became a dynamic, global is a fast emerging and highly competitive industry. In 2019, total global sales for flower bouquet exports were US\$9.4 billion. Netherlands, Colombia, Ecuador, Kenya and Ethiopia are world's top 5 flowers exporters in the world. In Indo-Pak subcontinent, flowers are traditionally used at marriages, deaths and religious festivals. Now, they became inseparable from the social fabric of human life. Now their use can be seen in the various forms ranging from nicely wrapped single cut-flower and garlands to bouquets used while visiting patients in hospitals, patients discharged from hospitals, decorating houses, offices and stages in wedding halls and other wedding ceremonies, welcoming special guests and pilgrims, official ceremonies of seminars/workshops/conferences/inaugural and closing sessions and various other functions. Currently, about 7080 hectares of arable land is under floriculture in Pakistan with major share of about 4450 hectares in Punjab.

In Punjab, Kasur is one of the main hubs of cut-flowers production, but other districts such as Lahore, Multan, Faisalabad and Rawalpindi are also prominent flower production pockets in Punjab. Though the demand of cut-flowers has grown in the country but the know-how about technical matters on cultivation, packing and efficient value addition/marketing methods is still far behind recommended standards (Omar et al., 2014). Faisalabad is 2nd largest city of Punjab and like other major cities of Pakistan, flower business is also expanding here. Here, the use of flower is in the form of loose flowers, cut flowers (in bouquets, garlands and wedding car decoration), and in graveyards.

Though flowers farming in Faisalabad is taking place within a radius of 5-6 km from the city market, but the supply is lesser than the demand. Total cost of production and total revenue of rose farm was Rs. 617932 and Rs. 902417 per acre respectively, making BCR as 2.41:1. On the other hand, total cost of production and total revenue for gladiolus farm was Rs. 438814 and Rs. 1349595 per acre respectively, making BCR as 3.07:1. According to our survey of wholesalers, retailers and commission shops of cut-flowers, almost 3/4th of rose flowers come from Pattoki Flower Market. Various value added products of loose and cut-flowers indicate that these are highly profitable business. In case of gladiolus, almost 97% of the demand is met from the supplies from Pattoki Flower Market. Gladiolus bouquets were giving profit in the range of Rs. 83 to Rs. 104.17/bouquet, with BCR as 3.07:1. The average size of bouquet of rose was fetching net-profit of Rs. 77, garland of rose flowers as Rs. 19 per piece and Rs. 37 on sale of small and large size garlands. The wedding cars are mostly decorated with rose, gladiolus and marigold. The mean cost of decorating wedding-car was Rs. 3250, while Rs. 5300 were charged from the customers, therefore, average profit earned was Rs. 2050. Respondents reported lack of proper flower storage facilities and flower supply/transportation issues as main constraints in floriculture business. Growing use of artificial flowers used for decoration in parties, marriage halls and official meetings is a serious threat in faster expansion of this business. Results depict that cut-flower business is profitable venture though risks of spoilage of flowers also prevails all times.

Cost of Production of Potato in the Central Punjab

The structure and level of Cost of Production (CoP) have major implications for the competitiveness of agriculture and income level of the farmers. Production costs not only shape the development of various farming systems, but also affect their sustainability and determine the overall food production potentials. CoP has now become a powerful tool to understand and compare the conditions of different farming systems (Ronzonet al., 2014). Potato is world's 4th most important food crop after maize, wheat and rice. It is rich in starch and carbohydrates and can be regarded as largest non-grain food commodity. Potato is now cultivated around the world and became integral part of the global food system. In 2019, total potato production in the world was 376.826 million tons. China, India, Ukraine, Russia and USA are world's 5 most potato producing countries in the world. In Pakistan, though large number of varieties are grown, but relatively more important ones are Desiree, Cardinal and Diamont. In 2020, 188.6 thousand hectare were planted under potato, while total production was 4.61 million tons, while around 95% of total potato production takes place in Punjab province. Okara, Sahiwal, Kasur, Pakpattan and Chiniot are its major production clusters in Punjab province. In Pakistan, potato area was on a regular rise from 2013-14 and attained a new peak of area and production during 2018-19 by plantation at 195.7 thousand hectares and production as 4.87 million tons during 2018-19, which resulted in highly depressed price of this commodity in the country. As a result, a decline in area as 7.1 thousand hectares and production as about 260 thousand tones was taken place in 2019-20.

A quick update on cost of production of potato and other crops was demanded in various meetings at PARC and MNFS&R. Therefore, keeping in view the resources available and urgency of the assignment, a quick survey of 50 growers was conducted in Chiniot district of Punjab. The total cost of production to potato in the study area for the year 2019 was estimated as Rs. 79750 with gross margin as Rs. 20642 and net returns excluding land rent as Rs. 5530. This clearly signifies that due to bumper crop in the country, the year 2019 was not good income earning year for the potato growers in the study area. This clearly calls for sound export back-up policies and promotion of value chains for this important crop, in order to ensure due returns to the efforts of farming community.

Production Constraints and Deficit of Edible Oil and Its Impact on the Economy

Edible oil is one of the important food item of daily consumption in Pakistan. At the time of independence, the country was self-reliant in edible oil but later on it began to import edible oil in small quantities to supplement domestic production. The import of palm was started in 1963 and it remained modest during 1970s and 1980s. Since 1969-70, edible oil consumption began to grow at exorbitant rates and domestic production failed to cope up with it, as a result edible oil deficit started to grow. At present, in food trade, the import bills are much higher than the food export earnings. During 2019-20 (July-March), 2.748 million tons of edible oil valued Rs. 321.535 billion (US\$2.046 Billion) was imported, while local production of edible oil during the year was only 0.507 million tons. The total availability of edible oil from all sources provisionally estimated at 3.255 million tons, making per capita availability of edible oils as around 15 kilogram per annum. This also implies that the country produces only 15.6% of edible oils of total national demands. Pakistan imports crude and refined cooking oils (Palm and Palm Olein) mainly from Malaysia and Indonesia and soybean oil from North America and Brazil. According to Daily Tribune (January 21st 2017), Pakistan has become the 3rd largest importer of cooking oil after China and India -- Statement from Westbury Group Chief Executive, Mr. Rasheed Jan Muhammad in a one-day conference on edible oil. This study reviews situation of edible oil and oilseeds production along with documenting the production constraints of edible oil crops in Pakistan.

In Pakistan, domestic sources of edible oil production profile consists of the oil extracted cotton seed, rapeseed/mustard, sunflower and canola. In terms of production of edible oilseeds, cotton seed contributes about 81%, rapeseed/mustard as 13%, sunflower as nearly 4% and canola as 2% only. In terms of production of edible oil, the share of cotton seed falls at about 60%, rapeseed/mustard as nearly 26%, sunflower as 9.25% and canola as approximately 5%. This clearly implies that our edible oil production is dominated by cotton production, of which cotton seed is a by-product.

There are both major and minor constraints that affect the oilseed production in the country and deter the farmers from adoption of oilseed crops. Unstable marketing hamper promotional and developmental efforts to dispose of the produce of the farmers. Low economic returns and inadequate support of essential production elements including credit, quality seed, production technology and

lack of machinery. Currently 0.839 million hectares are under oilseed cultivation and country produces 0.427 million tons of edible oil from all sources. An additional area of 4.8 million hectares is required to full fill the whole requirement of the country. On the other hand country is producing surplus wheat and sugar after full filling its domestic needs. The surplus area under wheat and sugarcane can be brought under oilseed cultivation gradually to reduce the import bill. Olive plantation has successfully done in Punjab and can be a good replacement. Linseed and safflower are the minor oilseed crops of the country but due to inefficient production technology the cost of production remains high. Long term and consistent oilseed policy is the need of the time to enhance oilseeds production in the country to minimize the import bill.

Cost of Production of Canola in Faisalabad District

Edible oil is one of the important food item of daily use. Pakistan has been constantly and chronically deficient in its production. As per HIES (2018-19) survey, the per capita annual consumption of ghee and cooking oil edible is >12 kilogram while its per capita availability falls at 14.5 kg. In Pakistan, two groups of oilseed crops are mainly grown, i.e. traditional (rapeseed-mustard, canola, groundnut, sesame & linseed) and non-traditional (sunflower, safflower & soybean) are grown. During 2010s, the area under traditional oilseed remained stable whereas it has been drastically fallen down for non-traditional oilseed crops. Therefore, for boosting the domestic production of oilseed crops in the country, under the Prime Minister's Agriculture Emergency Program, a 5-years long mega project amounting Rs.10.964 Billion "National Oilseeds Enhancement Program" was launched in 2018-19. Its salient features are: i) registration of oilseeds growers for granting the subsidy; ii) subsidy of Rs.5000/= per acre, maximum upto 20 acres; iii) fifty percent subsidy on the purchase of oilseed machinery; iv) ensuring the availability of hybrids of oilseeds through national and multi-national companies; v) establishment of procurement centers in collaboration with All Pakistan Solvent Extractors Association (APSEA) monitored by government representatives; and, vi) arrangement of demonstration plots in oilseed crops growing areas. The availability of certified seed of oilseed crops has been enhanced from 488 thousand tons in 2017-18 to 1540 tons during 2019-20. As the area under traditional oilseed crops group has been dominated by rapeseed/mustard/canola, was enhanced from just 199 thousand hectares in 2017-18 to 350 thousand hectares during 2019-20 (in two years period only) vis-à-vis production from 225 thousand tons to 302 thousand tons, respectively.

The present exercise was conducted to update the cost of production estimates to be used for many research and development purposes. The total cost of production per acre of canola sarson (including all costs) was estimated as Rs. 30492 at an average yield of 21.66mtds/acre making cost of production at farm gate as Rs. 1315 per 40-kg. After including transport and marketing costs in the nearest food grain market, the farmers' reserve price at market gate becomes Rs. 1465. As the respondent farmers received mean price of Rs. 2265 per 40-kg, therefore, their profit including all costs becomes Rs. 803 per 40-kg. On per acre basis, net-income excluding all costs, not-excluding land rent and net-income minus variable costs were Rs. 20649, Rs. 33149 and Rs. 35158, respectively. Considering Benefit-Cost Ratio (BCR), it was 1:0.68 for all costs included, 1:1.08 for excluding land rent and 1:1.15 when variable costs are subtracted. All this clearly implies that strong incentives for area expansion under this crop in the Punjab province. At the same time, there is a danger of price collapse in the post-harvest by the marketing agencies. It is therefore, recommended that canola crop should be brought under the ambit of support price policy like wheat and sugarcane.

Prospects of Sunflower Crop Production in Water Scarcity and Edible Oil Supply Gap Scenario

Oilseeds sector, due to every increasing consumption of edible oil, has attained critical importance in Pakistan's economy. The non-traditional oilseed crops like sunflower, soybean and safflower were introduced in Pakistan during mid-1960s -- the era of Green Revolution, but their area remained low due to relatively more public R&D emphasis on promoting the cultivation of major crops. Over the time, sunflower has emerged as an important oilseed crop in the world and become a leading non-traditional oilseed crop cultivated in the country. Though sunflower can be cultivated in all four provinces of Pakistan, its plantation is more concentrated in Punjab and Sindh.

On the international market arena, the prices of edible oils has been on a regular decline since January 2011, except for sunflower whose prices started falling from May-June 2011. This regular decline in edible oil prices not only discouraged local production incentives & prospects in terms of decline in

area under oilseed crops in the country. More specifically, in Pakistan, the decline in area under oilseed crops began after 2005-06. In sunflower case, the decline in sunflower area started from 2008-09 onwards, and it is still continued. The factors causing erosion to the enthuse of farmer to plant more area under oilseeds include low level of import duties especially on palm oil, non-availability of remunerative prices, low interests of policy makers to control the edible oil import bills and discouraging oilseeds marketing mechanism. Besides generating update on the estimates of cost of production of sunflower, the study in hand also attempted to assess prospects of sunflower crop production in water scarcity and demand-supply gap scenario of edible oilseeds in the country. The data for study was gathered from 70 growers of this crop from Muzaffargarh, Multan and Bahawalpur districts -- the sunflower production clusters in Punjab.

Average area owned by the sample sunflower growers was 7.93 acres while their mean operational land holding was 36.15 acres. The total cost of production of sunflower was Rs. 48717 per acre, net-income including land rent was Rs. 18358 per acre and on excluding the land rent, the net-income shrinks to Rs. 1215 per acre only, making BCR as 1:1.02 with non-significant differences across farm size groups. Among variable costs, relatively higher shares were for fertilizer and irrigation as 15.4 percent and 13.13 percent, respectively. Majority of the farmers (95%) sold their produce to either village traders or the local market. On our sample farms, nearly three-fifth of the farmers (58.82 percent) reported decreasing trend of sunflower crop in their respective areas while remaining has reported it as virtually stagnant during past five years. Main reason for decreasing trend of sunflower crop was low productivity and lack of competitiveness of sunflower with other competing crops.

The Dynamics of Water Management Strategies of Farmers in Agro-ecological Zones of Punjab under the Water Scarcity Scenario

The 21st century has brought its own challenges and new dimensions in several environmental and socioeconomic sectors in Pakistan, particularly in the water sector arising from increasing water demand for growing agricultural and domestic needs. Pakistan's water profile has been drastically changed overtime from being a water abundant country (at the time of introduction of Green Revolution technologies) to currently experiencing water stress. Population growth, rapid urbanization, industrialization, as well as use of water-intensive obsolete farming practices --- all have contributed to Pakistan's increasing demand for water. Dominance of flood irrigation in the hot and semi-arid condition, led to heavy water losses through evaporation. Simultaneously, the supply is also hampered by its small water storage capacity and climatic changes that have made rainfall more erratic, leading to floods in some years and droughts in the others. Excessive pumping of aquifers (potential groundwater reservoirs) has raised major concerns over its sustainability and issues related to secondary salinization. Poor water infrastructure and inadequate lining of canals, along with breaching (sometimes illegal) of water courses, further exacerbates the situation of water availability and supply. Pollution of available surface and ground water resources, mainly due to inputs from agricultural wastes/run-offs and dumping of untreated industrial and domestic sewage on to land and in water courses, is another factor hampering the supply of fresh water (Qureshi and Ashraf, 2019). Keeping in view the existing situation, the study under consideration was planned to evaluate various water management strategies adopted by the farmers for growing various crops by estimating their water productivity in different cropping zones of Punjab.

The data for the study was gathered from two districts per cropping zone and interviewing of 40 farmers per district on a pre-designed semi-structured questionnaire, i.e. Rice-wheat (Gujranwala and Hafizabad), Mixed cropping (Okara and Sargodha), Cotton-wheat (Rahim Yar Khan and Bahawalpur) and Low-intensity (Layyah and Mianwali). The survey was conducted on various distributaries (at head, middle and tails) running through the sample districts. Overall, conjunctive use of both canal and tubewell water was observed at three-fourth of sample farms. Perennial canal water is available to our sample farmers in all cropping zones except rice-wheat zone, on weekly turn basis. About tubewell types, mainly diesel tubewell (74.4%) followed by electric ones (25.6%) were found at sample farms in rice-wheat zone; diesel tubewell (58.2%) followed by tractor driven (40.3%) in cotton-wheat zone; diesel tubewell (56.8%) followed by tractor driven (36.5%) in mixed cropping zone; and all three in mixed cropping zone with decreasing orders as diesel (56.3%) followed by electric (28.2%) and tractor driven (15.5%). The mean depth of tubewell bore on sample farms was estimated as 176 feet, with decreasing order bore depth across zones as 233 feet in mixed zone followed by 209 feet in cotton-wheat, 145 feet in low intensity zone and 135 feet in rice-wheat zone.

As far as adoption of various water conserving technologies is concerned, a number of techniques (e.g. laser land leveling, crop plantation by zero tillage, direct seeding, bed planting, ridge sowing, drip irrigation, sprinkler irrigation, run-off minimizing by diverting flows, use of moisture meters, mulching, etc.) are available in the technologies shelf. Each one has associated installation and operational costs, operational eases and difficulties vis-à-vis the amount of water saved/conserved compared to flood irrigation. In Pakistan, the diffusion of laser land levelling has been relatively more compared to other techniques. Secondly, methods like drip irrigation, sprinkler irrigation, bed planting etc. are relatively more practiced for producing high value crops like fruits and vegetables. The same has been observed during our field survey. During the survey, 189 adopters of laser land leveling, 6 cases of direct seeding rice practitioners and only one case raised bed planting were interviewed. Among these, relatively highest diffusion prospects of diffusion of laser land levelling has been reported by the farmers, whereas relatively low diffusion prospects were observed for the technologies like bed planting and rice sowing by direct seeding (DSR).

Contribution of Agriculture Sector in Pakistan's Economic Growth: An Empirical Analysis

The importance of agriculture sector in Pakistan economy is a time proven reality. In Pakistan's planning history, agriculture is ignored from time to time and used to attract the attention of policy makers when the country has either faced extensive crop failures due to various reasons or food production fell short of demand. Whether agriculture is crucial for accelerating the rate of growth in the economy or the industrial sector as the only engine of growth and how the tertiary agriculture is linked up with other sectors of the economy is a debatable issue. Yet, it remained answered with empirical evidence. The uneven patterns of growth in the agriculture, industry, services and exports are the outcome of various policy and implementation reforms, which have triggered a renewed interest in studying the inter-sectoral relationship between agriculture and other sectors. The prime objective of this chapter is to investigate the importance of Pakistan agriculture in inter-sectoral perspectives.

This study was designed to statistically test the contribution of agriculture sector in economic growth of Pakistan through estimation of relationship between agriculture sector and Pakistan's economic growth using Autoregressive Distributed Lag (ARDL) bounds test and Error Correction Model (ECM). Time series data on selected variables was utilized from 1981-2018. Study found that real agricultural value added has a positive impact on the growth of real GDP per capita in the long-run where one percent increase in real agricultural value added increases the real GDP/capita by 0.73%. This indicated that the promotion of agriculture sector leave far reaching effects with respect to economic growth of the country. Coefficient of error correction term (ECT) is -0.66 meaning that if there is any disequilibrium, it will restore @ 66 percent in the first period. Analysis also suggested that measures should be taken for stabilizing the terms of trade (TOT) to enhance the economic growth as fluctuation in TOT negatively affect the economy. Moreover, results also pointed out the prevalence of Malthusian theory in Pakistan which necessitated the need to accelerate the technological advancement and investment in human capital to enhance the economic growth as suggested by exogenous growth theory.

Prospects and Constraints of Onion Production and Marketing at Small Farms Sindh: A Case Study of District Tando Allahyar

Onion (*Allium cepa* L.) is one of the important condiments widely used by every household in Pakistan. Though it is planted in all the four provinces of the country, but Sindh has relatively largest share in area and production. Though Punjab falls at second position in terms of onion area, but its total production is much lesser than Balochistan, which is third largest contributor in onion area in the country. In other words, per hectare yields of onion are much higher in Balochistan than Sindh and Punjab provinces. In Sindh province, the major onion growing districts in decreasing order are Jamshoro followed by Mirpur Khas, Matiari, Sangarh, Shaheed Benazirabad, Dadu, Umerkot and TandoAllahyar. According to Agriculture Census (2010), among these, relatively marginal sized farms (i.e. upto 5 acres) are Mirpur Khas, Umerkot and TandoAllahyar. The present study was conducted to generate updated information on cost of production and production practices adopted for onion cultivation at small sized farms in Sindh as well as identify constraints at smallholder farms during production and marketing of this important cash crop. Keeping in view the budget constraints,

a sample of 24 onion growers were selected randomly from TandoAllahyar district of Sindh. The results were obtained in respect of six months maintenance costs and returns for various categories of onion cultivation during the year 2018-19. The sample farmers' profile shows that on average, they were 36.5 years old, with farming experience of nearly 14 years and more than half of them (54.3%) were illiterate. Their mean operational land holding was 4.96 acres. NasarPuri – the most popular onion variety – was found planted at 87.5 percent of sampled farms. It was also found that sample farmers were not planting hybrid varieties, due to hot weather conditions prevailing in the area. They plant onion nursery in Kharif season during May-June, transplant it July-August and harvest from late October till December. The main production constraints of sampled farmers were the high inputs prices of inputs particularly the seed cost and labor charges on hoeing and weeding (because onion cultivation is a highly labor intensive activity) and excessive rains during monsoon season. On marketing side, sudden fall in prices due to abundant supply, low storage capacity at farmers' part and high transport costs force them to accept any price offered by the traders in the market. The mean cost of production was estimated as Rs. 115120 per acre at an average yield of 8260 kg/acre. The mean gross revenue was Rs. 154875 and gross margins as Rs. 52755 per acre and net income was Rs. 39755 per acre after deducting land rent making Cost-Benefit Ratio as 1:1.35. It is worth mentioning here that our sample farmers were obtaining good yields which is close to the potential of 22 tons/ha. So, due to huge price fluctuations, sampled farmers were not able to get potential benefits from their onion crop. It was concluded that high net returns was possible if government intervene and reduce the high fluctuation in onion prices in the markets in future.

A Study of Consumer Response about PARC Yogurt Purchased from PATCO Shop at NARC

In the present study, feedback was generated on consumers' response purchasing PARC yogurt from PARC Agro-tech Company Limited (PATCO) Display Centre in National Agricultural Research Center (NARC). The underlying motive was to examine the consumption competitiveness of PARC yogurt against popular brands from Nestle Pakistan, Adam's and Milk Pak, etc. PARC yogurt is also relatively cheaper than these brands. For comparison analysis purposes, two groups of consumers were made, i.e. PARC employees and outsiders (i.e. buyers from outside, friends and relatives of NARC/PARC employees). In total a sample of 27 respondents was gathered. Chi-square test was applied to test the differences statistically. Besides, the interesting finding showed that out of 27 respondents 17 of them were outsiders, indicating a good response at the beginning of this intervention in PATCO business. Further, 21 out of 27 sample respondents has reported our yogurt was consumed by all family members (i.e. 12 PARC employees and 9 outsiders). As a matter of fact, yogurt was used throughout the year however, increased consumption of yogurt was observed in summer (67%) as compared to winters and at other times of the year almost (33%). Overall acceptance level of yogurt was high (72.73%) for consumers from outside in contrast with PARC employees (19%). Likewise, most of the buyers from outside NARC were highly satisfied in terms of taste, flavor, appearance, price and packing size as compared to PARC buyers. It is certainly a highly encouraging response. It is recommended to ensure sustainable supply of PARC yogurt along maintaining its quality and standards with some improvement in the packaging, if possible.

Banana Market Integration and Co-integration: Implications for Sustainable Agricultural Development

The prices are control and guide the consumption, production and decisions of the market over time, form and places in the market driven economy. Therefore the market integration of agricultural commodities are deeply investigated which added the valuable information regarding the mechanism of the market adjustment and provide justification for government intervention. These papers estimate the degree of market integration in the provincial banana markets in Pakistan by using the ADF and Johansons Co-integration analysis. The monthly wholesale price series from January, 1976 to December, 2016 are used for analysis. The results indicate that banana provincial markets are perfectly integrated with each other and Hyderabad is the dominate market for banana in Pakistan. All the other provincial markets are well integrated with the Hyderabad. That results revealed that high degree of market integration are fairly competitive and give the little reasoning public and private sector for intervention planned to improve the market efficiency and enhance the competitiveness.

Farmers' Perception, knowledge and Responsive Strategies at Farm Level about Climate Change in Central Valley of Khyber Pakhtunkhwa-Pakistan

Knowledge about climate smart agricultural production technologies is the main factor of agricultural development. Knowledge gap is at the crux of the yield gap. Present study assessed farmers' perception, knowledge level and responsive strategies at farm level regarding climate change in central valley of Khyber Pakhtunkhwa-Pakistan. For this purpose, sixty farmers were randomly selected comprised of 30 farmers each from districts Charsadda and Nowshera. Knowledge index and multiple regression model was applied. The farmers' knowledge level was measured in fourteen climate smart improved agricultural production technologies. Present study explores that overwhelmingly majority (98.3 percent) of the farmers were aware about climate change. More than four-fifth (86.7 percent) had adjusted their sowing as per climate change scenario. Most of the farmers (81 percent) perceived that low production was the major impact of climate change. The farmers (83.3 percent) had frequently irrigated their crops during high temperature while in low temperature, 41.7 percent of the farmers applied fertilizer and irrigation. The knowledge score obtained from obtainable 28 scores for farmers of districts Charsadda and Nowshera was 10.83 and 9.17 scores respectively. The overall scores obtained by the sampled farmers was 10 out of 28 obtainable scores. Majority (68 percent) of the sampled farmers had medium knowledge level. The overall knowledge level was 35.71 percent in recommended climate smart improved agricultural production technologies. The farmers of district Charsadda had high knowledge level (38.67 percent) as compared to the farmers of district Nowshera (32.75 percent).

The empirical results regarding climate smart improved agricultural production technologies showed that the farmers of district Charsadda had highest knowledge level in crop rotation (73.34%), maize (OPV) varieties on ridges/seed bed (66.67%), early maturity (short duration) sugarcane varieties (60%) while in district Nowshera, the farmers had medium knowledge level in crop rotation (56.67%), pesticides safe handling and uses (50%), maize (OPVs) varieties on ridges/seed bed (48.34%), laser leveler (45%), wheat crop recommended fertilizer application per acre (43.34%), maize crop recommended fertilizer application per acre (43.34%). Similarly, in district Charsadda, medium knowledge level was found in pesticides safe handling and uses (50%), wheat crop recommended fertilizer application per acre (48.34%), maize crop recommended fertilizer application per acre (46.67%) and sugarcane crop recommended fertilizer application per acre (43.34%). However, least knowledge level was found in wheat cultivation on ridges/seed bed (26.67%), IPM techniques (26.67%), early maturity (short duration) maize (OPVs) varieties (25%), heat and drought tolerant maize (OPVs) varieties (23.34%), drought and heat tolerant wheat varieties (18.34%), laser leveler (16.67%) and organic farming (16.67%) in district Charsadda. Likewise, in district Nowshera, least knowledge was found in early maturity (Short duration) maize (OPVs) varieties (28.34%), sugarcane crop recommended fertilizer application per acre (25%), IPM techniques (25%), drought and heat tolerant wheat varieties (21.67%), wheat on ridges/seed bed (21.67%), heat and drought tolerant maize (OPVs) varieties (18.34%), organic farming (16.67%) and early maturity (short duration) sugarcane varieties (15%).

The results of the regression model showed that education, land holdings, contact with agricultural extension department, farm services centers membership and district (locality of the farmers) had substantial effect on knowledge level of farmers. Lack of improved knowledge (52%), lack of financial power (20%), irrigation problems (10%) and high cost of inputs (10%) were the most important problems faced by the sampled farmers about climate smart improved agricultural production technologies. The agricultural departments need to develop and disseminate climate smart technologies. Government and private organizations should arrange trainings and awareness programs regarding climate change to overcome the effect on agriculture.

Assessment of Pond Fish Farming in District Peshawar of Khyber Pakhtunkhwa: Livelihood Assets and Profitability

Khyber Pakhtunkhwa has advantage of having water resources suitable for Cold water fisheries, Semi Cold water fisheries and Warm water fisheries. Polyculture type of pond fish farming exists in different forms depending on water availability and land quality in shapes like square, rectangle, U-shaped and triangle. This study was designed to explore the livelihood and economics of pond-fish farming in Peshawar district of Khyber Pakhtunkhwa. For this purpose, seven pond fish farmers from district Peshawar of Khyber Pakhtunkhwa were interviewed. It was found that the surveyed pond fish

farmers were quite young, educated with pond fishing experience of 4.08 years and 29 percent had developed their skills of fish farming through obtaining formal training from the Fishery Department of Khyber Pakhtunkhwa. The main objective of pond fish farming for majority was income generation and had land suitable for fish farming. The water sources were ground seeped water, river canal, irrigation channels and pumping of underground water through machine. The fry/fingerlings Grass Carp, Silver Carp, Rohu Species, Morvi and China raised were obtained from Punjab province. The total household income from farming was Rs. 806000 per annum, with a composition of 29 percent from fish farming, 27 percent from crop farming, 24 percent from farm and non-farm employment, 13 percent as foreign remittances, 6 percent from livestock farming and 1 percent from vegetables cultivation. The limited credit facility was available in the study area as 29 percent stated they availed it from landlord and the input dealer for fish farming. The distance to facilities related to fish farming like fishery offices, fishery input market and fishery output market had located at a distance on average more than 10 km. Half of the sampled respondents had necessary items for fish farming. Technology use information/technical assistance was obtained from fellow farmers (43 percent), own experience (29 percent), Fisheries Department (14 percent) and using internet (14 percent). The sampled pond fish farmers were worrying about poisoning and poaching. The government support was in the form of financing, training and information provision.

The average pond size was estimated as 1.82 acres. Total cost of fishing farming was estimated as Rs. 202957 per pond with a composition of fixed and variable costs as Rs. 78275 per pond and Rs. 124683 per pond, respectively. The gross revenue was estimated at Rs. 293861 per pond, while the gross margin was Rs. 169179 and net-farm income was Rs. 109922 per pond. The returns on total cost (0.45), return on variable cost (1.36), BCR (1.45), NPV (489, 575), IRR (0.16) and ROI (0.64) were found favorable for investment on pond fish farming and encouraging. The problems mentioned were high rates of service charges of fisheries experts, expensive feed, high cost of water while using power machine, non-availability of seed fish/fingerlings on time, non-availability of feed, water scarcity for those using canal water, social problems like watch and ward. The suggestions perceived were arrangement of more demand driven training to the farmers, feed availability on reasonable prices, regular visits by fisheries experts from Department for giving suggestions on pond, provision of quality seed fish/fingerlings on time, subsidy on water (Tubewell), subsidy on inputs, awareness in area regarding social issues like watch and ward, financial support and involvement of water management Department in Fishing, mainly for those that watering their ponds from canals.

Adoption and Impact Assessment of Zero Tillage Drill Technology for Wheat in Rice-Wheat System in Usta Muhammad, District Jaffarabad, Balochistan

The purpose of this study was to see which factors are mostly affecting the adopter and non-adopter growers of zero tillage technology in rice-wheat system of Usta Muhammad District Jaffarabad Balochistan and also to compare and evaluate the cost and crop yield per acre of wheat crop by using conventional and zero tillage technologies, to examine the cost benefit ratio and its constraints and recommendation.

The mostly farmers adopted the zero till technology first time in 2015 through ICARDA project while during 2018-19 among the total area 13.11 acres almost 8 acre was sowing through zero tillage technology. Some adopters attend farmer field day about the zero tillage technology and some farmers aware already of ZT Drill disseminated under the project before this field day and the source of awareness was ICARDA SF project in study area. Adopter farmers reported the many benefits of this technology but most important benefits were obtained high yield and low expenses. The non-adopters reported they did not continue zero tillage technology due to risk and small land holding. The impact of zero tillage technology for adopter farmers were improved cost of production while non-adopters farmers. It had no effect or decreased/worsened cost of production.

The cost of production overall for conventional practice in wheat crop was higher per acre as compared to zero tillage. By adopting this technology farmer in wheat crop save leveling, ploughing, weedicide and fertilizer applications in zero tillage practices. Further result revealed that total expenditures per acre were Rs. 21659 and Rs. 16587 of conventional farmers followed by adopters of zero tillage practices respectively. Net income of adopter farmers of zero tillage practices was received high than those farmer's which conventional practices in the study area.

During the survey results show that by adoption of zero tillage farmers faced many constraints in adoption of this technology like extension and financial factors mostly lack of local manufacturing

facility, non-availability of quality drill at desired time, lack of extension services, lack of mass awareness media about benefit of zero tillage, unavailability of subsidy on ZT machine, and lack of credit facilities for purchase of ZT machine.

Effects of Climate Change on the Cropping Area and Yield of Wheat and Rice Crops in Punjab

The crops that grows for food need specific climatic conditions to show better performance in view of economic yield. This study is undertaken to investigate the effects of climate change (viz. changes in maximum temperature, minimum temperature, rainfall, humidity and sunshine) on the yield and cropping area of wheat and rice crop in Punjab. The results of regression analysis for wheat showed that rainfall and morning humidity was significantly affecting wheat area at 5 percent level of significance whereas the evening humidity, maximum and minimum temperature and sunshine were not significant for wheat area model of Punjab, Pakistan. In case of wheat yield, the variables of rainfall and morning humidity, minimum temperature and sunshine were found significant at 10 percent level of significance. The results of regression analysis pertaining to rice area indicated rainfall was significant at 1 percent level of significance. On the other hand, evening humidity, minimum and maximum temperature were found to be non-significant means that did not affect rice area. Likewise, regression model for rice yield indicated that rainfall and morning humidity were statistically significant whereas evening humidity, minimum and maximum temperature and sunshine were found to be non-significant. In short, the variables rainfall and morning humidity have influenced wheat area, while wheat yield was greatly affected by rainfall and morning humidity, minimum temperature and sunshine. Moreover, the rainfall had an effect on rice area while rice yield was affected by rainfall and morning humidity. To cope with and mitigate the adverse effects of climate change, there is a need for the development of heat- and drought-resistant high-yielding varieties to ensure food security in the country.

Development of Fruit Candy through Reverse Osmosis and Freeze Drying

Consumer interest in natural products is now a global trend. This tendency manifests itself in new concepts of types “functional food,” “Vitafood,” and “nutraceuticals,” formally expressing the relationship between diet and health. Candy is defined as preparations of sugar, honey, or other natural or artificial sweeteners in combination with chocolate, fruits, nuts, or other ingredients or flavorings. Fruit candies or candied fruit is gaining popularity among health conscious consumers as it provides health benefits of fruit and curtails sweet craving. Different formulations of date, tamarind, pineapple and cereal bars have been evaluated for their functionality by various researchers and are reported to be a rich source of vitamins, minerals, dietary fiber and natural sugars which could be potentially used in food security approaches. Present study was designed to develop fruit candies from guava, watermelon and Kinnow to provide a healthy and nutritious snack in the market. These fruits are produced in Pakistan in bulk and due to their perishability and non-sufficient and expensive storage facilities, major proportion of these fruits goes wasted. These candies will also provide solution to wastage of fruit along with the provision of healthy sweets to children which will ultimately be hoarded from harmful effects of sugar based bonbons with artificial flavors.

Results indicated that significant differences were observed for method used for candy development for selected physio-chemical parameters during storage. Guava, watermelon and Kinnow candies developed through reverse osmosis scored better scores for taste, flavour, mouth fullness and overall acceptability than candies developed through freeze drying. All the tested parameters i.e., pH, acidity, TSS, total and reducing sugars for all the fruit candy samples were in acceptable range during storage time.

DIRECTORATE OF SCIENTIFIC COMMUNICATIONS AND PUBLICATIONS

Directorate of Scientific Communications and Publications (DSC&P) progress report during 2021-22 is as under:

Media Activities

DSC&P is providing scientific and functional media coverage and photographic services to the scientists of PARC/NARC and its establishments. In 2019-20 DSC&P produced and uploaded 10 documentaries on different crops and provided the facility of video recording of different crops

including Wheat, Hybrid Rice, Sesbania, Canola, Garlic, Pulses and Floriculture at NARC. It also provided video coverage and editing facility for more than 40 important functions events and meetings including meeting of PARC BOG, IPARCC meeting, training sessions, exhibition, and important visits of dignitaries and also provided the sound system and audio facility for different 50 functions and events. 10,236 photographs were snapped for field /lab experiments and 97 significant events were covered.

PARC Website

PARC Website (www.parc.gov.pk) developed in 1998 and formally inaugurated in August 2000 is being maintained and updated regularly. Website is regularly updated on the imparted information provided by different Centres, Institutes, Directorates and Programs of PARC and Directorate of Public Relations & Protocol.

NARC Library

Seventy two new books/documents and 129 journal issues were added to library stock. Library has started building digital collections and during the current year, 4875 books/documents were added in digital library. 80 requests for literature search received throughout Pakistan were entertained and 9765 abstracts/ references supplied. For facilitating scientific community in review of Pakistani literature 1610 new records were added to abstracting data base "Pakistan Agriculture Database" which thus holds a total 11346(+) records with its access on internet under PARC Website. Internet based union database of journals in agricultural libraries containing information of 3029 journal/magazine titles with available volumes and issues in 36 libraries were updated with 83 new volumes besides its updation by participating libraries. Forty reprints were supplied to foreign agencies / scientists and local scientists.

Input to AGRIS database of FAO

Information of 1530 Pakistani published agricultural research articles/documents were shared with international scientific community by sending input of FAO AGRIS database.

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 AGRIS of FAO; CAB Abstracts; Pakistan Sciences Abstract of PASTIC. PJAR has signed contract with a British publisher partner Smith and Franklin after approval by the competent authority 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-Journal-of-Agricultural-Research/24>.

Annual Report

Annual Report is a regular activity report of PARC published every year and uploaded on PARC Website can be seen and downloaded from 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 32 (2019) were published and available online on PARC website.

DIRECTORATE OF HUMAN RESOURCE DEVELOPMENT (HRD)

The directorate of Human Resource Development (HRD) of PARC deals in capacity building of man power by processing of cases for the award of foreign fellowships at Post Doc, Ph.D and M.Sc levels besides other long/short term trainings, visit of meetings/symposia etc. This also facilitates for trainings to scientist and non-scientist officers in national institutions of Pakistan besides trainings at graduate/post graduate levels in country. In the second part of the financial year 2019-2020, like other countries of the world, Pakistan had to face Covid-19 Pandemic. In most of the short term trainings (146 foreign/local cases) virtual facilities were used for Poultry Production and Health, Plant Genetic Resources, Sustainable Mechanization for Smallholder Farmers, Vegetable Breeding for the Tropics, R&D Postharvest and Processing etc. Amid Covid-19, computerized technologies were used to train scientists and to disseminate agriculture knowledge for farmers and researchers.

AGRICULTURAL ENGINEERING DIVISION

The Division's main thrust remained to design, develop, adapt, and introduce energy-efficient and precision agricultural machinery with a focus on promotion of energy-efficient farm mechanization and post-harvest technologies for cereal, fruits, vegetables, and other crops. Division is also playing an important role in coordination among the stakeholders related with promotion of agricultural mechanization in the country. The Division is also exploring and utilizing solar thermal energy for drying of dates and chilies value addition in production catchment areas of Sindh and Balochistan besides providing technical inputs for development of National and International machinery standards.

ON-GOING DEVELOPMENT PROJECTS

Ispaghool Processing Machinery

Ispaghool or psyllium (*Plantagoovata*) is an ancient herb originated from Iran and later on its cultivation was started in the Middle East, Egypt, India and Pakistan. Ispaghool husk is widely used as a remedy for stomach ailments. In Pakistan, Ispaghool crop is cultivated in TharParkar and Cholistan areas of Sindh and Punjab provinces, respectively. Traditionally, this crop is sown by broadcasting method, harvested using sickles and threshed manually. The average yield of the crop is about 8-10 maunds per acre. The threshed seed contains many impurities like dust, straw, stones and weed seeds. The raw seed is cleaned by passing it through different sieves. The seed is de-husked using stone type chakies to detach husk from seed. The mixture of detached husk and seed is separated through winnowing method using a pedestal fan. Husk powder present in the mixture diffuses in the air and causes respiratory diseases among labourers. In this process, dust gets mixed in husk, which not only reduces quality of husk but also makes it unhygienic for human consumption. For getting health benefits from ispaghool husk, it should be free from all impurities.

To address above problems, an innovative Ispaghool processing technology was designed, developed, and successfully demonstrated in the country. This plant includes an ispaghool thresher, de-bearder, seed cleaner, de-husker-winnower and air classifier, which processes ispaghool seed under hygienic conditions.

The plant can process about 1.5 tonnes of seed in one shift (10 hours). It requires at least three labourers including one plant operator for its operation. The processing cost and income of ispaghool plant is Rs. 9,965 and Rs. 10,827/40 kg seed, respectively with a net profit of Rs. 862 for 40 kg seed. The net profit for one day (10 h) shift is Rs. 32,311, when 1.5 tonnes of ispaghool seed is processed daily.



Ispaghool processing machinery developed at AEI, NARC

Manual and Tractor-Mounted Maize Planters

In Pakistan, maize is the third most important cereal crop after wheat and rice. It contributes 2.2 % to the value added in agriculture and 0.4 % to national Gross Domestic Product (GDP). Two maize crops are grown in the country: spring maize (from mid-December to end March in the Punjab and from October to mid-February in Sindh) and autumn maize (from mid-May to August in Punjab and from June to mid-September in Sindh).

Flat sowing of grain maize has been replaced with ridge/bed sowing nowadays to save irrigation water. Ridge sowing not only improves the irrigation efficiency but also develops a good root structure of crop. In Punjab province maize planting on ridges/beds is done manually, which is labour (women labour) intensive operation. Manual dibbling is an expensive planting method and gives uneven planting depth and spacing. It causes labour shortage and therefore delays maize planting

activity. Uneven planting depth and spacing is very common in manual dibbling, which effects the crop yield. All these factors contribute to a decreased productivity and a low profit. Although there are a few manual and tractor-mounted planters in the country, but planting precision is not up to the desired level.

A manual maize planter was designed and developed at AEI, NARC for planting maize crop. The performance of the machine was very good, but maize planting at beds was difficult using this machine. Three other manual planters were identified and procured for maize planting. These planters were preliminarily tested at AEI area and identified that a dibbling-type planter had better precision than plate-type and roller-type planters. A tractor-mounted planter will be developed based on this concept.



Testing of manual maize planters at AEI

Productivity Enhancement of Wheat – Pak Seeder

The total rice-wheat area in the Punjab is 1.25 mha, which is 57% of the total rice-wheat area in the country. For enhancing wheat productivity, timely sowing of crop is very crucial. The paddy crop is mainly harvested using a combine harvester leaving very heavy residue and stubbles in the field. Handling of combine harvested paddy residue has been becoming a great concern to the farmers in rice-wheat cropping system and sowing of wheat crop is vulnerable to delay. Generally, the rice residue is burnt in the field, which is an easy and cost-effective method of straw disposal. However, burning of residue not only results in loss of precious crop nutrients, but also poses a great threat to the environment, human health, and economy. The smog restricts road and air traffic and causes respiratory problems in humans and animals.

A rice residue management technology called as Pak Seeder has been developed and successfully introduced in rice wheat zone, which can directly sow wheat crop in the combine-harvested paddy fields with minimal disturbing of soil. Pak Seeder is a resource conservation technology (RCT) and rice-wheat growers can conserve soil, residue, and scared water resources. Furthermore, the time and money can be saved by adopting this technological intervention. This technology not only improves soil biological and physical health, but also increases wheat and rice yield.



Pak Seeder in field operation

Pak Seeder technology has not been completely adopted by farmers due to its operational and sustainability issues, which need to be addressed for its success. For this, relevant farmers and manufactures were visited to identify issues in this technology. Issues were discussed with local agricultural machinery manufactures for fine-tuning of this technology. In coming years, the new version of this technology would be more reliable and sustainable, and adoption of this technology would be fast by farmers of the rice-wheat cropping system.

Groundnut Digger-Inverter

Groundnut is a major kharif crop of rain-fed areas of Potohar. It is also cultivated in irrigated areas of Khyber Pakhtunkhwa and Sindh provinces. But, about 90 % groundnut is grown in rain-fed areas of the upper Punjab. It is a cash crop and major source of income of barani farmers. A well-drained, coarse textured and sandy loam soil is suitable for groundnut production.

The groundnut crop is traditionally harvested manually with a khurpa, kasola or a spade and leftover pods are collected manually from the soil as much as possible, which is labour-intensive and time-consuming operation. The tractor rear mounted blade type digger is also used to harvest the crop. The blade harvested crop is gathered manually and shifted to the threshing floor for threshing. The groundnut leftover losses due to improper groundnut harvester in the soil during harvesting are very high. The lacking in availability of proper and efficient harvesting machinery are the factors contributing to lower crop productivity. A significant amount of groundnut is lost in the soil. Recoverable digging losses of existing harvesters were up to 20-30%, which are very high.



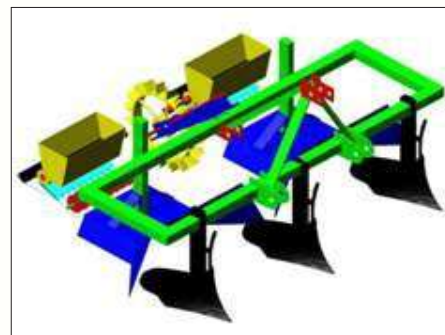
Groundnut digger and digger - inverter

Keeping in view the high groundnut leftover losses and other related factors, a tractor operated groundnut digger-inverter was identified and imported from America. The machine was commissioned for its field testing and evaluation at farm level. The unit will be extensively tested at farmer's field for its performance evaluation. Based on the field test results, necessary modification will be incorporated into the machine as per local groundnut farming conditions. This technology will be demonstrated at farmers' fields in collaboration with local agricultural machinery manufacturers.

Tractor-Operated Bed Planter for Onion Seeds Sowing

Onion (*Allium cepa* L) is one of the important condiments widely used in all households throughout the year. Onions may be eaten raw, fried, and pickled. The onion crop was cultivated on an area of 0.13 million hectares with total production of 1.67 million tonnes during year 2015-16. The production of onion grew positively witnessing a growth of 0.2 percent comparing to production of same period last year.

There are two cropping seasons of onion in Pakistan i.e., spring and autumn. Different sowing methods are being used in the country to sow onion crop. In spring cropping, first nursery of onion is sown, then this nursery is transplanted in field and on maturity crop is harvested in the month of June. For autumn crop nursery raising is too difficult due to hot month of June. Mostly farmers in Punjab resort another onion sowing method and brought seedlings from Sindh, due to hot summer, 30-40% seedlings die during transportation before transplanted into the field.



Tractor operated onion bed planter

To overcome this menace, onion production in autumn is now being done by set sowing. Sets are small onion of about 17-21 mm diameter, directly sown in soil. In Balochistan, onion cultivation is done by broadcast direct seeding method. All these methods, nursery sowing, set sowing, and broadcast method are manual. These methods require a lot of manpower and it is a continuous fatigue on farmers from nursery raising, bed shaping or furrow making, transplanting seedlings on furrows. Moreover, due to manual sowing later none of inter-cultural operation is done mechanically. To increase farm profit and reduce farm drudgery, farm mechanization is indispensable for onion sowing. In this regard Agricultural Engineering Institute (AEI) has done many endeavors to provide

indigenous solution to farming community.

The sowing of onion seeds will possibly be done by two methods, i.e., direct sowing and set producing (autumn crop) through mechanization. The development of indigenous onion planter, visited few potential agricultural machinery manufacturers and discussed the onion planter development process and identification of different machine gadgets, material used and also visited engineering faculty of different universities for further refinement of design and material used, exchange of useful development ideas and then finalized the different parts of machine along with their specifications. The machine production drawings were made with the help computer AutoCAD software. Then accordingly, the fabrication of onion planter was completed in AEI prototype development.

Productivity Enhancement of Rice – Rice Mechanization

Farm machinery plays an important role in farm mechanization, which ensures more productivity with minimum labour use and timely field farm operations, improves the agricultural productivity and reduces the losses. In Pakistan, selective mechanization has been adopted for major and cereal crops and the concept of farm mechanization is limited to the use of tractor only. Use of appropriate machinery minimized the cost of inputs and reduces the harvesting and postharvest losses. The estimated grain loss from wheat, rice and oil seed crops is around 10-15% due to use of inappropriate machinery. Currently three rice sowing methods are being adopted in the country, such as manual transplanting, mechanical transplanting, and direct seeded rice (DSR). The manual transplanting is laborious and time-consuming process and plant population achieved by this process is 50% less as compared to mechanical transplanting. This is a new technology introduced recent years in Pakistan and is gaining popularity. The benefits of this technology are timely sowing, optimal plant population, and water saving. The DSR drills have quality problem due to poor manufacturing processes & standards and seed rate calibration problems.



Calibration of DSR Drill Machine

The efforts are under way to improve the quality and working of these machines. Different meetings were conducted with rice farmer, service providers, and machinery manufacturers involved in manufacturing and marketing of the DSR drills. After detailed technical discussions, some problems were noted regarding DSR drill. Preliminary testing of DSR drill was carried out at AEI, NARC to assess its performance and problems. Field testing of DSR drill is under progress and based on field and preliminary testing of DSR drill, modifications will be suggested for improvement of DSR drill. An improved version of DSR will be developed by providing technical assistance to rice machinery manufacturer.

Postharvest Management and Processing of Peach

Peach is a delicious summer fruit, which is traditionally sold in the market without any initial postharvest processing and brings less profit to its growers. The estimated postharvest losses of fruit and vegetables in the country are 25-40%. Some key factors are responsible for postharvest losses in peach crop produced in Swat valley of KPK include poor production and pre-harvesting, crude harvesting methods, non-removal of field heat, inappropriate packaging, and mishandling in transportation.

When the packaging of peach is done without initial postharvest treatments (like washing sorting and grading), it loses its worth due to deterioration of its quality and brings high losses to its growers. All

metabolic activities such as breathing and decaying, etc. are carried-out in harvested produce. Temperature has a big effect on metabolic activity of harvested produce, lowering the temperature after harvest as quickly as possible will slow down the deterioration process and therefore extend shelf life of the produce. The rapid cooling of peach after harvest is very important to remove field heat of the produce. Currently in Pakistan, peach is marketed without any pre-cooling treatment. The quality losses of peach can be reduced by putting it in cold water or in refrigerated storage for some time. After washing air-dryers are used to remove moisture from the fruit surface.

An ALP funded project was initiated for postharvest processing and packaging of peach for marketing in the national as well as in the international markets. In this regard, a survey was conducted in the peach growing areas to see the existing processing and packaging facilities and infrastructure. Farm level processing machinery was identified, which is being procured for processing of peach and other fruits and vegetables. Meetings were also held with the processing machinery manufacturers in this regard.

Others On-going Development Projects

There are seven on-going development projects executed by different research & development institutions and engineering faculties of agricultural universities with the funding from Agricultural Linkages Program (ALP) of PARC Islamabad given as under:

- i. Solar powered temperature and relative humidity monitoring for the multipurpose silo bin, The School of Electrical Engineering and Computer Sciences (SEECS), NUST Islamabad.
- ii. Designed and development of a tractor operated carrot harvester and trimmer, Agricultural Mechanization Research Institute Regional Office, Faisalabad.
- iii. Smart phone based on tree mango fruit maturity and quality estimation using near infrared spectroscopy and machine vision, Department of Mechatronics, EME Rawalpindi.
- iv. Design, development, and computational modeling of a solar assisted cold storage system for the preservation of perishables agricultural products, Faculty of Agricultural Engineering and Technology, University of Agriculture, Faisalabad.
- v. Development of low cost zero-energy cooling chambers for field heat removal and storage of fruits and vegetables and its transfer to small farmers, Nuclear Institute of Food and Agriculture (NIFA), Peshawar.
- vi. vegetable drying and value addition- A way forward to establish rural entrepreneurship in south Punjab, Bahauddin Zakariya University, Multan
- vii. Postharvest processing of chilies for producing quality produce, Arid Zone Research Institute (AZRI) Umerkot.

Short listed Development Project For ALP Funding (9th Batch)

More than sixty-four preliminary engineering project proposals were received from different R&D institutions, agriculture, and other universities for funding under PARC Agricultural Linkages Program (ALP) 9th Batch out of which the following eleven (11) project proposals were selected on merit for further processing and reviewing by different professional reviewers:

- i. Strengthening of AEI research and development facilities.
- ii. Production of standard compost at NARC, a joint project of LRRRI and AEI.
- iii. Adaptation and commercialization of silage making machinery in Pakistan, AEI, NARC.
- iv. Development of hybrid indirect type solar dryer for drying of fruits and vegetables, NIFA Peshawar.
- v. Development of optimal solar thermal desalination system employing evaporation and condensation through heat recovery method, University of Agriculture, Faisalabad.
- vi. Develop an innovative technique for processing the olive fruit waste to achieve leftover oil for edible use, The School of Chemical & Material Engineering (SCME), NUST Islamabad.
- vii. Introduction, promotion, and adaptation of mechanized seeding and transplanting of vegetables, Agricultural Mechanization Research Institute (AMRI), Multan.
- viii. Design and development of indigenized compost windrow turner for the enrichment of soil nutrients, MNSUA, Multan.
- ix. Study on modified atmospheric packaging of peaches, strawberry, okra, and peas under controlled storage conditions, Agriculture Research Institute, Tarnab Peshawar.
- x. Development of dust control mechanism for wheat thresher to minimize environmental pollution

and control health hazard of farming community, Faculty of Agricultural Engineering, PMA Arid University, Rawalpindi.

xi. Development of prismatic solar collector for drying of fruit, vegetable, grains and feed heating, Agriculture University, Peshawar.

Developed Project Proposals/Concept Notes

The following project proposals/concept notes were prepared and submitted to the Directorate of Coordination, PARC for funding from PSDP or Foreign resources:

- I. Concept note on “Establishment of six (6) Machinery Display and Training Centers”.
- ii. Concept note on “Establishment of Agricultural Machinery Testing, Performance Evaluation and Training Center in Pakistan”.
- iii. Concept note “Establishment of Pilot Scale Facility and Display Centres for Processing and Value Addition of Fruits & Vegetables in Pakistan”.
- iv. Concept note “Relocation of Chinese enterprises of farm machinery manufacturers for producing the machinery locally”.
- v. Concept note on “Establishment of Post-harvest and Food Engineering”
- vi. Concept note on “Adaptation of postharvest processing technologies for dates in Balochistan”.
- vii. PC-1 on “Identification, adaptation, and testing of innovative post-harvest processing technologies for value addition of fruits & vegetables in Pakistan”.
- viii. PC-I on “Domestication and Commercialization of Medicinal & Industrial Cannabis”.

PLANNING AND DEVELOPMENT DIVISION

Failing to plan is planning to fail the planning is such a vital process which provides the information to top management needs to make effective decisions about how to allocate the resources in a way that will enable the organization to achieve its objectives.

Pakistan Agricultural Research Council (PARC) through Planning & Development Division (P&DD) with three directorates is supporting National Agricultural Research System (NARS) by coordination, designing, processing, monitoring and evaluation of research and development activities/projects funded under: a: Public Sector Development Program (PSDP) b: Agricultural Linkages Program (ALP) and c: Research Agreement Projects (MoU types). PARC establishment is providing the much-needed research funding to all components of the National Agricultural Research System (NARS) for the improvement of research and development efforts through Agricultural Research Endowment Fund (AREF). PARC has been playing a significant role in NARS infrastructure improvement and human resource development. In the following paragraphs the performance of P&DD in term of projects appraisal, implementation, desk monitoring, review and evaluation is given as under:

Appraisal, Processing and Approval of Projects

- i. ALP 8th Batch is still in operation. Out of 362 shortlisted proposals 133 project proposals were finally approved. Currently, 111 ALP projects are being implemented under PARC, Universities and other provincial research institutes throughout the Pakistan and 24 projects have been completed successfully.
- ii. Concept papers (1515) received under ALP 9th Batch 1515 are in process of preliminary appraisal by technical divisions, PARC and by two national referees.
- iii. During the year 2019-20, 15 PSDP project proposals (12 for DDWP and 03 for CDWP/ECNEC) were processed for funding under Public Sector Development Program (PSDP). Out of 15 proposals 09 have been considered by the competent forum and finally approved with total cost of Rs. 58002.554 million.

Public sector development projects for next five years (2019-24)

S. #	Title of Projects	Total Cost (Rs. in million)
1.	Productivity enhancement of rice	15789.402
2.	Productivity enhancement of sugarcane	4937.225
3.	Productivity enhancement of wheat	30455.353
4.	Productivity enhancement of pulses	1437.358
5.	Updation of agro-ecological zones of Pakistan through satellite and in -sito data mapping	60.450
6.	Sino-Pak agricultural breeding innovation project for rapid yield enhancement.	433.936
7.	commercialization of potato tissue culture technology in Pakistan	158.830
8.	Strengthening, Up-gradation and Accreditation of National Labs in Compliance with National and International Standards on Food Quality, Safety & SPS Requirements. Accreditation of national lab. For agriculture trade	400.000
9.	Mainstreaming of Mountain Agricultural Research Centre (MARC) for the promotion of High Value Agricultural in Gilgit -Baltistan. Strengthening of mountain agricultural research Centre (MARC) Gilgit-Baltistan	330.00
Total		58002.554

iv. Under Research Agreement Projects (MoU type) 29 proposals were processed (09 foreign and 20 local) for funding under different national and international donors during the year 2019-20. So far, one proposal on honeybee has been approved.

Projects implementation and Desk Monitoring

Regular monitoring is an essential management practice which plays an imperative role in the successful implementation of projects. To have an oversight on the implementation of the on-going

projects P&DD is regularly reviewing the financial & technical progress of projects through involving finance & technical divisions and solving day to day issues regarding the revision of projects, change of PIs, revision of budget, timely releases of funds, inspection and handing over /taking over of capital assets on completion of projects, preparation of annual cash plan of PSDP of projects etc.

Discipline wise completed and on-going projects under ALP

S. #	Discipline	No. of Projects Completed	Total Cost (Rs. in million)	No. of Project s On-Going	Total cost (Rs. in million)
1.	Plant Sciences	12	53.536	49	297.648
2.	Animal Sciences	05	14.201	28	133.717
3.	Natural Resources	06	28.120	19	108.809
4.	Social Sciences	01	3.059	03	10.476
5.	Agricultural Engineering	0	0	12	93.020
Total		24	98.916	111	643.670

The detail of completed and on-going projects under Agricultural Linkages Program (ALP) is presented Table Twenty-four projects had been completed with total cost of Rs. 98.916 million and 111 projects are on-going with total cost of Rs.643.670 million during the year 2019-20 under various disciplines. Among the on-going projects, the maximum 49 number of projects are under plant sciences and 03 numbers of projects are under Social Sciences.

Region wise implemented and monitored on-going projects

S. #	Discipline/Region	Plant Sciences	Animal Sciences	Natural Resources	Social Sciences	Agricultural Engineering	Total
Agricultural Linkages Program (ALP)							
1.	NARC	13	05	07	01	05	31
2.	PARC Outstation	09	0	0	0	01	10
3.	Other Federal	10	03	0	0	02	15
4.	Punjab	10	13	07	02	04	36
5.	Sindh	0	0	02	0	0	02
6.	KPK	05	03	0	0	0	08
7.	Balochistan	0	02	01	0	0	03
8.	Gilgit Baltistan	01	0	0	0	0	01
9.	FATA	0	0	01	0	0	01
10.	AJ&K	01	02	01	0	0	04
Sub-Total		49	28	19	03	12	111
Public Sector Development Program (PSDP)							
1.	NARC	06	01	01	0	0	08
2.	PARC Outstation	0	0	01	0	0	01
Sub-Total		06	01	02	0	0	09
Research Agreement Projects (MoU Type)							
1.	NARC	07	02	05	04	0	18
2.	PARC Outstation	03	0	0	0	0	03
Sub Total		10	03	05	04	0	21
Grand Total		66	32	26	07	12	141

In-House review and On-site Monitoring of Projects

In order to know whether the projects are on track or not to achieve the set objectives, P&DD is

regularly conducting in-house and on-site monitoring and evaluation of PSDP, ALP and research agreement projects by involving a financial / technical expert at mid/end of the project implementation period. During the year (2019-20) in-house review of research agreement projects (MOU types) was conducted under the chairmanship of Chairman, PARC in which 17 MoU type projects were reviewed. Recommendation / suggestions on each projects were given on the spot.

In-house review of Research Agreement Projects (MoU types) on-going Projects

S. #	Source of Funds	No. of Projects reviewed
1.	Research Agreement Projects (MoU type)	17
2.	Public Sector Development Program(PSDP)	07*
Total		24

* Review was held at M/O NFS&R and Secretary M/O NFS&R presided over the review meetings.

The detail of projects reviewed and onsite monitored are presented in Table-4. At PARC, 17 research agreement projects (MoU type) 07 PSDP projects were reviewed during the year 2019-20.

Financial Status of Projects

The detail of annual cost of ALP projects is presented in Fig. 1. The total cost of ALP projects during 2015-16 was approximately Rs. 70 million and it was steadily going up to Rs. 110.79 million and 397.60 million in 2016-17 and 2017-18 respectively.

The detail of financial allocation of PSDP projects is given in Fig. 2. This indicates that financial allocation of the PSDP projects was Rs.930 million in 2014-15, however, it slowly reached Rs.1190.8

Fig.1: Financial status of ALP Projects from 2015-16 to 2018-19

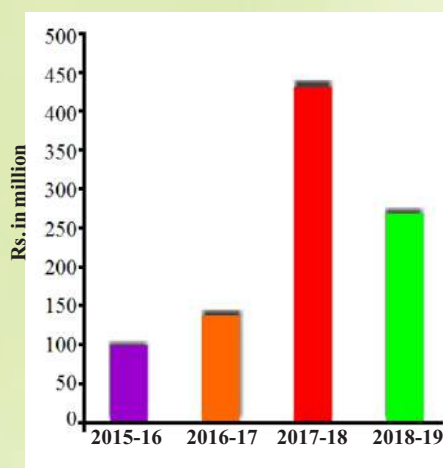


Fig.2: Financial status of PSDP Projects from 2014-15 to 2019-20

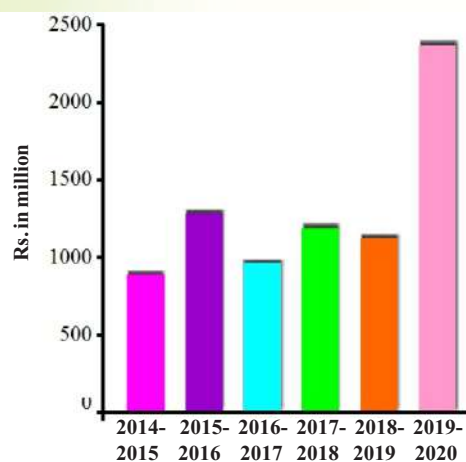
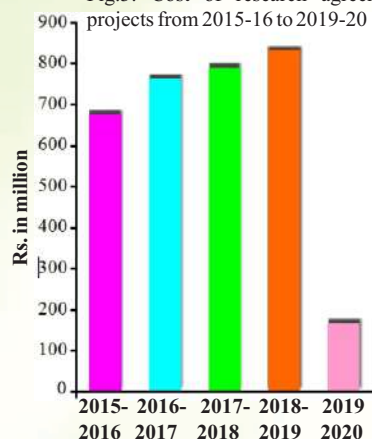


Fig.3: Cost of research agreement projects from 2015-16 to 2019-20



million in 2018-19. The GoP has currently allocated Rs.2493 million for PSDP project in 2019-20. As the Council has privilege to compete for financial assistance from the national and international donors. Fig. 3. indicates the financial assistant received under research agreement projects from 2015-16 to 2019-20. The research agreement projects cost of the national / international donors was Rs.653.84 million in 2015-16 and remained around up to Rs. 800 million till 2018-19. In 2018-19 some of international project were completed that's why the cost of research agreement projects plummet to Rs.138.149 million in 2019-20. However, some of the research agreement with international organization are underway for implementation in the current year.

Development of PARC Performance Contract, Job Description and Key Performance Indicators (2019-20)

On the directives of GoP, Planning & Development Division has developed PARC performance contract, Job description and key performance indicators of higher management /scientists and submitted to the concerned quarter for the year 2019-20. The performance contract includes:

- i. PARC goals.
- ii. Outcomes and output against each goal.
- iii. Key performance indicators against each outcome/output.

After a series of meetings, the Performance Contract and Key Performance Indicators(KPIs) in respect of Chairman, PARC and technical divisions/ planning division were developed and after formal approval the information was forwarded to M/o NFS&R.

COORDINATION AND MONITORING DIVISION

One of the main mandates of PARC is to coordinate agricultural research at national and international level. For this purpose, Coordination and Monitoring Division was created in 2012. The aim of this Division is to develop well-coordinated National Agricultural Research System (NARS) in the country as well as to link it with international, UN and CGIAR systems. The Division is involved in establishing linkages with national and international institutes, private companies, universities and NGOs through MOUs/Agreements and also by holding/facilitating national and international workshops/meetings/seminars/ conferences. The Division is also striving for Human Resource Development of the Council and NARS. The main achievements of this Division are as under:

Identification of Areas for bilateral Cooperation with foreign countries

Identified the areas of cooperation between Pakistan and National Agricultural Research System (NARS) of many friendly countries including Turkey, China, Korea, Belarus, Qatar, United States and Saudi Arabia and facilitated the Ministry of National Food Security & Research, Ministry of Foreign Affairs, Ministry of Economic Affairs and Ministry of Climate Change for strengthening bilateral cooperation with relevant Ministries of the mentioned countries.

Preparation of Briefs/ Talking Points

Prepared brief & talking points for meetings related to the agricultural research & development, for the Federal Minister, National Food Security & Research (NFS&R), and other high government officials with foreign Ambassadors and delegates. Facilitated in Holding following meetings with Foreign and National Delegates:

- i. Meeting on establishment of Korea Program on International Agriculture (KOPIA) Center in Pakistan.
- ii. Pak-China Joint Working Group meeting on agricultural cooperation.
- iii. Pak-China Joint Working Group meeting on Socio Economic development.
- iv. 11th meeting on Interprovincial Agriculture Research Coordination Committee (IPARCC).

Inter Provincial Research Coordination Committee

The aim of establishment of IPARCC is to develop formal coordination linkages with provincial research system including Gilgit-Baltistan. 11th meeting of IPARCC was conducted, in which the role of all stakeholders was discussed. It was emphasized to approach the policy makers for making legislation regarding development of livestock vaccines, using local strains to effectively control the diseases caused by viruses and bacteria.

Renewal of PARC's Membership in international organizations

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

Visa Processing Facilitation

PARC facilitated the visa processing of 24 foreign participants of Workshops/Seminars & Internationally Recruited Staff (IRS) of various agricultural research organizations, being posted in Pakistan.

Signing MoUs/ Agreements

Around 10 national level MOUs/ Agreements have been signed with universities/ Agri-tech companies/ NGOs/ Public-Private Sectors for development and dissemination of research technologies forum.

PARC is striving all the time to train their scientists at far with International Level. In this regard, Human Resource Directorate of PARC has trained the following number of scientific staff locally and abroad.

Training	Program	No. of nominees
Foreign Long Term	MS/M.Phil/Diploma	1
	Ph.D	2
	Post Doc	2
Foreign Short Term	Short term courses/ workshop/ meetings/ conferences	20
Local Long Term	MS/ M.Phil/ Diploma	5
	Ph.D	3
Total:		33

FINANCE DIVISION

HIGHLIGHTS

The funds of the Council consist of the following as per article 18 of PARC Ordinance:

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

The annual accounts of the Council are audited by independent Chartered Accountants as well as the Auditor General of Pakistan under the PARC Ordinance 1981.

An Overview of PARC's Budget

(Rs. in million)

Budget Head/ Funding Source	2018-19	2019-20	
	Actual	Budget	R.E
Current Expenditure (GoP Grant)	3182.966	3001.565	3001.540
Own Resources (PARC)	65.566	80.000	67.950
Total :	3248.532	3081.565	3069.490
Development Expenditure (PSDP)	458.003	2363.183	1586.148
Agricultural Linkages Program (ALP)	168.556	370.876	370.876
Memorandum of Understanding (MoU's)	45.096	24.716	17.215

Current Expenditure

(Rs. in million)

Objects	2018-19	2019-20	
	Actual	Budget	R.E
Establishment Expenses	2942.776	2734.828	2734.807
Operational Expenses	305.756	346.737	334.683
Total :	3248.532	3081.565	3069.490

Development Expenditure

Development Expenditure budget of Rs.2363.182 million was allocated for the following on-going PSDP Projects for the year 2019-20 which was subsequently revised to Rs.1586.148 million surrendering Rs.770.035 million. The detail of projects is as under:

On-going Projects

(Rs. in million)

Sl.#	Title of the Projects	Approval Date/ Forum	Total Cost	Budget 2019-20	Revised Budget 2019-20
1.	Commercialization of Soyab Crop (Glycic MaxL) on pilot scale in Pakistan	DDWP 27-01-2015	57.939	18.351	14.088
2.	Monosex (All Male) Tilapia seed Production and Culture in Pakistan.	CDWP 19-09-2013	54.525	16.192	9.827
3.	National Pesticides Residues Monitoring System in Pakistan (PARC)	DDWP 06-08-2013	799.367	300.000	187.711
4.	Up-gradation of AZRI D I KHAN	CDWP 30-04-2018	691.564	275.000	199.827
5.	Strengthening/Up-Gradation of Agriculture and Livestock Research System of (AZRI) Umerkot, Sindh	DDWP 03-05-2017	528.592	150.000	111.087

6.	National Surveillance Program for Avian Influenza & New Castle Disease in Pakistan	DDWP 08-08-2017	50.422	33.520	33.020
7.	Productivity Enhancement of Wheat	ECNEC 29-08-2019	30.455	650.000	520.980
8.	Productivity Enhancement of Rice	ECNEC 29-08-2019	15.789	450.000	345.204
9.	Productivity Enhancement of Sugarcane	ECNEC 29-08-2019	4.937	200.000	117.393
10.	Pulses Project	ECNEC 29-08-2019	1.437	100.000	47.011
11.	Genome Projects	Unapproved		170.120	-
Total				2363.183	1586.148

Agricultural Linkage Programme (ALP) Budget 2019-20

Keeping the principal amount Rs. 1300.0 million of the Endowment Fund intact, the funds generated through income from such investments are used to finance the research activities/programs under ALP. The position of utilization of ALP funds has been tabulated hereunder:

Province wise allocation of projects

(Rs. in million)

Sl. #	Location	Budget 2019-20		Revised Budget 2019-20*	
		Total Number of Project Executed	Total Amount	Total Number of Project Executed	Total Amount
1.	Federal	46	95.770	46	122.541
2.	Punjab	54	56.338	54	90.699
3.	KPK	24	34.018	24	43.407
4.	Sindh	19	6.973	09	16.799
5.	Balochistan	05	5.825	05	7.671
6.	PARC, H.Qtr.	01	20.858	01	25.977
7.	AJK	05	2.337	05	9.691
8.	Block Allocation	Block Allocation	147.257	-	52.591
9.	Sponsoring of Short Term Exchange of Agri. and Scientist & Experts		0.000	-	0.000
10.	Scientist Award		1.500	-	1.500
11.	Membership Fee to Foreign Agencies		-	-	-
Total : -		154	370.876	144	370.876

*As on 13-05-2020

MoUs

A total of 07 projects at a total cost of Rs.24.716 million were approved under MOU's with different national and international organizations for the year 2019-20. An over view of expenditure for F.Y 2018-19 and Budget and Revised Budget of F.Y 2019-20 is as follows:

MoU's 2019-20

(Rs. in million)

Objects	2018-19 Actual	2019-20	
		Budget	R.E.
Budget	45.096	24.716	17.215
No. of Projects	19	07	07

An Overview of PARC's Budget

(Rs. in million)

Budget Head/ Funding Source	Revised Budget 2019-20
Current Expenditure (GOP Grant)	3001.540
Ow Sources (PARC)	67.950
Total:	3069.490
Development Expenditure (PSDP)	1586.148
Agricultural Linkage Programme (ALP)	370.876
Memorandum of Understanding (MoU's)	17.215
Total:	1974.239
Grand Total:	5043.729



Sahibzada Muhammad Mehboob Sultan, Federal Minister for NFS&R being briefed during his visit at Wheat Display Stall on the occasion of World Food Day-2019 held at NARC on October 16. Rao Muhammad Ajmal Khan, Chairman NA Standing Committee on NFS&R, Dr. Muhammad Hashim Popalzai, Federal Secretary for M/o NFS&R and Dr. Muhammad Azeem Khan, Chairman PARC are also present on the occasion.



Rao Muhammad Ajmal Khan, Chairman NA Standing Committee on NFS&R presiding over the meeting of the Committee at PARC on October 16. Dr. Muhammad Hashim Popalzai, Federal Secretary for M/o NFS&R, Dr. Muhammad Azeem Khan, Chairman PARC and other members of the committee are also present in the meeting.

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Pakistan Agricultural Research Council
Plot No. 20, Sector G-5/1, Islamabad