NIFA

Annual Report 2020-2021

Nuclear Institute for Food and Agriculture (NIFA), Peshawar

NIFA

Annual Report

2020-21

Compilation:

- **Dr. Muhammad Imtiaz** — **Deputy Chief Scientist**
- **Dr. Fazle Subhan** — **Principal Scientist**
- **Dr. Inamullah Khan** — **Principal Scientist**
- **Muhammad Zubair Shah** — **Principal Engineer**
- **Mr. Rauf Ullah** — **Principal Librarian**
- **Mr. Sultan Muhammad** — **Computer Operator**

NUCLEAR INSTITUTE FOR FOOD & AGRICULTURE
P.O. Box – 446, Peshawar

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ISBN: 978-969-8198-11-4

: (0092-91) 2964060-62 **Fax: (0092-91) 2964059**

Email: mails@nifa.org.pk web: http://www.nifa.org.pk

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NIFA ANNUAL REPORT 2020-21

PROLOG

Climate change threatens our ability to ensure global food security, eradicate poverty and achieve sustainable development. Climate change has both direct and indirect effects on agricultural productivity including changing rainfall patterns, drought, flooding and the geographical redistribution of pests and diseases. Such negative impacts of climate change are already being felt in Pakistan in terms of reduced yields and nutritional quality of essential crops. Substantial research and development (R&D) efforts are required to maintain current yields and to ensure food security. Nuclear Institute for Food and Agriculture (NIFA) is striving to develop climate resilient crop production technologies and climate smart high yielding crop varieties through innovative R&D plans. NIFA is committed to achieve food security and ensure food safety through research and development (R&D) by nuclear and other contemporary advanced techniques in the areas of Food and Agriculture. The major achievements of four research divisions during the period under report are summarized as below:

PLANT BREEDING AND GENETICS DIVISION

New candidate irrigated wheat line CTHN 162056 showed excellent performance in National Uniform Wheat Yield Trial (Normal) and ranked 1st throughout the country, it produced the highest mean grain yield of 4701 kg ha^{-1} over all the candidate lines throughout Pakistan. Similarly NIFA rainfed line NRL 1664 showed excellent performance in National Uniform Wheat Yield Trial and produced 2-16% higher grain yield than the checks. Four promising genotypes along with commercial checks were tested at 13 locations of KP, including NIFA, under irrigated conditions for assessment of grain yield and stability. According to the results, the genotype CTHN-172114 secured 1st position while CT-171010 secured 2nd position on KP basis by producing mean grain yield of 4505 and 4149 kg ha^{-1}, respectively. NIFA elite line NRL 1825 ranked 1st among the tested genotypes in Khyber Pakhtunkhwa Wheat Yield Trial by producing grain yield of 4660 kg ha^{-1} under rainfed conditions with a yield increase of 13-21% over the check. Based on high yield and

disease resistance 209 wheat genotypes were selected from preliminary, advanced and international wheat nurseries/trials(irrigated & rainfed).

Oilseed brassica program through consistent research endeavors have developed a new high seed and oil yielding variety NIFA Sarson-T20, approved for general cultivation in the province by Khyber Pakhtunkhwa Seed Council in its 40th meeting on April 7, 2021. Four rapeseed candidate lines viz; RR-8-2; RM-1-2; RM-1-9 and RRM-106-1 were assessed in National Uniform Rapeseed Yield Trial (NURYT) 2020-21. Performance of all lines remained mediocre to the national check. The results of 08 rapeseed recombinant/mutants advanced lines evaluated in zonal trials at four locations demonstrated that RRF_3/016-62 achieved highest genotypic mean (2283 kg ha^{-1}) followed by RRF_3/016-101 (2250 kg ha^{-1}) & RRF_3/016-82 (2204 kg ha^{-1}) against Supper Canola (2172 kg ha^{-1}). In replicated seed yield trials at NIFA; 39 rapeseed and 7 mustard genotypes were tested; one mustard and sixteen rapeseed genotypes gave numerically higher seed yield (2778-3611 kg ha^{-1}) than respective checks. In line with objectives of the breeding program, different numbers of selections were also made in F_2/M_2- F_4/M_4 breeding generations. Varietal maintenance was accomplished through raising/selecting true to type progeny rows and blocks for genetic purity.

Pulses group of NIFA has developed two first-ever black-seeded mungbean varieties NIFA Spinghar-21 and NIFA Sikaram-21, approved by the KP Seed Council on April 7, 2021 for general cultivation in Kurram. 128 advanced green-seeded recombinants and mutants were evaluated for yield and related traits in 07 sets of replicated yield trials in kharif 2020. A total of 29 genotypes produced significant average higher seed yield of 1632-2569 kg ha^{-1} against average seed yield of chick varieties Ramzan (1941 kg ha^{-1}), NIFA Mung-17 (1680 kg ha^{-1}) and Sona Mung (1403 kg ha^{-1}). Mungbean NUYT comprising of 15 entries was planted at NIFA in kharif 2020. 10 out of 48 black-seeded mungbean genotypes evaluated in 03 sets of replicated PYTs in kharif 2020 produced significant higher seed yield of 1042 to 1563 kg ha^{-1} against average seed yield of KBM (174 kg ha^{-1}), NBM (903 kg ha^{-1}) and check varieties Ramzan (938 kg ha^{-1}) and NIFA Mung-19 (972 kg ha^{-1}).

In common beans, two years mandatory DUS of two common bean candidate varieties NIFA Lobia Red and NIFA Lobia Yellow were completed and proposals for the said candidate varieties have been submitted to 41st meeting of Technical Committee of the KP Seed Council to be held in near future for recommendation. 08 common bean genotypes were also planted in adaptation yield trial

at various locations of KP for testing wider adaptability of genotypes for grain yield and related traits.

In case of chickpea, 20 advanced genotypes were screened for physiological traits related to heat tolerance under field condition at NIFA. 08 genotypes showed better performance for the physiological traits as well as per plant biological and grain yield.

In peach two exotic and twenty local germplasm were evaluated for early blooming, dwarfism and fruit maturity. Flowering were observed in 11 plants and fruit setting in three plants were noted in local selections. Evaluation of Mutants plants of Early Grand & Florida King are in progress for further evaluation in NIFA peach orchard. Bud wood of *cv.* Fazli Manani irradiated with (20 and 30 Gy) gamma rays for creation of variability were budded on the Mariana rootstock and shifted to orchard for evaluation. The earliest sprouting 4-5 days was recorded the control plants as compared to irradiated material of 30 Gy treatment. The effect of different budding dates of four plum varieties were investigated for early sprouting, percent bud sprout, buddling length and height in the nursery. The highest bud sprout was recorded in 20th October (95.5 %) followed by 10th October (94.3%).

FOOD AND NUTRITION DIVISION

In Food and Nutrition Division (FND), R & D efforts are focused on value addition and shelf life extension of food/agricultural commodities through gamma radiation and other contemporary techniques. Food & Nutrition Division is striving hard to achieve Sustainable Development Goal "Zero Hunger" through food safety and security. FND generated income through sale of indigenously produced food products (squashes, jams and syrups, mushroom and mushroom spawn), Rapid Test Kits (RTKs), and services (Gemstone irradiation and analytical services). A net sale of Rs.0.78536 million from food products is being made including 3046 jams and 4515 squashes bottles. Under ALP research project, experiments were carried out on the storage stability of fruit and vegetables (peach, strawberry, tomato and pumpkin) in Zero Energy Cooling Chambers (ZECC) and outside under thatched shed.

Seven Mushroom Training Workshops (MTW) and seven Mushroom Model Farms (MMF) were organized/established for popularization of mushroom cultivation as cottage industry at Khyber Pakhtunkhwa, upper Punjab and Baluchistan.

Ganoderma or Reishi (*Ganoderma lucidum*) medicinal mushroom was successfully cultivated on low cost substrate at NIFA for the first time among public R&D organization in Pakistan. Three plant extracts/ botanicals (*Melia azedarach*, *Azadirachta indica* and *Withania coagulans*) efficacy testing trial for the management of yellow rust disease in wheat under natural field conditions was conducted. Efficiency of botanical extracts (three spray efficiency) under field conditions ranged from 76.2% to 92.8% which is encouraging as bio pesticide for future product development and possible commercialization.

Production and purification of bacteriocin were performed. The purified bacteriocin was characterized for tolerance against, acid, bile, salts, surfactant and enzymes. It was observed that 3% bacteriocin application increased the shelf life of guava for 12 days as compared to control who became spoiled after 4 days. Probiotic yoghurt was made with NIFA-N2A-1 owing the shortest fermentation time as compared to other strains. Probiotic yoghurt remained edible for the period of one month.

Meal Ready to Eat (MRE) samples were irradiated with target doses of 14 and 15 kGy respectively. Total Viable Counts (TVC) significantly decreased and the overall observed value was 4.69 to 2.21 (log CFU/gm) for control and irradiated MRE samples. Sprout inhibition was successfully achieved for garlic at optimum dose of 400 Gy as compared to the control samples.

SOIL AND ENVIRONMENTAL SCIENCES DIVISION

Soil and Environmental Sciences Division is actively engaged in applied research on the issues of plant nutrition, water management and soil fertility management using conventional and nuclear techniques. The scientists have developed environment friendly packages of production technology for various field and horticultural crops, perfected tunnel farming technology for off-season vegetables production and developed organic fertilizer products (compost and compost tea) for particular use by vegetable and nursery growers. The technologies and products developed are transferred to stakeholders through awareness seminars, training workshops and demonstrations.

Biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding or modern biotechnology. It aims to increase nutrient levels in crops during plant growth and for this purpose screening of genotypes was carried out under hydroponics and field conditions. The findings from a study conducted under

hydroponics depicted that Zn efficiency of ten wheat genotypes varied between 44 to 75%, the genotypes NRL-1929 being the most efficient one and NRL-1901 being the least. Off-season vegetables farming in high tunnel has wide scope in the context of Khyber Pakhtunkhwa where farmers have small land holdings and job opportunities for rural youth are very limited. Experiments were conducted to optimize fertilizer doses for improving yield of tomato, bell pepper and bitter gourd. Preliminary findings revealed that yield and net returns under technically managed experimental tunnels (10 Marla) may be up to ten times higher than conventional methods of farming. The technologies of tunnel farming and compost/compost tea were demonstrated to the vegetable growers and relevant stakeholders through a one day training event organized at the institute.

Sustainable wheat production under current scenario of declining soil fertility and changing climate has emerged as a challenge. A long term field experiment established at the experimental farm of the institute is in progress to monitor impact of conversion to organic farming practices in comparison with conventional chemical fertilizer based farming. Preliminary findings from the trial depicted that that it was possible to maintain soil fertility under organic farming systems without compromising wheat grain yield.

Organic fertilizer products are in high demand owing to environment related issues arising from the intensive use of chemical fertilizers. Under a PSF funded project, a small facility has been established at the institute to prepare a liquid bio fertilizer product, compost tea from agro-waste compost indigenously prepared at the composting site of institute from wastes available at farm. A series of laboratory scale studies were conducted to standardize the protocol for the formulation of compost tea. Efficacy trials conducted on potato and spinach showed positive impact of application of compost tea on improving growth and yield as well as disease suppression.

PLANT PROTECTION DIVISION

Research endeavors at Plant Protection Division (PPD) address the protection of fruit vegetables crops and humans from insect pests and pathogens causing losses directly to humans and indirectly to the fruit, vegetables and crops for animal and human consumption. The scientists have devised environment friendly control techniques to mitigate the crop losses. A degree-day model was developed as a forecasting tool for the whole calendar to investigate the onset, peak and decline of fruit fly population. The peach fruit fly was found to exhibit 96% dominance over oriental fruit

fly. A composite of food attractant with yeast attracted significantly higher number of both male and female of *B. zonata* and *B. dorsalis* fruit flies. Dry formulations of different food baits revealed no attraction of female fruit flies towards any of the food bait. In development of efficient Bait Matrix for the subterranean termite's management, granule form of poplar wood resulted in maximum weight consumption and aggregation of termites. Amino acids (L-Proline, L. Glutamic acid), Vitamin B12, ascorbic acid, and Vitrum mixture of vitamins resulted in strong attractants for termites. Agar @ 0.5g/Kg food verified as best bait solidifying material.Trials on the use of insect growth regulators showed that IGRs are effective alternative to synthetic larvicides for mosquito control. Used bottles/ soft drink containers modified as traps for mosquitoes' surveillance were found effective for mosquitoes' trapping in the field. These traps are low cost and recommended for use in mosquito surveillance.

PLANT BREEDING AND GENETICS DIVISION

Wheat Irrigated

Maintenance of NIFA released wheat varieties

NIFA since its establishment has released a number of improved varieties Viz. Fakhr-e-Sarhad NIFA Bathoor-08 and NIFA Aman for the irrigated areas in the province in order to meet the increasing demand of seed from the government organizations, seed companies and farming community. Therefore, continuous efforts are being made at NIFA for maintenance of varietal purity of the released NIFA wheat varieties for irrigated areas of Khyber Pakhtunkhwa (KP). One hundred and thirty eight (138) blocks and 176 progeny rows of the above mentioned varieties were planted at experimental farm of the institute. Rows / blocks having off-type plants were discarded and the desired blocks/rows were harvested and threshed for production of quality seeds during the next cropping season.

Evaluation of candidate wheat lines in National Uniform Yield Trials (NUYT) under irrigated conditions

Country-wide field evaluation of candidate wheat varieties is a vital link between genetic improvement and the production environment. Two genotypes CTHN-162056 and CTHN-162009 based on higher grain yield and disease resistance in Khyber Pakhtunkhwa Wheat Yield Trial (KPWYT), were subjected to the 1st year mandatory evaluation in the National Yield Trial (NUYT). The agronomic data of the trial recorded at NIFA was submitted to the National Wheat Coordinator for necessary compilation at country level. NUYT pooled analysis showed that CTHN-162056 secured 1st position and produced the highest mean grain yield of 4701 kg ha^{-1} over all the candidate lines throughout Pakistan.

Evaluation of advanced wheat lines in Khyber Pakhtunkhwa Yield Trials (KPWYT) under irrigated conditions of KP

Multi-location testing / zonal trials of advanced wheat lines are pre-requisite for development of new genotypes with wider adaptability and selection of suitable candidate varieties for evaluation in NUYT. For assessment of grain yield and stability four promising genotypes (CT-171010, CT-171058, CTHN-172114 and CTHN-172116) along with commercial checks were tested at 13 locations of KP, including NIFA, under irrigated conditions. According to the results communicated by the Director Outreach of the KP Agricultural Research System, the

genotype CTHN-172114 secured 1st position while CT-171010 secured 2nd position on KPK basis by producing mean grain yield of 4505 and 4149 kg ha^{-1}, respectively.

Microplot yield trials (MPT) under irrigated conditions of KP

Multilocation testing of elite material is a pre-requisite for genotypes to be considered as candidate variety. Sixteen genotypes including two checks (NIFA Aman and Gulzar-19) were evaluated for grain yield and response to prevailing diseases. Four of the genotypes (CT-18048, CT-18062, CT-18063 and CT-18145) showed resistance to Yr and out yielded the check cultivars (5446 to 5666 kg ha^{-1}), by producing grain yield in the range of 5777 to 6333 kg ha^{-1}. These genotypes will be further evaluated in KPWYT 2021-22.

Agronomic evaluation of elite wheat genotypes in advanced yield trials (AYTs)

Based on yield and response to prevailing diseases in preliminary yield trials, evaluation of desirable genotypes in advanced yield trials (AYTs) is a prerequisite for further evaluation in MPT and KPWYT. The selected genotypes are being tested in AYTs conducted at NIFA.

A total of 36 genotypes including checks were evaluated in two sets of advanced yield trials (AYTs) under normal planting conditions. In all, nineteen (19) genotypes out-yielded the check cultivars (NIFA Aman, Gulzar-19 and Khaista-17) by producing grain yield in the range of 6022-7066 kg ha^{-1}. Grain yield of the check cultivars was recorded in the range of 5022-5910 kg ha^{-1}.

Agronomic evaluation of genotypes in preliminary yield trials (PYTs) under irrigated conditions

In all, 80 genotypes were evaluated in four (4) sets of preliminary yield trials under normal planting conditions. Based on higher grain yield and disease resistance, 27 genotypes out-yielded both the check cultivars (NIFA Aman and Gulzar-19). The selected genotypes produced grain yield in the range of 6488-7555 kg ha^{-1} as compared to the check cultivars NIFA Aman (Ave. 5988 kg ha^{-1}) and Gulzar-19 (Average. 5883 kg ha^{-1}). The selected genotypes will be subjected for further evaluation in AYTs during the next cropping season (2021-2022).

Field evaluation of exotic wheat germplasm

Global exchange of wheat germplasm, in particular CIMMYT through provision of observation nurseries and trials to cooperating institutions plays a pivotal role for having desirable ideotypes for wheat breeders.

53rd IBWSN (International Bread Wheat Screening Nursery) consisting of 284

genotypes received from CIMMYT, Mexico, was evaluated with local checks NIFA-Aman. Based on plant type, yield performance and disease reaction (Yr and Lr), a total of 55 genotypes were selected for further evaluation. The selected genotypes out yielded the check cultivar NIFA-Aman (8693 kg ha^{-1}) by producing grain yield in the range of 8800 – 11067 kg ha^{-1}.

8th WYCYT (Wheat Yield Consortium Yield Trial-2020-21) consisting of 33 entries was evaluated in two replications with NIFA Aman as a local check. Based on higher yield and disease resistance, 07 desirable genotypes were selected and included in advanced yield trial-III for further evaluation. The selected genotypes out yielded the check NIFA Aman (8889 kg ha^{-1}) in the range of 9389 -11110 kg ha^{-1}.

Preliminary yield trial (PYT) under Pak-China Coordination Project was conducted in three replications along with two checks NIFA Aman (8250 kg ha^{-1}) and Gulzar-19 (9000 kg ha^{-1}). Four genotypes (CIBW-2, CIBW-3, CIBW-4 and CIBW-5) out yielded the check cultivars by producing grain yield in the range of 9250 -10000 kg ha^{-1}.

41st ESWYT (Elite Spring Wheat Yield Trial) consisting of 50 genotypes was also evaluated for yield performance and reaction against diseases (Yr and Lr) with local check NIFA-Aman. Out of 48 test genotypes, 18 were selected for further evaluation and confirmation of their desired traits. The selected genotypes out yielded the check variety NIFA Aman (5600 kg ha^{-1}) by producing grain yield in the range of 5833–7000 kg ha^{-1}.

NIFA Disease Screening Nursery (NDSN) consisting of 124 genotypes included in station trials from NUWYT, KPWYT, MPT, AYTs and PYTs (2020-21) was evaluated for disease reaction against yellow rust (Yr), leaf rust (Lr) and loose smut (Ls) using standard checks Morocco as disease spreader.

Creation of new genetic variability and raising of segregating populations

Raising and maintenance of different segregating populations developed through conventional hybridization and induced mutation using gamma irradiation as mutagen is the most important breeding strategy. It is routinely carried out as a part of wheat improvement program at NIFA. The effort may ultimately results in the development of high yielding, disease resistant and widely adaptable homozygous genotypes to be released as genetically improved wheat varieties for boosting wheat production.

Genetic variability through hybridization

Thirteen genotypes of F5 populations were tested in NIFA Observation nursery (NON-2020-21) along with check cultivar NIFA Aman. The material was thoroughly evaluated during the growth period for disease / lodging resistance, high tillering capacity and early maturity. Out of 13, 06 genotypes out yielded the check cultivar NIFA Aman (6902 kg ha^{-1}) by producing grain yield in the range of 6926-8125 kg ha^{-1}. The selected genotypes were included in PYT-IV for further evaluation in the upcoming cropping season of 2021-22.

Nine desirable recombinants of F_4 populations resulted from 09 cross combinations were evaluated in the field. Based on stability, plant type & disease resistance, 09 desirable recombinants were selected for further evaluation in NON 2021-22.

F_3 population resulted from 05 cross combinations was raised in the field. Based on higher yield and disease resistance regarding their hybridized traits, 34 desirable recombinants were retained for further evaluation as F_4 population during cropping season 2021-22.

F_2 segregating populations resulted from 3 cross combinations were raised in the field in space planting. The material was thoroughly evaluated during the growth period for disease/lodging resistance, high tillering capacity and early maturity. In all, 26 desirable recombinants were selected for confirmation of their desired traits during the next Rabi season (2021-22).

A crossing block consisting of 80 diverse genotypes was planted on two different dates for acquiring floral synchrony among early and late flowering parents. Based on transfer of genes for disease resistance and other economically important traits to otherwise well adapted cultivars/genotypes, 11 fresh cross combinations were attempted. The seeds were irradiated 100 Gy dose of gamma rays. The F_1 will be raised in the field along with their respective parents for comparison during Rabi season 2021-22.

Genetic variability through induced mutation

M_2 segregating population resulted from the seed treatment of two well adapted varieties (Fakhr-e-Sarhad and NIFA Bathoor-08) each with 250 and 350 Gy doses of gamma rays was space planted in the field along with their respective control for comparison. Based on disease resistance and best ideotype, seventy three (73) desirable mutants were selected to be further evaluated during Rabi season 2021-22 for their respective mutated traits.

M_1 segregating population resulted from the seed treatment of two well adapted varieties (Fakhr-e-Sarhad and NIFA Bathoor-08) each with 200 and 300 Gy doses of gamma rays was space planted in the field along with their respective control for comparison. The material will be space planted during Rabi 2021-22 and based on disease resistance, high tillering capacity and better ideotype, desirable mutants will be selected from M_2 population.

Demonstration Plots and Seed Multiplication on farmer's field

Demonstration plots on farmer's field always plays an important role in varietal proliferation and it also helps the farming community to have easy access to the quality seed on their door step. In the year 2020-2021 1000 kg of the four cultivars of NIFA (NIFA Awaz, NIFA Aman, NIFA Insaf and NIFA Lalma) were provided to forty-one farmers of District Bunir, Swabi, Mardan and Nowshera, via their respective District Director Agriculture Extension Department of KPK. The seed was provided free of cost with an undertaking that the produced seed will be provided to the neighboring farmers. The reports from the farmers revealed that 37.28 tons of seed was produced from 41 plots in the four districts and this will be available for cultivation during 2021-22.

Source seed (10.25 metric tons) was also supplied to DDA, Bunir on the request of Director Seed KPK. The report submitted by the DDA, Bunir shows a production of 215.75 metric tons of seed. However, the DDA was only able to procure approximately 10% of the produced seed. Being small growers of the region most of the farming community withheld the seed for its disposal on their own on higher prices, as the procurement price offered by the KP government was low.

Wheat Rainfed

Performance of exotic and indigenous wheat germplasm

During 2020-21 three international wheat nurseries and trials i.e. 38th Semi-Arid Wheat Screening Nursery (38th SAWSN), 19th High Temperature Wheat Yield Trial (19th HTWYT) and 21st Elite Spring Bread Wheat Yield Trial (21st ESBWYT) comprising of 284, 50 and 50 exotic genotypes respectively were evaluated under rainfed conditions at the institute. Data regarding yield, yield components and disease resistance were recorded for each genotype at different growth stages. Based on field performance 22 best genotypes were selected from SAWSN, 11 from HTWYT, and 10 from ESBWYT for further confirmation and evaluation. In the 3rd NIFA

Wheat Observation Nursery, 86 genotypes from advanced generations were planted and harvested. Based on field performance 31 wheat genotypes were selected for further confirmation in preliminary yield trials during Rabi 2021-22.

Performance of wheat genotypes in various yield trials under rainfed conditions

Twenty-four (24) promising wheat genotypes including NIFA Awaz and PS 19 as standard checks were assessed for grain yield, yield components, and disease resistance in 02 Advanced Yield Trials at the institute. Based on grain yield and disease resistance 04 promising genotypes i.e. NRL 1901, NRL 1903, NRL 1908, and NRL 1909 were selected from Advanced Yield Trial-I and 05 promising genotypes (NRL 1911, NRL 1918, NRL 1920, NRL 1928, and NRL 1929) from Advanced Yield Trial-II. The overall grain yield in AYT-I was in the range of 4407 kg ha^{-1} to 5244 kg ha^{-1} and 3889 kg ha^{-1} to 5481 kg ha^{-1} in AYT –II. NRL 1903 ranked 1st by producing a grain yield of 5244 kg ha^{-1} showing an increase of 8 % over the check cultivar Awaz in AYT-I. In AYT-II NRL 1928 ranked 1st by producing grain yield of 5481 kg ha^{-1} showing an increase of 13-19% over check cultivars Awaz and PS 19 respectively. The lowest grain yield of 4407 kg ha^{-1} was produced by NRL 1904 in AYT-I and 3889 kg ha^{-1} by NRL 1919 in AYT-II.

Forty-eight (48) newly selected genotypes were tested for grain yield, disease resistance, and other agronomic traits in 04 preliminary yield trials (PYT-I, PYT-II, PYT-III & PYT-IV) under rainfed conditions at the institute. Wheat varieties NIFA Awaz and PS-19 were included as standard checks in each trial. On the basis of high yield and disease resistance, a total of 15 genotypes were selected from these trials. The grain yield of selected genotypes in these 04 preliminary yield trials ranged from 5844 kg ha^{-1} to 6867 kg ha^{-1}. These selected lines will be further tested in advanced yield trials during the coming growing season.

The relative effects of the environment, genotypes, and their interaction on grain yield and agronomic attributes were assayed using 36 promising bread wheat genotypes grown in replicated trials in the plains, southern parts and northern part of Khyber Pakhtunkhwa. Wheat variety "Wadan" was used as a grand check. The trials were conducted with standard cultural practices with no irrigation. NIFA three elite wheat lines (NRL 1812, NRL 1816, and NRL 1825) were among the evaluated genotypes. NIFA elite line NRL 1825 ranked 1st among the tested genotypes by producing a grain yield

of 4660 kg ha^{-1} with a yield increase of 13-21% over the checks. This line will be further evaluated in national trials during 2021-22. NIFA candidate varieties, NRL 1643 and NRL 1664 were subjected for 1st and 2nd year mandatory evaluation in National Uniform Wheat Yield Trials (NUWYT) at different sites in the country. NRL 1664 produced a grain yield of 3818 kg ha^{-1} on a country basis and 3512 kg ha^{-1} on KP basis under rainfed conditions with 2-8 % higher grain yield over the checks. The line also showed excellent results under irrigated conditions in the national trial. It produced 4341 kg ha^{-1} on a country basis and 5826 kg ha^{-1} on KP basis with 2-16% higher grain yield over checks.

Evaluation of segregation material and creation of genetic variability for desired traits

Continued raising of different segregating populations achieved through gene pyramiding and the single gene mutation is the most important breeding strategy that ultimately results in the availability of diverse homozygous genotypes. A crossing block consisting of 40 genotypes was planted on three different dates for acquiring floral synchrony among early and late flowering parents. Based on the transfer of genes for disease resistance and other economically important traits in well adapted cultivars/genotypes, fresh crosses among different wheat cultivars/genotypes were carried out. Each cross combination was planted in 02 rows with 2.5 m length and having 25 plants per row. In the F_2 generation, 08 cross combinations were raised with a population of 2000 plants per cross. Finally, 95 best plants were visually selected and threshed individually for further evaluation. In F_3 generation based on disease resistance, spike shape, shattering resistance, plant architecture and uniformity 07 out of 43 progenies selected from cross Yr5/Barsat, 02 out of 09 progenies selected from cross YR10/RIL1201, 03 out of 09 progenies selected from cross YR10/Tatara, 05 out of 18 progenies selected from cross NBL1701 (Lalma/Marvi//WX)/ YR-5, 11 out of 17 progenies selected from cross RIL1201(Lalma/Tatara)/YR-10, 08 out of 21 progenies selected from cross YR-15/RIL 1202, 07 out of 14 progenies selected from cross Insaf/Yr5//Lalma, 06 out of 12 progenies selected from cross Shahkar/Aman//YR-10, 03 out of 16 progenies selected from cross Barsat/Sarang//Shahkar/3/PR105/Yr5 and 07 out of 24 progenies selected from Shahkar/PR105//YR-10/3/ Lalma /Yr5.

In F_4 generation, based on target traits 04 out of 07 progenies selected from cross

Insaf/Yr5, 02 out of 07 progenies selected from cross Lalma/Yr5, 17 out of 35 progenies selected from cross TDM/Tatara//Yr5, 05 out of 08 progenies selected from cross Insaf/Aman//Yr5, 05 out of 05 progenies selected from cross Barsat/Sarang// Shahkar/PR105, 01 out of 03 progenies selected from cross Lalma/Awaz//Yr5, 13 out of 16 progenies selected from cross Lalma/PR-105//Shahkar, 08 out of 10 progenies selected from cross Barsat/ PS-15// Yr5, 06 out of 14 progenies selected from cross Shahkar/Sarang//Yr5, 24 out of 31 progenies selected from cross Shahkar/PR-105//Yr10, 05 out of 07 progenies selected from cross Shahkar/Aman//Yr10, 10 out of 14 progenies selected from cross Barsat/RIL1609, 12 out of 13 progenies selected from cross Insaf/Sarang//Shahkar/PR105, 07 out of 08 progenies selected from cross Tatara/RIL-1105 and 10 out of 10 progenies selected from cross Lalma/NBL1701.

Breeder Nucleus Seed production of NIFA rainfed varieties

Consistent efforts were made by the NIFA wheat breeders to maintain seed purity and to produce Breeder Nucleus Seed (BNS) by growing progeny blocks/rows of these varieties on the available land at the institute. In total 290 progeny blocks and 250 progeny rows were grown for wheat varieties NIFA Awaz, NIFA Lalma, NIFA Insaf and Tatara. After regular observations, 235 progeny blocks and 190 progeny rows were selected and the rest were discarded. A total of 500 kg BNS of NIFA rainfed wheat varieties NIFA Awaz, NIFA Lalma, and NIFA Insaf was produced. These cultivars showed resistance to prevailing yellow and leaf rust races. The BNS seed will be used for the production of Pre-Basic seed in the coming Rabi season.

Oilseed Brassica

Evaluation of oilseed brassica mutants/ recombinants in various yield trials

Four rapeseed candidate lines viz; RR-8-2; RM-1-2; RM-1-9 and RRM-106-1 were assessed in National Uniform Rapeseed Yield Trial (NURYT) 2020-21. None of the candidate lines could significantly performed better than the national check inclusive of the recombinant RR-8-2 that had outclassed the check in the preceding year. Due to bordering difference with the check, all the candidate lines will be re-evaluated in following cropping season.

Based on high seed and oil yields performance of 08 rapeseed recombinant/ mutants advanced lines (RRF_3/016-49; RRF_3/016-62; RRF_3/016-101; RRF_3/016-20;

RMF_3/016-28; RRF_3/016-30; RRF_3/016-31 & RRF_3/016-82) were assessed in multi-location adaptation trial at selected sites in the KP & Punjab (NIFA, Peshawar, AZRC, DI Khan, BARI, Chakwal, BKU, Charsadda and BARS, Kohat).The results of the four locations demonstrated that RRF_3/016-62 achieved highest genotypic mean (2283 kg ha^{-1}) followed by RRF_3/016-101 (2250 kg ha^{-1}) & RRF_3/016-82 (2204 kg ha^{-1}) against Supper Canola (2172 kg ha^{-1}). Location means revealed BARI, Chakwal was the most productive site (3193 kg ha^{-1}) followed by NIFA, Peshawar (3118 kg ha^{-1}).

At station trials, in Preliminary Yield Trial-I (PYT-I); NRPTM-4 was the only comparable mustard genotype in seed yield (2778 kg ha^{-1}) with the commercial check (2755 kg ha^{-1}) while rest remained much averaged. Thirty nine (39) rapeseed genotypes were tested in three PYTs. The genotype RM-2-2-2/18 outclassed the check in seed yield (4074 kg ha^{-1}) while fifteen genotypes gave numerically higher seed yield (3009-3611 kg ha^{-1}) than the check Super Canola. In non-replicated trial; 17 rapeseed test entries out of 52 performed better than either one or both respective parents and harbored 9-37% high seed yields (2593-4074 kg ha^{-1}).

Selection and advancement of breeding materials at early generation stage

Ten (10) and thirty nine (39) test entries out of thirty two (32) F_4 and ninety eight (98) F_3 plant to progeny rows selected & advanced from Chinese hybrids, presented higher seed yield up to 26 and 47 % as against hybrid progenitor while out of 90 single plant progeny rows of M_3 rapeseed material; 19 mutant entries exhibited increased seed yield (2-66%) against parent.

F_2 and M_2 generations were developed from 15 crosses and through irradiating Super Canola at 1.2 & 1.4 kGy, respectively. One hundred (148) single plant selections were made in line with purpose of raising recombinant & mutant specifically concentrating on more branches, grains per pod, low ramification, early maturity, disease tolerance and high seed yield. F_1 generation of six cross combinations and M_1 of single gamma radiation dose were raised and bulk harvested separately. To create genetic variability and to transfer the desired quality and agronomic characters in a variety of interest; three hundred twenty five (325) stigma were pollinated in four different combinations.

Oilseed Brassica - varietal maintenance program

Quality seed production is the key to high seed yield. Therefore, a varietal genetic

safeguarding cycle was maintained through raising progenies rows and progeny blocks to produce Breeder Nucleus Seed (BNS). True to type progeny blocks were selected on the basis of varietal characteristics. A total of 480 kg basic seed (B.S) and 150 kg pre-basic (P.B.S) of oilseed brassica varieties NIFA Gold and NIFA Sarson-T20 were produced respectively at NIFA and certified by FSC&RD.

Oilseed Analysis

Near Infrared Reflectance Spectroscopy (NIRS) is a quick and cost effective technique being utilized at NIFA since long for quality analysis of oilseeds. For on-going project at NIFA, about 1155 samples of oilseed germplasm and breeding materials were analyzed for fatty acid profile and glucosinolates contents. Regards to Quality Analysis Service of brassicas; approximately 531 samples of brassicas were analyzed at nominal cost for academician, researchers of different universities and R & D organizations both at provincial and federal levels.

Variety Development

A new high seed and oil yielding variety NIFA Sarson-T20 was approved for general cultivation in the province by Khyber Pakhtunkhwa Seed Council in its 40th meeting on April 7, 2021.

Pulses

Mungbean

Evaluation of mungbean advanced lines in various yield trials

A total of 36 green-seeded recombinants along with three check varieties Ramzan, NIFA Mung-17 and Sona Mung were evaluated for yield and yield components in 02 sets of Advanced Lines Yield Trials (ALYTs) in kharif 2020 at NIIFA. A total of 08 genotypes produced significant ($p \leq 0.05$) higher seed yield of 1632 to 2118 kg ha^{-1} against average seed yield of Ramzan (1771 kg ha^{-1}), NIFA Mung-17 (1528 kg ha^{-1}) and Sona Mung (1403 kg ha^{-1}).

92 green-seeded recombinants from 05 different cross-combinations (6601 x Ramzan, NFM-5-36-24 x NFM-5-63-18, NM98 x NFM-5-36-24, V2802 x Ramzan, and V2709 x NM92 were planted in 05 sets of Preliminary Yield Trials (PYTs) along with two check varieties i.e. Ramzan, and NIFA Mung-2017 in kharif 2020 to evaluate for yield and yield related traits. Of these, 21 recombinants produced significant ($p \leq 0.05$) higher seed yield of 1875 to 2569 kg ha^{-1} as compared to average seed yield of Ramzan (2110 kg ha^{-1}) and NIFA Mung-17 (1840 kg ha^{-1}).

National Uniform Yield Trial comprising of 15 green-seeded test entries was planted at NIFA in kharif 2020, and the results were sent to National Coordinator (Food Legumes), PARC, Islamabad.

In case of breeding black-seeded mungbean, 48 recombinants from a cross-combination KBM x NBM along with black-seeded parents KBM and NBM and two green-seeded check varieties Ramzan and NIFA Mung-19 were evaluated for yield and related traits in 03 sets of replicated preliminary yield trials at NIFA in kharif 2020. A total of 10 recombinants produced significant ($p \leq 0.05$) higher seed yield of 1042 to 1563 kg ha^{-1} against average seed yield of KBM (174 kg ha^{-1}), NBM (903 kg ha^{-1}) and check varieties Ramzan (938 kg ha^{-1}) and NIFA Mung-19 (972 kg ha^{-1}).

Adaptability yield trial comprising of 04 recombinant lines derived from a cross KBM x NBM along with black-seeded parents KBM and NBM and green-seeded check variety NIFA Mung-19 were evaluated at ARS, Chitral in kharif 2020 for wider adaptability of yield and related traits of these lines. Of these, 02 lines NBM-2-2-4-5 and NBM-5-3-7 produced significant ($p \leq 0.05$) higher seed yield of 1456 and 1263 kg ha^{-1} against seed yield of KBM (962 kg ha^{-1}), however their yield was statistically lower than NBM (1434 kg ha^{-1}) and NIFA Mung-19 (1332 kg ha^{-1}). Similarly the same genotypes were evaluated in adaptability yield trial planted on 05 different locations on farmers' fields in Kurram in kharif 2020 along with black-seeded parents KBM and NBM and green-seeded check variety NIFA Mung-19. The same two genotypes i.e. NBM-2-2-4-5 and NBM-5-3-7 produced higher average seed yield of 1703 and 1684 kg ha^{-1} compared with black-seeded parents KBM (average seed yield of 804 kg ha^{-1}) and NBM (1553 kg ha^{-1}), however their yield was lower than NIFA Mung-19 (average seed yield of 1737 kg ha^{-1}).

Evaluation of mungbean segregating material

Early generation segregating material (F_2/M_2 generation) comprising of 06 different cross-combinations i.e. NFM-5-63-3 x KBM (14 single plants), V2817 x KBM (15 single plants), NIFA Mung-2017 x KBM (13 single plants), AZRI Mung-06 x KBM (10 single plants), Ramzan x KBM (11 single plants) and NM-2016 x KBM (10 single plants) were evaluated for yield and related traits at NIFA in kharif 2020. Based on seed color, better plant type, MYMV resistance and high per plant grain yield, a total of 09 single plants from 05 cross-combinations (NFM-5-63-3 x KBM, NIFA Mung-2017 x KBM, AZRI

Mung-06 x KBM, Ramzan x KBM and NM-2016 x KBM) were selected. Similarly, F_4 generation from a cross-combination 'KBM x NBM' comprising of 06 single recombinant plants was evaluated in kharif 2020. The entire population was discarded for not fulfilling the above-mentioned desired criteria. A total of 18 single recombinant plants from 02 cross-combinations (KBM x MBM and Ramzan x KBM) were evaluated in F_5 generation in kharif 2020 at NIFA. Both cross-combinations were discarded for not fulfilling the desired criteria. F_6 generation derived from 03 cross-combinations (KBM x NBM, Sona Mung x NM-2011 and ML-5 x Sona Mung) was evaluated at NIFA in kharif 2020, and a total of 10 single lines from 02 cross-combinations (Sona Mung x NM-2011 and ML-5 x Sona Mung) were selected for evaluation for yield attributes in replicated yield trials, whereas the entire cross-combination of KBM x NBM was discarded for not fulfilling the pre-set criteria. Similarly, 10 lines derived from cross-combinations KBM x NBM and Ramzan x KGM were evaluated in F_7 generation at NIFA in kharif 2020. No selections were made due to un-availability of desirable lines in the population. M_2 generation consisting of 500 mutant plants developed from a parent (KBM) irradiated at 400 Gy of γ rays, and M_5 generation from a parent (KGM) irradiated at 300 Gy of γ rays consisting of 10 single mutant lines were evaluated at NIFA in kharif 2020 for single plants/lines selections based on desired traits for further evaluation in seasons to come. The entire M_2 population was discarded as no desirable single mutant plant was found particularly for MYMV resistance, whereas one single mutant line from M_5 generation of KGM was selected for evaluation for yield and related traits in replicated trials. In spring 2021, F_1/M_1 generation of 04 cross-combinations (Ramzan x NBM-2-14-4-6, x NBM-2-14-4-6 x Ramzan, NBM-2-14-4-6 x NIFA Mung-19 and NBM-2-14-4-6 x V2817) was planted at NIFA, and a total of 79 expected single recombinant plants were picked, threshed and bagged individually cross-combination wise.

In case of quality seed production, 750 kg of pre-basic/basic seeds of NIFA mungbean varieties i.e. Ramzan, NIFA Mung-17 and NIFA Mung-19, was produced in 2020-21.

Common bean

Evaluation of common bean genotypes in adaptation yield trials

Two years' mandatory DUS of two common candidate varieties NIFA Lobia Red and NIFA Lobia Yellow were completed by the

FSC & RD, KP Region. Proposals for varieties have been submitted to 41st meeting of Technical Committee of the KP Seed Council to be held in near future for recommendation.

Common bean adaptability trial comprising of 06 entries was planted at ARI, Mingora, Swat, ARS Chitral and on farmers' fields at different locations in Kuram for testing wider adaptability of the test entries for yield and yield components. Of these, 02 genotypes 'NCB-Tajaki and NCB-Charsadda watani produced higher average seed yield of 2041 and 2029 kg ha^{-1} at all locations compared with other genotypes.

Evaluation of common bean segregating material

F_1/M_1 generation from 02 cross-combinations (NCB-Charsadda watani x Kuram local and Kuram local x NCB-Charsadda watani) comprising of a total of 09 plants was planted at ARI, Mingora Swat in kharif 2020. All recombinant plants were harvested, threshed and bagged individually and cross-combination wise. F_2/M_2 generation from these recombinants-cum-mutants was evaluated for plant type, and yield and yield components at NIFA in spring 2021. Both cross-combinations were discarded on the basis of not fulfilling the desired criteria. In order to create genetic variability for seed color, plant type and high grain yield, three new cross-combinations i.e. NCB-Charsadda watani x NCB-Tajaki, Himalaya-1 x NCB-Kenya and NCB-Tajaki x NCB-G-4729 were successfully attempted in spring 2021. All crossed pods were individually picked and bagged cross-combination wise.

Chickpea

Screening of chickpea genotypes for physiological traits related to heat tolerance

20 advanced chickpea genotypes were screened for physiological traits i.e. net photosynthesis rate, membrane injury index and canopy temperature depression at flowering, pod formation and grain-filling stages in Rabi 2020-21 under PSF Project at NIFA. 08 genotypes performed better for net photosynthesis rate (average value of 19.7 µmol m^{-2} s^{-1}), membrane relative injury (average value of 42%) and canopy temperature depression (average value of 4.9 °C) compared with rest of the genotypes.

Horticulture

Improvement of Peaches for yield and quality

i. Exotic/local germplasm collection and evaluation

PW & Z-4 exotic germplasm 24 plants were evaluated for early blooming, dwarfism and

fruit maturity. Initially agronomic parameters plant height (cm), branches per plant, internode length (cm) and stem thickness (mm) were studied. Data recorded for plant height in 10 plants of PW range from 200-284 cm, number of branches per plant ranges from 16-21, stem diameter 33.5-58 & internode length 3-5 ranges, similarly data recorded for plant height in 9 plants of Z-4 plant range from 200-250 cm, number of branches per plant range from 8-19, stem diameter 27.35-46.45 & internode length 2.5-5 ranges, as compared to Early Grand (check variety) plant height (290), branches per plant (20), internode length (3) and stem thickness (62). Local germplasm 20 plants were studied for desirable characters/evaluation. Flower initiation in 11 plants and fruit setting in three plants were noted as compared to check variety Early Grand.

ii. Creation of genetic variability through induced mutation

Mutants plants from each variety i.e., Early Grand & Florida King were studied for further evaluation in NIFA peach orchard. Data on flower initiation, number of flowers per plant, full bloom, fruit setting, days to fruit setting and number of fruits of individual mutant plants were recorded. Number of fruits range from 7-19 were recorded in Early Grand mutant plants as compared to control range from 4-25. Similarly, number of fruits range from 2-5 were recorded in Florida King mutant plants as compared to control range from 1-10.

iii. Study the detopping effect on peach nursery plants

The detopping experiment were conducted in peach nursery using different detopping dates of the budded plants. Detopping were done at 5 days interval started from 24th June 2021 till 9th July, 2021. Data showed that minimum days to sprouting (24.8) were recorded on 1st detopping after 10 days of budding while maximum days to sprouting (28.66) were recorded on 4th detopping after 25 days of budding.

Improvement of plum for higher yield and better fruit quality

i. Evaluation of irradiated plum materials in orchard

Bud wood of *cv*. Fazli Manani irradiated with (20 and 30 Gy) gamma rays for creation of variability were budded on the Mariana rootstock and shifted to orchard for evaluation. The earliest sprouting 4-5 days was recorded the control plants as compared to irradiated material of 30 Gy treatment. Similarly the lowest plant height of 130 cm the lowest internode length of 1.7 cm was recorded in 30 Gy mutant plants as compared to control (150 cm and 2.0 cm). Internode

length and seedling diameter were not much effected by 20 Gy doses and were at par with control.

ii. Effect of different budding dates on growth parameters plum varieties on Mariana rootstock

The effect of different budding dates of four plum varieties i.e. Blasting Star, Santa Roza, red beauty and Fazli Manani were investigated for early sprouting, percent bud sprout, buddling length and height in the nursery. The experiment was arranged in two factorials split plot design, replicated 03 times with four different budding dates i.e. 1st October, 10th October, 20th October and 30th October with 10 days interval. Standard cultural practices like weeding, hoeing, irrigation and cutting/pruning were carried out during the whole experiment in the nursery. The highest bud sprout was recorded in 20th October (95.5 %) followed by 10th October (94.3%). In varieties mean the highest bud success (94.5) was recorded in red beauty followed by Blasting star with 93.2 % bud success. The lowest days to bud sprout (105) was recorded in 30th October followed by 141 days in 20th October budding date. In variety means the lowest days of 135 was recorded in Santa Roza followed by Red beauty with 136 days. Santa Roza also took the highest buddling length of 33 cm followed by Fazli Manani (29 cm) and Blasting Star (26 cm).

iii. Raising of new plum cuttings

For raising new nursery plants Marianna plum cuttings (>3000) were planted in the nursery during December 2020. The plants were budded in October 2021 with different varieties including black amber irradiated with 20 and 30 Gy doses of gamma rays. For efficiency of budding different concentrations of IAA and IBA and GA3 in 300, 600, 900 and 1200 ppm concentration has been used for promoting budding efficiency. Budding is in progress and will be completed up to 30th October 2021.True to type and disease free nurseries (6000 sapling) of peach and plum were produced and disseminated in the farmers.

NIFA wheat varieties Demonstration Blocks

Seed production field of green-seeded mungbean variety 'NIFA Mung-19 planted at NIFA in spring 2021 under PSDP Pulses Project

Seed production field of NIFA black-seeded mungbean variety NIFA Spinghar-21 planted at NIFA in spring 2021 under PSDP Pulses Project

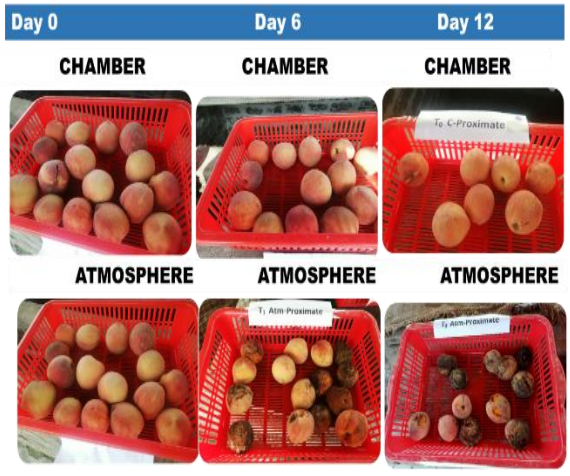
09.06.2021. Seed Certification Officer, FSC & RD, KP Region carrying-out inspection of mungbean crop planted under PSDP Pulses Project for Pre-basic seed production


09.06.2021. Seed Certification Officer, FSC & RD, KP Region carrying-out 2nd year DUS of NIFA common bean candidate varieties 'NIFA Lobia Red and NIFA Lobia Yellow'

FOOD AND NUTRITION DIVISION

Development of low cost zero-energy cooling chambers for field heat removal and storage of fruits and vegetables and its transfer to small farmers

Experiments were carried out on the storage stability of fruit and vegetables (peach, strawberry, tomato and pumpkin) in Zero Energy Cooling Chambers (ZECC) and outside under thatched shed. All fruits and vegetables were collected from farmer's fields. Collected samples were sorted out on the basis of shape, color, size, skin flexibility, skin bruises and compressions and then kept inside and outside each chamber separately for quality parameters analysis and physiological loss in weight (PLW) study. It was noted that peach fruit stored in chambers remained fresh up to 12 days and exhibited better results as compared to those stored outside the chambers.



Average temperature inside and outside cooling chambers (under thatched shade) was 28.2°C and 32.7°C respectively while average relative humidity inside and outside cooling chambers (under thatched shed) was 79.6% and 65.6% respectively. Decrease in the chamber temperature is primarily caused by the evaporative cooling of the porous chamber walls. Evaporative cooling system not only lowers the air temperature surrounding the produce, but also increases the relative humidity of the air.

Highest PLW (42.3%) was noted in peach fruit stored outside the chambers in contrast to those stored inside ZECC (7.5%). Other chemical analysis (Vitamin-C, Total Phenolic Content (TPC), Titratable Acidity and pH) also showed better results in peach stored inside ZECC as compared to peach stored in atmosphere. Similarly, shelf life of okra was extended to 10 days inside Zero energy cooling chambers. Results of strawberry fruit in ZECC depicted that it was not fit for storage in ZECC due to its high moisture content and soft texture.

Zero Energy Cooling Chambers were constructed at farmers' fields in Peshawar, Nowshera and Charsadda districts and trainings were conducted for the dissemination of the ZECC technology at

farmers filed. Local farmers along with agriculture extension officers and staff, participated in the training programs.

Training on ZECC at Nowshera

Training on ZECC at Charsadda

Adaptation of Electron Beam (EB) and X-ray Applications to treat Meal Ready to Eat (MRE) and Fruits & Vegetables in Pakistan

Meal Ready to Eat (MRE) samples were irradiated with target doses of 14 and 15 kGy respectively, to get the optimum irradiation doses for its shelf life extension at room temperature. Total Viable Counts (TVC) significantly decreased and the overall observed value was 4.69 to 2.21 (log CFU/gm) for control and irradiated MRE samples. In the mentioned treatments irradiation dose of 14 kGy showed better results in terms of safety and overall acceptance during the storage period of 90 days at temperature of 27 ^{o}C.

Sprout inhibition was successfully achieved for garlic at optimum dose of 400 Gy as compared to the control samples.

Irradiation of MRE at Pak Electron Beam Irradiation (Pvt.) Ltd. With 10 MeV EB and 5 MV X-ray for Food and Pharma

Production of indigenous food bio-preservatives from dairy microflora

Based on previous year findings of ALP project, production and purification of

bacteriocin were performed in 2020-21. Selected strains namely *Enterococcus lactic* NIFA-1 (MT974113*), Enterococcus faecium* NIFA-N2A1 (MT043863), *Enterococcus faecium* NIFA-3 (MT97457) were grown on modified MRS media at 37 ^{o}C with vigorous shaking. Cell free supernatant were collected and precipitated by using 60% ammonium sulfate at 4 ^{o}C with gentle shaking. The PPT was purified by using 3000 Da cutoff dialysis membrane and eluted through the Sephodex G-75 in glass column where flow rate was maintained 0.5ml/min. Each fraction was checked for antibacterial activities. Bacteriocin was characterized for tolerance against, acid, bile, salts, surfactant and enzymes. In next step these strains were characterized for probiotic potential. Each strain was tested by different assays such as tolerance to pH, temperature, bile salt, GIT enzymes and antibiotic sensitivity. Similarly, haemolysis analytical profile of selected strains of *Enterococcus faecium* was performed indicating no haemolysis (γ). All isolated strains were sensitive to selected antibiotics except Nalidixic acid (NA) that showed resistant. Mostly, strains revealed maximum probiotic potential at pH 5-7, temperature of 37°C and 1% GIT enzymes. Strains tolerate (0.1% and 0.3%) concentration of bile salt. In the final step, application for food preservation and probiotic yoghurt preparation was performed. Freeze dried bacteriocin was reconstituted and applied as 1, 2, 3 % coating material. Results were compared with 1, 2 and 3 % CMC and with application of 2, 5 and 10 kGy radiation. It was observed that 3% bacteriocin application increased the shelf life of guava for 12 days as compared to control who became spoiled after 4 days. Probiotic yoghurt was made with NIFA-N2A-1 owing the shortest fermentation time as compared to other strains. Probiotic yoghurt remained edible for the period of one month. Similarly, lactic cheese was made by using three selected strains and NIFA-1 showed better keeping quality and sensory attributes. In conclusion, fermented food of this region has very good source of probiotic lactic acid bacteria, especially *Enterococcus faecium* and *Enterococcus lactis* that have a great potential to be used in food industry.

Lactic cheese development with NIFA-1

Popularization and cultivation of edible mushroom and Bio-pesticide formulation and application

Popularization of Mushroom cultivation technology as cottage industry was carried out at Khyber Pakhtunkhwa (KP), upper Punjab and Baluchistan.

Four hundred and twenty-five (425) manpower (farmers, landless poor community, and agriculture research and extension staff members) were trained. Seven (07) mushroom training workshops (MTW) and seven (07) model mushroom farms (MMF) were organized/established at KP-03 (Dear Ismail Khan, Bannu and Tirah Valley), Baluchistan -02 (Quetta and Mastung) and upper Punjab-02 (Choa Saidan Shah and Kotli Sattian). As a follow-up participants were assisted with technical guidance during mushroom cultivation process where needed. Around 300 kg of mushroom spawn was produced and sell to farmers on subsidized rate.

Ganoderma or Reishi (*Ganoderma lucidum*) medicinal mushroom was successfully cultivated on low cost substrate at NIFA for the first time among public R&D organization in Pakistan. Different culture media (Potato Dextrose Agar-Natural, Potato Dextrose Agar- Synthetic, Malt Extract Agar and Liquid Culture Media) were tested for the identification of efficient medium for colonization of *Ganoderma lucidum* where, Potato Dextrose Agar-Natural stood rapidly colonizing medium (07 days) followed by Potato Dextrose Agar-Synthetic (09 days). Similarly, different cereal grains (Sorghum, wheat, millet, barley and their combination in 1:1 ratio with each other) were tested as substrate where, sorghum was identified as efficient substrate (11 days) for Ganoderma spawn production.

Three plant extracts/ botanicals (*Melia azedarach, Azadirachta indica* and *Withania coagulans*) efficacy testing trial for the management of yellow rust disease in wheat under natural field conditions was conducted. These botanicals showed yellow rust urediospore germination inhibition of 98.69% to 99.57% in laboratory experiment. Efficiency of botanical extracts (three spray efficiency) under field conditions was measured which ranged from 76.2% to 92.8% which is encouraging as bio pesticide for future product development for managing yellow rust.

Reduction of post-harvest losses by product development/ value addition

The objective of the project is value addition of low-quality citrus sources for the preparation of nutritionally enriched juice blends. For the purpose three blends of grape fruit, sour orange and lemon with sweet

orange each were prepared. Proportion of low quality citrus i.e. grape fruit, lemon and sour orange were kept at 80, 60 and 40 as compared to sweet orange which was taken as 20, 40 and 60 in juice blends. The blends were evaluated for vitamin C, total acidity, pH, TSS, total phenol content and organoleptic.

Decrease in Vitamin C content of all combinations was observed. However, T1 (80:20 combination) of blend one i.e. sour and sweet orange shows least Vitamin C loss (i.e. 56 %) over three month period as compared to all other combinations of both juice blends. Minor / non-significant changes in total acidity, pH and TSS were observed. So far as total phenol content of the blends is concerned, T1 combination of blend one shows 14 % increase which is quite promising for antioxidant activity of juice blend.

Development of simple and low cost technology for the removal of astringency from persimmon fruit

Experiments were conducted to remove astringency from persimmon fruit. Various treatments were: T1-Control = Placed in Open Carton Boxes, T2 = Packed, sealed and vacuum in green Plastic bags, T3 = Packed and sealed in Green Plastic bags, and T4 = Modified Atmosphere Chamber (Treatment of fruit for astringency removal under vacuum for 96 hrs). The Storage stability of treated and untreated fruit was studied. Astringency level was determined during the study through sensory evaluation and biochemical analysis.

Persimmon fruit treated in the astringency removal chamber (T4) followed by T2 received highest organoleptic acceptability score and remained wholesome for two weeks at room conditions. There were large variations in results for the variously treated fruits due to variation in the ripening of individual fruits.

Income Generation Activities of FND

S.#	Name of Item	Amount (Million Rs.)
1.	Rapid Test Kits (RTKs)	1.25639
2.	Gemstone Irradiation	0.8996
3.	Food Products	0.78536
4.	Analytical Services	0.1406
5.	Mushroom/mushroom spawn	0.3518
	Total	**3.43375**

SOIL & ENVIRONMENTAL SCIENCES DIVISION

Biofortification of zinc in wheat for balanced human nutrition

Biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology. Biofortification differs from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops.

So far, our agricultural system has not been designed to promote human health; instead, it only focuses on increasing grain yield and crop productivity. This approach has resulted in a rapid rise in micronutrient deficiency in food grains, thereby increasing micronutrient malnutrition among consumers. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions.

Screening of wheat genotypes for Zn efficiency in chelate-buffered nutrient solution

The seeds of ten wheat genotypes were surface sterilized with sodium hypochlorite and germinated on moist filter papers in petri dishes in an incubator at 20±1 ºC. Three days after germination, 2 seedlings of each cultivar were transplanted into white thermopore sheet placed in stainless steel container of 50 L capacity filled with 40 L of the chelate-buffered nutrient solution and were placed in net house. Zn^{2+} activities of 2, 10 and 40 pM were employed to the plant. The plants were initially grown in nutrient solutions containing half strengths of all macro and micronutrients, except for Zn and K_3HEDTA (which were at full strength) until day 10 after which the full-strength solutions were used. The nutrient solutions were replaced with fresh mixtures on days 10, 15, 19, 24, 28 and 32 following transplantation. The pH values of the solutions were adjusted to 6.0±0.01 with 0.1 M HCl or 0.1 M KOH as required. Harvesting of the plants was carried out on day 35 after transplantation. The tissue samples were then air dried on paper towels and later dried in a forced draught oven at 70±1 °C for 48 hours (until constant weight) and were analyzed for micronutrients and P by standard procedures of analysis.

The increase in the levels of Zn^{2+} activity improved the growth of plants and resulted in vigorous dry matter production. The variable response of genotypes under study was observed to the applied Zn activities thus

exhibiting the variable production of DM that was used to determine Zn efficiency. The Zn efficiency of these genotypes varied between 43.68 to 75.03%, the genotypes NRL-1929 being the most efficient one and NRL-1901 being the least. The genotype NRL-1929 produced maximum dry biomass of 23.5 g at 2 pM whereas NRL-1901 produced the minimum (9.6 g). The wheat genotype NRL-1929 accumulated Zn concentration of 19.17 µg/g at pM Zn^{2+} activity that was significantly higher than rest of the genotypes. Due to higher biomass production and accumulation of Zn at 2 pM, the wheat genotype NRL-1929 had accumulated significantly higher Zn content of 450 µg/g. However, the highest P uptake (2.15 µg/g) was gained by NRL-1907. The lower P uptake by NRL-1929 (1.5 µg/g) may be attributed to higher Zn accumulation by this genotype at the same level of Zn application (2 pM).

Fertilizer requirement for newly developed candidate lines of oilseed brassica

Edible oil is one of the important commodities of everyday use. Pakistan produced 30% of edible oil and about 70% are imports at the cost of huge foreign exchange. Increasing domestic oilseed production can reduce this huge oil import bill. Brassica oil seed crop in Pakistan having 44-46% of good quality oil. Big gaps exist between potential yield 3500 kg/ha and national average yield 922 kg/ha. Brassica oilseeds have the potential to reduce the edible oil import bill if, brassica oilseed crops are properly managed. There are many factors responsible for its low yield; one of them is the improper/imbalance use of plant nutrients/ fertilizer. Keeping in view all these, an experiment was conducted to identify suitable NPK levels for oilseeds brassica new varieties/lines developed at NIFA. Two advance candidate lines V1 (PR-8-1) and V2 (PR-8-2) *of Brassica napus* developed at NIFA were tested for high yield and best level of NPK fertilizer. The experiment was laid out in micro plots using split-plot design with three replicates. Keeping lines in main plot and NPK levels in sub plot. Recommended row to row distance for sowing and other cultural practices were followed. The fertilizer (NPK) treatments/ levels were applied in split doses included Control (T_0) (0-0-0), T_1 (30-20-20), T_2 (60-40-40) and T_3 (90-60-60) kg ha^{-1}. Half N and full PK were applied at the time of sowing and the remaining half N in the form of urea was applied before flowering at vegetative growth stage. Plant height was recorded at the time of maturity before harvesting. The

trial was harvested in mid of April and after drying in field yields of each plot were recorded. The overall performance of the experiment was good. Fertilizer application enhanced yield of brassica lines over control. The maximum grain yield of 3761.1 kg/ha was recorded for line no. V2 (PR-8-2) followed by 3533.3 kg/ha for line no. V1 (PR-8-1) where NPK were applied @ 90-60-60 kg/ha. To confirm these results the experiment will be repeated.

Integrated nutrient management of young (non-bearing) deciduous fruit orchards

Stone fruits (Peach and Plum) are important fruits of Pakistan particularly in the province of Khyber Pakhtunkhwa. Yield of stone fruits remain low due to a multiple factors, imbalanced use of fertilizers being the main factor. Soils in Khyber Pakhtunkhwa are deficient in organic matter as well as macro & micro nutrients. This deficiency is the major factor responsible for low fruit yield and poor quality. Three field experiments on young deciduous fruit orchards are in progress at NIFA experimental farm; two on peach orchards having two different varieties i.e. Early Grand and Florida King and one on plum fruit orchard of one-year plants. There are total six treatments having one tree per treatment with three replications in RCB design. N, P, K & Zn fertilizers were applied at the rate of 60, 50, 50 & 20 g $tree^{-1}$ respectively to peach orchards and 30, 25, 25 & 10 g $tree^{-1}$ respectively to plum orchard. Soil samples were taken from two depths i.e., 0-15 cm and 15-30 cm. Analytical results showed that nitrogen ranged from 0.03% to 0.045%, phosphorus from 2.5 to 6.0 ppm, potassium from 46 to 153 ppm, organic matter from 0.6% to 0.8% and EC from 0.61 to 1.08 dS/m. Pretreatment leaf samples analysis showed that %N in leaves ranged from 1.7 to 2.5% of the all the experimental orchards. All mineral fertilizers and Farmyard manure (FYM) were applied to the periphery of tree canopy before flowering.

Improving off-season vegetables production under high and walk-in tunnels through integrated management of nutrients and water

The main purpose of tunnel farming is to grow summer vegetables under the tunnels by providing favourable environment in winter. It results in early availability of summer vegetables in the market when their prices are much higher as compared to normal growing season. Fertilizers and water are exorbitant inputs so need to be utilized in a judicious manner. The farmers in Khyber Pakhtunkhwa have small land holdings and normally grow traditional crops through traditional methods of irrigation. Under this

situation tunnel farming is the best option to get maximum production from such scarce sources as compared to conventional farming practices.

The critical timing, optimum methods and economical levels of fertilizers & irrigation for tomato, bitter gourd and bell pepper were identified for growing off-season vegetables in high and walk-in tunnels using furrow and drip irrigation systems. Time of fertilizer application proved very crucial for achieving higher yields of tomato, bitter gourd and bell pepper. The highest marketable tomato fruit yield (2.35 t/10 marla tunnel), maximum protein (12.54%), total acidity (0.45%) and N, P & K uptake were achieved with application of NPK @ 10-10-15 kg ha^{-1} at 7 days interval followed by 1.86 t/10 marla tunnel by the same treatment at 14 days interval. While minimum tomato yield was obtained (0.534 t/10 marla tunnel) at control. The maximum vitamin C (27.98 mg $100g^{-1}$) content was recorded with application NPK @ 10-10-15 kg ha^{-1} at 21 days interval.

The yield data indicated that maximum bitter gourd fruit yield (2.05 t/10 marla tunnel), maximum physiological loss in weight (23.60 %) of bitter gourd fruits and maximum fruit NPK were obtained in treatment receiving NPK @ 10-10-15 kg ha^{-1} at 7 days interval through drip irrigation system. The minimum fruit yield (0.392 t/10 marla tunnel) was recorded in control where no fertilizer was applied. Total production of bitter gourd was recorded as 0.982 ton out of 10 Marla tunnel.

Similarly, bell pepper grown in walk-in tunnel produced maximum fruit yield (1.22 t/10 marla tunnel), N, P, K and Ca contents when NPK fertilizers were applied at the rate of 75-75-90 kg ha^{-1} at 30 days intervals, followed by 0.86 t/10 marla tunnel when NPK fertilizers dose of 50-50-60 kg ha^{-1} was applied at 30 days intervals.

Monitoring the long term impact of conversion to organic farming systems

There had been a positive impact on yield enhancement through the introduction of fertilizer responsive wheat varieties in post green revolution. The intensive use of chemical fertilizers to achieve higher wheat yield has introduced multiple problems of yield stagnancy, deterioration of soil health and loss of biodiversity. The overall impact of continuous use of higher doses of chemical fertilizers has negative environmental footprint and decline in net returns from farming. The problems of farming sector are further aggravated by erratic impact of climate change. Situation demands to

identify suitable farming options that can maintain wheat yield and soil fertility under changing climate in conjunction with increased net returns from farming. Organic farming system offers solutions to aforesaid issues.

To identify sustainable faming options for the farming community, a long term trial was established at the experimental farm of the institute during 2018-2019 and trial is in progress during 2020-21. Two distinct blocks of land (1 kanal each) were planted under organic and conventional (chemical) farming systems. Wheat remained the test crop under both farming systems during winter season. During summer, maize and sesbania were planted under chemical and organic farming systems, respectively. Nutritional requirements under organic farming system were met through incorporation of green manure crop (sesbania) and farmyard manure into the soil. Owing to the higher demands of organic vegetables, potatoes were incorporated in trial during 2020. Soils under each farming system were analyzed up to 90 cm with every 30 cm increment for the determination of soil organic matter, organic carbon, nitrogen, phosphorus and potassium contents.

Preliminary findings depicted that it was possible to maintain soil fertility under organic farming systems without compromising wheat grain yield. Wheat grain yield of 6.57 and 6.07 t ha^{-1} were recorded under chemical and organic farming systems, respectively. Water use efficiency calculated based on wheat grain yield was slightly higher under chemical fertilizer based farming system (12.1 kg ha^{-1} mm^{-1}) than that under organic farming (10.7 kg ha^{-1} mm^{-1}). Protein content in wheat grains were better under chemical farming (10.9%) than under organic farming (10.5%). Wheat crop under chemical farming exhibited better uptake of nitrogen, phosphorus and potassium than organic farming system. Organic carbon contents of wheat shoots under organic farming systems (52.2 %) were slightly higher than those under chemical fertilizers based farming (51%). Maize biomass yield of 30 t ha^{-1} and organic potato tuber yield of 4 t ha^{-1} were also recorded from ongoing trial. Study is anticipated to provide recommendations for production of organic wheat and potatoes besides providing data sets generated through systematic organic farming research that are already desperately lacking at the national level.

Pilot scale production and popularization of compost tea as organic fertilizer nutrient source

Intensive use of chemical fertilizers for increasing crop yield has led to the environmental pollution. Situation demands to identify and popularize technologies that help the farmers to improve yield with minimal deterioration of land and water resources. Compost and compost tea (CT) offer great prospects in this regard. Compost tea has the potential to improve crop yield. It is economical to use and easier to handle and transport than compost. Compost needs to be applied as much bulky as about 30 tons per hectare which is very hard for the farmers to take to their fields without any proper transportation. Under the project, a series of laboratory scale studies were conducted to standardize the protocol for the formulation of compost tea under aerobic conditions and identify optimal temperature for storage of compost tea. The newly developed product of compost tea was then tested under field conditions to study its efficacy as organic fertilizer. About 1000 L of compost tea was distributed amongst interested farmers.

During 2020-21, a field experiment was conducted to study effect of compost, compost tea and various levels of inorganic fertilizers on yield of potato. The experiment was laid out in randomized complete block design with eight treatments and three replication. Treatments included control, NPK @ 250-150-150 kg ha^{-1}, compost @ 15 t ha^{-1}, compost @ 30 t ha^{-1}, NPK @ 125-75-75 kg ha^{-1} + CT (1:5) @ 4000 L ha^{-1}, CT (1:5) @ 4000 L ha^{-1} alone, NPK @ 250-150-150 kg ha^{-1} + CT (1:5) @ 4000 L ha^{-1} and NPK @ 125-75-75 kg ha^{-1} + compost @ 15 t ha^{-1} + CT (1:5) @ 4000 L ha^{-1}. The results revealed that maximum tubers yield (10.6 t ha^{-1}) and chlorophyll content (50.1%) were recorded in the treatment receiving NPK @ 125-75-75 kg ha^{-1} + compost @ 15 t ha^{-1} + CT (1:5) @ 4000 L ha^{-1}. This yield was 25.5% more than the treatment receiving NPK @ 250-150-150 kg ha^{-1}), and it was followed by treatment receiving NPK @ 250-150-150 kg ha^{-1} + CT (1:5) @ 4000 L ha^{-1}. Results indicated that compost tea may be a good substitute for chemical fertilizers in future to improve yield through organic sources of plant nutrition. Results need further confirmation through field experiments prior to developing reliable recommendations for potato growers.

A pot experiment was conducted on to study the effect of compost tea and inorganic fertilizers on growth and yield of Spinach. The experiment was laid out in completely randomized design with 9 treatments and 3

replicates. The treatments included control, compost @ 30 t ha^{-1}, compost @ 15 t ha^{-1}, NPK @ 100-100-40 kg ha^{-1}, compost @ 30 t ha^{-1} + NPK @ 50-50-20 kg ha^{-1}, compost @ 15 t ha^{-1} + NPK @ 50-50-20 kg ha^{-1}, NPK @ 100-100-40 kg ha^{-1} + compost @ 30 t ha^{-1} + CT (1:5) @ 4000 L ha^{-1}, NPK @ 50-50-20 kg ha^{-1} + compost @ 15 t ha^{-1} + CT (1:5) @ 4000 L ha^{-1} and CT (1:5) @ 4000 L ha^{-1}. Seventy (70) days after sowing, data on fresh weight/pot and chlorophyll content were recorded. Significant differences were observed among treatments for fresh weight/plant. Fresh weight per plant ranged from 105-147 g. The maximum value of fresh weight per plant (147 g) was recorded in treatment receiving half of the recommended rates of NPK in conjunction with compost @ 30 t ha^{-1}.

Use of biological techniques to enhance NP uptake and improve mungbean yield

Ever increasing costs & environmental pollution risks associated with chemical fertilizers, fixation of phosphatic fertilizers and farmers' reluctance to apply costly chemical fertilizers to a minor crop like mungbean necessitate to identify innovative biological ways of improving mungbean yield. One sustainable and environment friendly option is the use of microbial inoculants of N-fixing (*Rhizobium* sp.) and P-solubilizing (*Bacillus* sp.) bacteria which may improve plant growth and yield through improved nutrient absorption. Positive impacts of such inoculants on productivity enhancement become significant when used in conjunction with chemical fertilizers. The current study was planned to identify appropriate combination of bacteria and chemical fertilizers for improving growth and yield of mungbean.

A: Isolation of N-fixing and P-solubilizing bacterial strains

For the isolation of N-fixing bacteria (*Rhizobium*), healthy unbroken pink nodules were obtained from the roots of mungbean plants grown on NIFA experimental farm. These nodules were washed with distilled water surface sterilized using $HgCl_2$ (0.1%) and 70% ethyl alcohol. 1 g of nodular extract was used for making 10 fold serial dilutions up to 10^{-8}. Then 0.1 ml of nodular extract suspension from 10^{-3} to 10^{-8} dilutions was inoculated into sterile YEMA (Yeast Extract Mannitol Agar) plates and these plates were incubated at 37^{o}C for 4-7 days. After the incubation period, N-fixing bacteria were identified as large mucoid elevated colonies.

For the isolation of P-solubilizing bacteria (*Bacillus*), about 1 kg soil sample was collected from the rhizosphere soil of cultivated area of NIFA. 1 g of the composite

soil was used for making 10 fold serial dilutions up to 10^{-8}. Then 0.1 ml of each dilution was spread on sterile Pikovskaya's agar medium (PVK) and these plates were incubated at 28±2°C for 7 days. After incubation, P-solubilizing bacteria were identified as colonies showing clear zones.

Both the bacterial strains were stored for later on use in the inoculation of mungbean seeds for field experiment.

B: Response of mungbean to co-inoculation at various fertilizer levels

During Kharif 2021, a field trial was carried out to assess the co-inoculation potential of N-fixing and P-solubilizing bacteria on mungbean yield at various levels of fertilizers. Experiment was laid out in completely randomized design with twelve treatments in three replicates and one mungbean variety was tested. Treatments included: Control, NP @ 10-20 kg ha^{-1}, NP @ 20-40 kg ha^{-1}, Rhizobial (R) inoculation, Bacillus (B) inoculation, Co-inoculation (R+B), NP @ NP fertilizers + Rhizobial (R) inoculation, NP @ 10-20 kg ha^{-1} + Bacillus (B) inoculation, NP @ 10-20 kg ha^{-1} + Co-inoculation (R+B), NP @ 20-40 kg ha^{-1} + Rhizobial (R) inoculation, NP @ 20-40 kg ha^{-1} + Bacillus (B) inoculation and NP @ 20-40 kg ha^{-1} + Co-inoculation (R+B).

The findings of this field study revealed that the application of NP @ 20-40 kg ha^{-1} along with Rhizobial (R) inoculation gave maximum plant height (65.3 cm), plant dry weight (14.7 g), plant dry matter (35.5%) and nitrogen contents in grain & shoot (3.5 & 2.4%, respectively). Similarly, 100-grain weight (4.8 g) and phosphorus contents in grain & shoot (0.41 & 0.26%, respectively) were recorded maximum when NP fertilizers (20-40 kg ha^{-1}) were applied along with both the microbes. It was found that inoculation with either microbe exhibited positive influence on the yield components and nutrient concentration in mungbean. Based on the findings of current study, it can be inferred that NP fertilizers application along with N-fixing and P-solubilizing bacterial inoculation seems to be crucial for obtaining higher yield of good quality mungbean.

Improving water and nutrient use efficiency of wheat based cropping systems in Khyber Pakhtunkhwa

Wheat is a key component of both rain-fed and irrigated cropping systems in Pakistan. Intensive use of costly inputs particularly chemical fertilizers has introduced the problem of environmental pollution. Water scarcity issue is becoming a limiting factor

for sustaining agriculture. The current era focusing on sustainable use of natural resources compels us to improve productivity while ensuring minimal wastage of applied inputs (fertilizer and water). It is critical to study water and nutrient dynamics under dominant wheat based rotations. The current study was, therefore, planned to provide technical evidence based guideline to farmers of Khyber Pakhtunkhwa for making rational decisions on choice of crops over a year for both sustainable use of scarce resources as well as for improving long term farm productivity.

To identify wheat based cropping system that can make efficient use of fertilizer and available water, a field experiment was executed at NIFA Research Farm in randomized complete block design with three replicates. The experimental plot was laid out into three blocks, one each for comparison of wheat with fallow, maize and mungbean with a permanent layout. During Kharif (2020), maize and mungbean were planted in 2 blocks while leaving the 3rd one fallow, to compare their performance in rotation with wheat. After crop stand establishment, probes were installed up to 1 m depth for recording data on soil moisture. The experiment received usual agronomic management for both the crops during the season. Biological yield and 100-grain weight of mungbean were recorded 3.63 t ha^{-1} and 4.9 g, respectively. Similarly, plant height, biological yield, dry matter yield and cobs yield of maize were recorded 205.33 cm, 31.08 t ha^{-1}, 8.61 t ha^{-1} and 3.85 t ha^{-1}, respectively. During Rabi (2020-21), wheat was planted in all the three blocks. The crop received usual agronomic management during the season. Data on soil moisture were recorded in both the seasons at fortnightly intervals using neutron scattering moisture probes. The biological yield of wheat in wheat-maize-wheat, wheat-fallow-wheat and wheat-mungbean-wheat blocks was recorded 10.85, 11.70 and 12.87 t ha^{-1}, respectively. Similarly, the grain yield of wheat in these blocks was recorded 4.13, 4.37 & 5.03 t ha^{-1}, respectively. Based on the findings of the experiment, it can be inferred that inclusion of leguminous crop like mungbean in rotation may increase yield of subsequent wheat crop and it may be attributed to its contribution in soil nitrogen content through biological nitrogen fixation.

PLANT PROTECTION DIVISION

A. BIOLOGICAL CONTROL

Eco-friendly techniques/Bio-control

Fruit worm, *Helicoverpa armigera* (Oliv.), wheat aphid, *Schizaphis graminum* (Rondani) and red flour beetles, *Tribolium castaneum* (L.) are the serious insect pests of tomato, wheat crops and store cereals which cause tremendous losses upto (30-40%). These R & D activities were carried out to develop and apply eco-friendly techniques (Bio-control, Entomo-pathogenic fungi, pheromone trapping and host plant resistance (HPR) for the control of fruit worm, aphid and red flour beetles to reduce pesticide use and enhanced good quality produce of vegetables and wheat crop.

Management of tomato fruit worm and wheat aphids

Efficacy of egg parasitoid, *Trichogramma chilonis* (Ishii) against tomato fruit worm, *Helicoverpa armigera* (Hub.), okra shoot & fruit borer, *Earias vittella* (F.) infestation under field conditions

Okra, *Abelmoschus esculentus* (L.) is attacked by many insect pests in Peshawar. For efficient control of Fruit worm, *H. armigera* and okra fruit and shoot borer, *E. vittella* control through egg parasitoid, *Trichogramma* is utmost important. Okra variety (Bhindi Syndicate SPL) was sown at NIFA farm. Minimum infestation of fruit worm, *H. armigera* (0.20 larvae/ okra plant) was recorded in 2000 *Trichogramma* pupae treated plot followed by 1500 pupae (0.27), 1000 pupae (0.32) and 0.40 in control. Minimum mean infestation of *Earias vittella* (0.50 larvae/ plant) was also recorded in 2000 *Trichogramma* pupae treated plot followed by 1500 pupae (0.58), 1000 pupae (0.67) and (0.92 larvae/ plant in control from July to November 2020. Our finding showed that okra plot (24 m^2) treated @ 2000 *Trichogramma* pupae was found less affected by fruit worm and spotted bollworm as compared to control.

Ecological studies of fruit worm, *Helicoverpa armigera* (Hub.) moths through pheromone baited traps

Maximum fruit worm moths (20.50/ trap) were recorded in pheromone baited traps in April followed by 6.75 moths/ trap in March, (4.50) in September, July (3.88), May (2.50), November (2.00), June (1.75), October (1.25), August (0.50) and no single moth was trapped in the months of December to February.

Evaluation of Entomo-pathogenic fungi *(Metarhizium anisopliae & Beauvaria bassiana)* against Red flour beetle, *Tribolium castaneum* (L.)

Entomo-pathogenic fungi, *M. anisopliae* & *B. bassiana* were applied alone and in combined formulations against red flour beetles, *T. castaneum*. Mortality of red flour beetle was observed three days post treatment. The combined formulation of both Entomo-pathogenic fungi @ 1 x 10^8 of each showed maximum mortality upto (43.3%) with no mortality in control treatment.

Evaluation of different wheat genotypes against aphid resistance

Wheat genotypes (123 nos.) were evaluated against aphid population during 2020-21 and results showed significantly higher mean aphid population (23.3 aphids/ tiller) on Tijban-10 while minimum mean 3.3 aphids/ tiller on Karwan. Aphid resistance index showed that 55 wheat genotypes were found resistant and 68 were found susceptible to wheat aphids.

Evaluation of different diets on biological parameters of Angoumois grain moth, *Sitotroga cerealella* (Oliv.)

Maximum adult emergence of *Sitotroga cerealella* (Oliv.) was recorded in oat in both free and no choice bioassay i.e., 132.3 and 92.6 respectively ($p \leq 0.05$). Minimum mean developmental time (27.5 day, maximum adult longevity (7.2 days) and maximum adult weight 0.9 mg was recorded in maize. Oat and maize were found most suitable cereals for *Sitotroga* on mass scale rearing in laboratory condition as a factitious host for egg parasitoids, *Trichogramma chilonis* (Ishii).

B. TERMITES

Termite are one of the most economically important pests of crops, orchards and buildings in Pakistan. Most of these termites are subterranean and cryptic in nature. Concealed habitat of subterranean termites makes their control very difficult. Conventionally, massive amounts of synthetic insecticides are used for termites' management; which are quite expensive and environmentally hazardous. Termite group is engaged in developing cost effective and environment friendly IPM techniques for the control of subterranean termites.

Exploitation of insecticidal characteristics of local plants for management of subterranean termites

Several local plants having insecticidal characteristics tested for their toxicity and deterrence against subterranean termites for their eco-friendly control so that use of synthetic insecticides can be minimized. Crude extracts of several plants i.e.

Cinnamon (*Cinnamomum verum*), Black pepper (*Piper nigrum*), Clove (*Syzygium* aromaticum), Garlic (*Allium sativum*), Neem seeds (Azadirachta indica), Ginger (*Zingiber officinale*), Green Chillies (*Capsicum annuum*), Oleander leaves (*Nerium oleander*), Turmeric (*Curcuma longa*), Eucalyptus leaves (*Eucalyptus globules*), Darek seeds (*Melia azedarach*) were prepared by soaking crushed plant parts in hot water for 24 hrs. Toxicity and deterrence tests were performed by treating blotting papers with extracts and exposing termite workers to it. We found clove and garlic most toxic and deterrent @ $\leq$ 5%. Turmeric was also proved to be good deterrent but it was not toxic. Further experimentation will be done to find out the synergistic and antagonistic effect by combining different effective extracts for development of organic eco-friendly product for management of termites.

Development of local attractive bait matrix and toxin delivery foraging stations for control of subterranean termite species

Laboratory experiments were performed for development of local attractive bait matrix for termites. Three different textures (Powder, Granules and small blocks) of sugarcane and poplar wood were used for termite's attraction. Granular form have maximum mean attraction (55%) and weight consumption (22%), followed by small block and powder form. While powder of poplar wood have minimum attraction and weight consumption. To make cellulosic material more attractive for termites, the preference of two amino acids i.e. L. Proline and L. Glutamic acid with three conc. @ 10, 20 and 40 ppm were evaluated in comparison with untreated blotting paper (control). Both amino acid L. Proline and L. Glutamic (@ 40 ppm) have increased attraction (70% and 78%) over control. Similar trend found in weight consumption for L. Proline and L. Glutamic acid @ 40 ppm, with 12.5% and 15.8% respectively more mean consumption then control. The additional effect of five vitamin (B12, Folic acid, Riboflavin, ascorbic acid and mixture of vitamin) on food weight consumption and aggregation of termites toward food were also evaluated against untreated food. Maximum mean aggregation (68%) was found in food treated with Vitrum (mixture of vitamin) over normal feed (control) i.e. 14%, followed by Riboflavin, B_{12}, folic acid and ascorbic acid respectively. Three conc. (0.25%, 0.5% and 1g/kg food) of solidifying material Agar were also evaluated. Maximum mean aggregation (75%) of termites workers towards food treated with Agar @ 0.5g/kg over control

(10%), followed by the attraction towards Agar @ 1 g/kg, while food with Agar 0.25 g/kg showed minimum attraction for termites workers.

C. FRUIT FLIES

Fruit flies cause tremendous losses and damages to fruits and vegetables at farm level, as well as to traders, retailers and exporters. In order to combat this menace, farmers mainly rely on the use of toxic chemicals, which pose potential health risk, destruction of beneficial insect fauna, environmental pollution, and development of insect pest resistance. Research on fruit flies is therefore, geared towards development and application of eco-friendly control strategies.

Assessment of various ovipositional devices for egg collection of fruit fly, *Bactrocera* species

Harvest of quality eggs in adequate number is a pre-requisite for the establishment of laboratory rearing of fruit fly *Bactrocera* spp. Identification of a suitable ovipositional device could be a step forward in the maintenance of laboratory culture of *Bactrocera* spp. on artificial diet. In this context, three different ovipositional devices (brown bottle, pepsi bottle & plastic cup) were assessed in two formats (free-choice and no-choice experiments) to identify suitable device for successful egg collection. The results of *B. dorsalis* indicated that maximum number of eggs (15.7 & 13.3) were collected in brown bottle, followed by pepsi bottle (9 & 10.3) and plastic cups (7 & 8.7). Similarly, in *B. zonata* maximum number of eggs (20 & 17) were recorded in brown bottles followed by plastic cups (10 & 13) and pepsi bottles (8.3 & 10) respectively. Hence, the brown bottle was found to be the most suitable and effective ovipositional device for efficient egg collection of *B. dorsalis* and *B. zonata*.

Assessment of various ovipositional stimulants for egg collection of *Bactrocera* species

Three different ovipositional stimulants (peach, guava and mango juice) were assessed under no-choice trials to identify the most suitable stimulant for efficient egg collection from *B. dorsalis* and *B. zonata*. The results of *B. dorsalis* indicated that maximum number of eggs (302) were recovered from mango juice, followed by peach (75 eggs) and guava (44 eggs). However, in *B. zonata* maximum number of eggs (43) were recovered from peach juice followed by mango (33 eggs) and guava (23 eggs). Hence, it is concluded that the most suitable ovipositional stimulant for efficient

egg collection in *B. dorsalis* is mango juice whereas, in *B. zonata* is peach juice.

Evaluation of different food attractants for developing female trapping system for fruit fly

Protein hydrolysate, yeast, protein hydrolysate+yeast and protein hydrolysate+ yeast+molasses were tested as dry formulations in peach orchard at NIFA/Tarnab, Peshawar for attracting female flies. The results indicated that there was no attraction of female fruit flies towards any of the food bait. Similarly, in another experiment, protein hydrolysate was mixed with methyl eugenol in different ratios @ 50:50%, 40:60%, 60:40% and 70:30% & compared with only methyl eugenol and protein hydrolysate for attracting male & female fruit flies. The results revealed that maximum population of male fruit flies (441.33) was captured in treatment of protein hydrolysate + methyl eugenol used in ratio of 50:50, whereas the lowest population male fruit flies (380.67) were recorded in treatment of Protein hydrolysate + methyl eugenol used in ratio of 70:30. However, all the tested formulations failed to attract female fruit flies. Moreover, it was also concluded that the peach fruit fly is exhibiting 96% dominance over oriental fruit fly.

Monitoring of adult fruit fly population fluctuation and development of a degree day model

The three years adult fruit fly population data (2017, 2018 and 2019) were utilized for the development of a degree day based forecasting model for predicting population dynamics of *B. zonata* in the fruit orchards. The results clearly demonstrated that degree days are more effective than calendar dates in terms of confirming the onset, peak and decline of pest population. For this purpose, four parameter logistic and four parameter sigmoidal models were assessed using the statistical package (Sigma Plot). The values of Adjust R2 and AIC were used to identify the best model for prediction. The results indicated that highest Adjust R2 value (0.9982) and the least AIC value (-71.5) were observed in case of sigmoidal model for the pooled data of three years. Hence, sigmoidal model is used for fruit fly population predicting. The degree day model as a forecasting tool for fruit fly population will help in timely initiating control tactics for fruit fly management and hence will save time and resources.

Attractiveness of different food baits to the fruit fly *Bactrocera* species in pear orchard

Various concentrations of different food baits viz. Protein hydrolysate, Torula yeast,

Casein, Yeast instant and Sugar molasses were evaluated for their attractiveness to the fruit fly, *Bactrocera* species in pear orchard located at Tarnab, Peshawar. The results revealed that yeast instant attracted significantly higher number of *B. zonata* and *B. dorsalis* and hence the highest cumulative population of both species followed by treatment of sugar molasses. Among all the treatments, Casein was found to be the least preferred attractant for *B. zonata* and *B. dorsalis*. Sex ratio (%) of *B. zonata* and *B. dorsalis* captured in different protein baited traps revealed that all the baits attracted higher number of female flies than male flies.

D. PLANT PATHOLOGY

1. Epidemiology of wheat pathogens, resistant genes/sources and chemical control

1.1 Status and seasonal progress of airborne and vector borne diseases

A set of diversified wheat genotypes were raised as stationary sentinel plot for epidemiological studies of yellow rust, leaf rust, powdery mildew and barley yellow dwarf at NIFA farm. Seven temporal disease observation were recorded. Yellow rust triggered as flicking and after completing latent period was prominent during mid-march and disease severity varied between 20-40%. Yellow rust severity overtime was increased and its highest values varied between 90-100 during April. Seasonal apparent infection rate for yellow rust estimated on selected 108 of the studied 260 genotypes remained 0.06. Leaf rust was observed with 10% severity in three genotypes while powdery mildew was not recorded during the season at NIFA farm. Aphid borne barley yellow dwarf disease of wheat was prevalent in 52 genotypes (20%) and disease severity reached up to 60%.

1.2 Pathogen intelligence, host resistance and chemical control

Information regarding yellow rust pathogen (*Puccinia striiformis f. sp. tritici* (*Pst*) virulence's, availability of durable *Pst* resistance sources and cultivation value of all stage *Pst* resistance genes/sources are the prerequisite for rust management and fostering host resistance development and deployment.

1.2.1 Temporal variability of *Pst* virulence's and all stage resistance genes

Temporal variability in *Pst* virulence's and races were investigated and postulated during the season at NIFA. Six different *Pst* races were postulated over season at NIFA farm and included 0E0, 78E175, 71E160, 71E164, 71E165 and 71E173 which carried up to 10 virulence's. Race 78E175 has the broadest

virulence spectrum and carries potential of hitting ten yellow rust resistance genes. *Pst* virulence's including *v1, v6, v7, v8, v9, v25, v27, v32* were consistently recorded during 2019-20 and 2020-2021 wheat growing seasons and were considered fixed in the local pathogen population and the corresponding all stage yellow rust resistance genes (*Yr1*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr25*, *Yr27* and *Yr32*) were inferred to be ineffective. Yellow rust resistance genes including *Yr10*, *Yr15*, *Yr24* and *YrSp* were found clean and considered as effective.

1.2.2 Partial resistance and fungicides for *Pst* management

a. Durable resistance

In order to retard or reduce yellow rust impact in 70% of the wheat landscape of low altitude districts of KP Province, initial inoculum of *Pst* from the source area (i.e. mid and high altitude districts) and exotic territories is essentially required to be reduced. To achieve this goal, a set 274 registered/approved wheat cultivars were tested under artificially induced *Pst* epidemic to identify allo and auto infection reducing genotypes which were determined using over season disease assessments by area under disease progress curve (AUDPC). AUDPC values were ranged from 0 to 1678. Fifty percent of the AUDPC values fall between 0-838. Values above 500 and less than 800 were considered as potentially durable and better slow rusting and are suggested for deployment in the source area for *Pst* management.

b. Resistance and yield protection.

Preliminary investigation was conducted to asses comparative yield reduction and *Pst* development using three each highly resistant (Fatehjang-16, Wardan-17 and Pasina-17), moderately resistant (Pakistan-2013, Boroloug-16, Anaj-17) and moderately susceptible (Shafaq-2006, Galaxy-2013, Land race) cultivars along with susceptible check (Morocco). Mean yellow rust severity of highly resistant, moderately resistant, moderately susceptible and susceptible check was less than 1, 13, 25 and 53%, respectively while corresponding yield/plot(g) (2367, 2317, 2100, 1367) and thousand kernel weights(g) were (46, 45, 41, 38). Disease severity correlation was negative and highly significant with thousand kernel weights(g) (-0.86) and yield/plot(g) (-0.70) while correlation between yield/plot(g) and thousand kernel weights(g) was 0.73 among tested cultivars.

c. Fungicidal efficacy against *Pst* and yield protection

Preliminary investigation was conducted in which efficacy of five fungicides (i.e. Tilit,

Success, Redomil, Topsin-M, Cymoxanil plus Mancozeb) were evaluated along with untreated control using Morocco as susceptible standard variety. Six replications of Morocco were established in randomized complete block design for five fungicide treatments and untreated control. Maximum area under disease progress curve (AUDPC) was recorded in control (1572) while the lowest (120) was recorded in Tilit treated plots. AUDPC in the remaining four treatments varied between 989-1077 which were statistically non-significant. Significantly highest yield per plot were recorded in both Cymoxanil plus Mancozeb (883 g) and Tilit (858 g) while control yield was 733 g. Remaining three treatments followed Cymoxanil plus Mancozeb and Tilit in yield/plot. Significantly highest thousand kernel weight was recorded in Tilit (42 g) which was followed by Cymoxanil plus Mancozeb (41 g), Redomil (40 g), Success (40 g), Control (39.7 g), Topsin-M (39.7 g). Further studies are required to confirm current preliminary results.

2. Development of disease resistant germplasm and varieties

Under this national coordinated program, NIFA is fostering the development of disease resistant elite wheat germplasm and varieties. Three sets of wheat germplasm including 740 elite genotypes in National Wheat Disease Screening Nursery (NWDSN), 97 candidate varieties (National Uniform Wheat Yield Trial-Nursery) and a set of 197 released varieties were received for testing at NIFA. These three sets of national importance were raised, tested and evaluated for all stage and partial resistance under *Pst* artificial epidemic conditions. Over season critical disease data of each set entries was recorded under local conditions which will be published in the final country report by Pakistan Agricultural Research Council (PARC), Islamabad for use by national breeding programs, provincial and federal seed councils for variety release and recommendation of released cultivars cultivation for avoiding *Pst* epidemic.

3. Wheat seed health analyses

One hundred and twenty-eight wheat varieties were tested for black point disease incidence in lab. One thousand seed of each variety were manually analyzed for black point incidence using magnifying lens with built in light source. Each of the twenty five percent wheat genotypes with black point incidence were less than 2, 2.7, 4.5 and 13.7%, respectively. Varieties having black point incidence below 3% are good for both sowing and edible purpose.

E. MEDICAL ENTOMOLOGY

Vector borne human diseases are increasing and dengue fever is one of them which has become endemic in Pakistan and no effective vaccine is available globally for its control. Therefore, vector control is the only option. Reliance mainly on insecticides for vector control cause health hazards, entomological problems and environmental constraints thus environment friendly vector control strategies has emerged indispensable for vector control. Research efforts are directed in carrying out environment friendly collaborative activities for vector control.

Bio-efficacy trials of selected plants against Culicid mosquitoes

Various plant extracts, viz., *Parthenium hysterophorus* (Gajar booti), *Nicotiana tabacum* (desi tobacco), *Melia azedarach* (Bakain/Chinaberry), *Fagonia indica* (Dhaman/Sacchi Booti), were compared in different concentrations and Temephos as standard chemical against the 3rd & 4th instars larvae of culicid mosquitoes. Results on laboratory bioassays trials of these indigenous crude plant extracts @ 3% concentration showed highest toxicity (100%) in Parthenium followed by Tobacco (96%) & Bakain (90%). Field trails are warranted to confirm the results.

Evaluation trials for developing low cost Mosquitoes Traps

Laboratory free choice tests for evaluation of gravid female mosquito's attraction to different color traps were categorized in order of preference as black › green › blue › transparent. Similarly, attraction of gravid female to various oviposition substrates resulted in more attraction to fish meal followed by chicken meal, hay infusion, casein, yeast and urea respectively. Black color indigenous traps with 0.5% fish meal formulation attracted the maximum gravid female (202 eggs/day) under laboratory and field conditions. The data is being utilized in standardizing an effective mosquito's trapping system by utilizing low cost attractants in scrap materials.

Utilizing ovitraps data in plotting Vector Index of Mosquitoes

The ovitraps data recorded were utilized in graphing vector index of the field population. The index determined by utilizing ovitraps' data highlighted the dominance of Culicid over the Anopheline mosquitoes. The mean index was found more than the threshold level of 5 in the months of August-November for Aedes mosquitoes. Overall, the trapping index of *Aedes* mosquitoes are significantly higher than the *Culex* species.

Assessment on the use of (IGRs) as ovicides, larvicides, and growth inhibitors

Bioassays were conducted on three Insect growth regulators (IGRs); Methoprene, Pyriproxyfen and Novaluron at their recommended field doses at 0.01ppm. Eggs, larvae and pupae were exposed to the IGRs at their field recommended doses**.** Less eggs laying and hatching was recorded from *Aedes aegypti*. Pyriproxyfen resulted in highest post hatching inhibition followed by Novaluron. Hatching of eggs was prolonged from 5 days (in control) to 12 days in treatments. None of the IGR prevented 100 % hatching of *Aedes aegypti* eggs. However, all IGRs were effective at larval stages of *Ae. aegypti* and inhibited development of larvae to pupal stage and emergence to adult stage was also halted. Pyriproxyfen resulted in 100 % larval mortality of *Ae. aegypti* within 5 days and Methoprene within 7 days. When pupal stages of *Ae. aegypti* were exposed to IGRs, they could not prevent the emergence of *Aedes aegypti* pupa to the adult stage.

Comparison of Dengue Guard with commercial products

Dengue Guard, a mosquito repellent was developed for protection against mosquito bites. Field trails on their liking for smell, effective time, acceptance, skin irritation and overall liking of Dengue Guard against two other commercial products on volunteers. Results showed that both Dengue Guard and product M provided significantly more protection time (5-6 hrs.) as compared to 2 hrs protection time for product L. On dislike to like scale of 1-5, no significant difference was recorded for smell of the all products. However, this score was highest (3.85) for product M followed by Dengue Guard and product L. Forty five 45% of volunteers liked the smell of product M as compared to 35% liking for Dengue Guard. Similarly, 35-45 % volunteers put product L in the good to vary good criteria as compared to 30-35% rank of Dengue Guard in the good to vary good criteria. Skin irritation was not recorded by any volunteer from any of the product. Dengue Guard Trade Mark registration process was initiated with Intellectual Property Rights Organization (IPO), Ministry of Science and Technology, Government of Pakistan during 2019 and got approval and was published during 2021 in the Trademark Journal 841.

Hunt for naturally existing tsl mutation in *Aedes aegypti* and *Ae. albopictus* for construction of more robust Genetic Sex Strain (GSS) for SIT

R & D work under this project including installation of ovitraps for collecting eggs of both dengue vector species were carried out

from different climatic and topographic zones of Pakistan. The area wise colonies were up-scaled to hunt for naturally existing temperature sensitive lethal (tsl) mutation for construction of genetic sexing strain for more efficient use of SIT dengue vector control. Initial screening is in process by exposing L1 larvae of dengue vector to temperature from 37 to 41 ^{o}C for time period ranging from 2 to 24 hrs.

SOCIO-ECONOMIC IMPACT

PLANT BREEDING AND GENETICS DIVISION

During 2020-21 a total of 14200 kg quality seed (Pre-Basic & Basic class) was produced which is sufficient to plant 285 acres of land. The institute will generate an amount of approx. Rs. 1.2 million from seed. The oilseed group has contributed Rs. 0.165 million to NIFA under income generation through sale of quality seed/grain and oilseed analytical services. 570 kg of quality pre-basic/basic seed (worth Rs. 0.247 million) of NIFA Mungbean varieties 'Ramzan, NIFA Mung-2019, NIFA Spinghar-21 and NIFA Sikaram-21 was sold to KP agriculture extension department through PSDP Pulses Project for further multiplication. Improved varieties of peach (Early Grand & Florida King) were produced & distributed among the progressive orchard growers. The disease free and true to type nursery has earned Rs. 316000/- as income generation during 2020-21.

FOOD AND NUTRITION DIVISION

Development and dissemination of technologies within farmer's communities and entrepreneurs, for food safety and security, is the main focus of Food and Nutrition Division (FND). Vitamin A and Iron spot test kits worth Rs. 1.25639 million were supplied to Food Fortification Program Pakistan, provincial food authorities and food departments, regulatory bodies and nutrition programs that are working to eliminate micronutrient deficiency in the country. Irradiation services were provided to gemstone traders for value addition of gemstones (Topaz, Kunzite, Tourmaline, Quartz, etc.). NIFA earned nearly Rs. 0.8996 from gemstone irradiation services, 19% increase in income as compared to previous year. Limited scale production of food products within the institute yielded around 0.78536 during year 2020-2021, 35% increase as compared to previous year 2019-20. FND is providing analytical services worth Rs. 0.1406, including water analysis (physiochemical and microbial), proximate analysis etc. to NIFA as well as other governmental and non-governmental organizations (NGOs). The consumer satisfaction with services is earning prestige for NIFA which results in more interest from R&D and academic organizations. Due to NIFA efforts, mushroom popularity within concerned corners of KPK, Punjab and Baluchistan is established now, raising demand for mushroom and its spawn. NIFA is striving hard to cope with

increasing demand from farmers and entrepreneurs for mushroom and its spawn and earn Rs. 0.3518 from mushroom and mushroom spawn. Food and Nutrition Division contributed Rs. 3.43375 million to overall NIFA's income generation in 2020-21.

SOIL AND ENVIRONMENTAL SCIENCES DIVISION

The team members of Soil and Environmental Sciences Division have devised economical and environment-friendly technology packages and products for field and horticultural corps. These technologies are in the phase of rapid absorption by the farming community of the province. Through the adoption of recommendations and technology packages, farmers have become able to optimize use of available farm labour and maximize net returns from farming business with the consequences of enhancement in socio-economic conditions. The identification of nutrient efficient genotypes has resulted in 20 to 30% increase in wheat yield and improved the quality of grain to overcome the mineral malnutrition. Through the adoption of tunnel farming technology, small vegetable farmers are getting up to 10 times more net returns than conventional vegetable production.

PLANT PROTECTION DIVISION

Cost of agriculture production rises directly from yield losses due to attack of insect pests and diseases such as yellow rust, leaf rust, powdery mildew, barley yellow dwarf and blights which are suspected to have caused 15-30% yield losses in different production zones. Effective utilization of pest and disease resistance varieties may pose positive effect on the economic returns. The technologies/ products developed at PPD for crop protection and disease management are ultimately transferred to the academia, researchers, agriculture extension specialists, and farmers as end users which in turn render economic benefits to the end users. Dengue Guard, a mosquito repellent product for protection against mosquitoes, fruit fly traps for fly control and tricho-cards for biological control of lepidopteron pests all have economic impact in the making of country. The sale of these products on concessional rates generates income to the institute besides its positive effect on environment and economic returns to the farmers.

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3. Awais, M., N. H. Khuhro, M. H. Khan, R. M. Memon and M. U. Asif, 2020. Laboratory test of the *Dirhinus giffardii* (Silvestri) (Hymenoptera: Chalcididae) against the pupae of Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae). Pure and Applied Biology, 9(1): 609-617. http://dx.doi.org/10.19045/bspab.2020.90066.

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6. Hussain, N., T. Mahmood, M. Liaquat, N. Safdar, W. Ahmed, A. Qayyum, K. S. Abbasi and M. Imran. 2021. Rheometry nutrition and gluten microstructure trends in wheat cultivars. Food Science and Technology. https://doi.org/10.1590/fst.60920

7. Imtiaz S., F. M. Sarim and S. A. Khalil. 2020. Comparison of various explants on callogenesis in Stevia Rebaudiana. Bioscience Research, 17(3): 1858-1864.

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10. Khan M. H., N. H. Khuhro, M. Awais, M. U. Asif and R. Muhammad. 2021. Seasonal abundance of fruit fly, Bactrocera species (Diptera: Tephritidae) with respect to environmental factors in guava and mango orchards. Pak. J. Agric. Res., 34(2): 266-272.

11. Khan M. H., N. H. Khuhro, M. Awais, R. M. Memon and M. U. Asif. 2020. Functional response of the pupal parasitoid, *Dirhinus giffardii* towards two fruit fly species, B*actrocera zonata* and *B. cucurbitae*. Entomologia Generalis 40(1): 87-95. DOI: 10.1127/entomologia/2020/0878.

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FUNDED RESEARCH PROJECTS

Sr. #	Project Title	Project Duration	Total Funds	Principal Investigator	Funding Agency
1.	Wheat Productivity Enhancement Program	2011-2022	Rs. 15.86 M	Dr. Fazle Subhan	USDA/ CIMMYT
2.	Promoting research for productivity enhancement in pulses – a country-wide umbrella project	2019-2024	Rs. 24.446 M	Dr. Gul Sanat Shah	PARC-PSDP
3.	Breeding heat tolerant and high yielding chickpea (*Cicer arietinum* L.) genotypes	2020-2023	Rs. 2.147 M	Dr. Iqbal Saeed	PSF
4.	Cooperative agreement for mutual trial planting of wheat varieties between CIB, CAS, China and NIFA, Pakistan	2021-2025	$ 5000	Dr. Syed Tariq Shah	CIB, CAS, China
5.	Adaptation of Low Energy Machine Generated Radiation Sources for Decontamination and Disinfestation of Food in Pakistan	2021-2026	€ 30000	Mr. Alamgeer Khan	IAEA
6.	Establishment of Nutrition Assessment Lab using Non-Radioactive Isotopes to Mitigate the Micronutrient Deficiency in the Pakistani Vulnerable Population	2020-2022	€ 378295	Dr. Zahid Mehmood	IAEA
7.	Adaptation of Electron Beam and X-ray Applications to Treat MRE and Fruits and Vegetables in Pakistan	2016-2021	€ 21000	Mr. Alamgeer Khan	IAEA
8.	Development of Low Cost Zero-Energy Cooling Chambers for Field Heat Removal and Storage of Fruits and Vegetables and its Transfer to Small Farmers	2019-2022	Rs. 5.608 M	Dr. Zahid Mehmood	ALP
9.	Production of indigenous food bio-preservatives from the microflora isolated from the fermented dairy products	2018-2021	Rs. 2.87 M	Dr. Talat Mahmood	ALP-PARC
10.	Pilot scale production and popularization of compost tea as organic fertilizer nutrient source	2018-2021	Rs. 2.7 M	Mr. Zahid Ali	PSF

11.	Environment friendly management of tomato fruit worm, *Helicoverpa armigera* through bio-control, *Trichogramma chilonis* coupled with SIT in tomato/okra in greenhouse and field conditions	2017-2022	€ 36000	Mr. Muhammad Zahid	IAEA
12.	Hunt for naturally existing tsl mutation in *Aedes aegypti* and *Ae. albopictus* for construction of more robust Genetic Sex Strain (GSS) for SIT	2020-2024	€ 24000	Dr. Misbah Ul Haq	IAEA

DETAILED LIST OF OFFICERS

Name	Designation
Dr. Gul Sanat Shah, Ph.D. Botany	Director / DCS
I. PLANT BREEDNG & GENETICS DIVISION	
Dr. Roshan Zamir, Ph.D. Horticulture	Head / DCS
Dr. Fazle Subhan, Ph.D. Crop Science	PS
Mr. Hafiz Munir Ahmad, M.Sc. (Hons.) Genetics & Breeding	PS
Dr. Muhammad Irfaq Khan, Ph.D. Biology	PS
Mr. Shahid Akbar, M.Sc. (Hons.) Horticulture	PS
Dr. Farooq-i-Azam, Ph.D. Genetics & Breeding	PS
Dr. Muhammad Amin, Ph.D. Statistics	PS
Dr. Syed Tariq Shah, Ph.D. Crop Genetics & Breeding	PS
Dr. Iqbal Saeed, Ph.D. Crop Genetics & Breeding	PS
Dr. Salman Ahmad, Ph.D. Genetics & Breeding	SS
Dr. Akhtar Ali, Ph.D. Breeding & Genetics	SS
Mr. Khurshid Ahmad, M.Phil. Chemistry	SS
Mr. Shehzad Ahmad, M.Sc. (Hons.) Plant Breeding & Genetics	JS
II. FOOD & NUTRITION DIVISION	
Dr. Maazullah, Ph.D. Agricultural Food Engineering	Head / DCE
Mr. Muhammad Zubair Shah, M.S. Chemical Engineering	PE
Dr. Zahid Mehmood, Ph.D. Food Science and Technology	PS
Dr. Muhammad Ibrahim, Ph.D. Plant Pathology	PS

Mr. Alamgeer Khan, M.S. Medical Physics	SS
Dr. Talat Mahmood, Ph.D. Food Science and Technology	SS
Mr. Ali Raza, M.Sc. (Hons.) Food Science and Technology	SS
Mr. Tauqeer Ahmad, M.Sc. (Hons.) Food Science and Technology	JS
Mr. Asim Irshad, M.Sc. (Hons.) Food Science and Technology	JS
III. SOIL AND ENVIRONMENTAL SCIENCES DIVISION	
Dr. Muhammad Imtiaz, Ph.D. Soil Science	Head / DCS
Mr. Mukhtiar Ali, M.Sc. (Hons.) Soil Science	PS
Dr. Syed Azam Shah, Ph.D. Agronomy	PS
Dr. Amir Raza, Ph.D. Natural Resources & Life Sciences	PS
Mr. Parvez Khan, M.Sc. (Hons.) Soil Science	PS
Mr. Zahid Ali, M.Sc. (Hons.) Soil Science	PS
Mr. Shahzada Asif Ali, M.Sc. (Hons.) Agronomy	JS
Mr. Noor-ul-Basar, M.Sc. Environmental Sciences	ARO
IV. PLANT PROTECTION DIVISION	
Dr. Syed Jawad Ahmad Shah, Ph.D. Plant Pathology	Head / DCS
Mr. Muhammad Zahid, M.Sc. (Hons.) Entomology	PS
Dr. Gul Zamin Khan, Ph.D. Entomology	PS
Dr. Inamullah Khan, Ph.D. Entomology	PS
Dr. M. Misbah ul Haq, Ph.D. Entomology	PS
Dr. Muhammad Hamayoon Khan, Ph.D. Entomology	SS
Mr. Muhammad Salman M.Sc. (Hons.) Entomology	SS
Mr. Muhammad Arfan, M.Sc. (Hons.) Entomology	JS
Mr. Usman Khaliq, M.Sc. (Hons.) Entomology	JS
Miss Noor Fatima, M.Sc. (Hons.) Entomology	JS

V. TECHNICAL SERVICE DIVISION	
Mr. Fiaz-ud-Din, B.Sc. Engineering	Head / DCE
Mr. Abdul Khaliq, M.Sc. Computer Science	PS
Mr. Asif Murad, B.Sc. Engineering	PE
Mr. Jahangir Khan, M.S. Engineering	SE
VI. ADMINISTRATION & ACCOUNTS	
Mr. Muhammad Shakeel Khan, M.A (Political Science), M.A (Persian) & MBA	Pr. Admin Officer
Mr. Yasir Muhib, MBA Finance	Sr. Account Officer
Mr. Raufullah, M.L.I.Sc.	Pr. Librarian

PROMOTIONS/ TRANSFERS/ RETIREMENTS/ APPOINTMENTS

Promotions:

S. No.	Name	From	To	On
1.	Dr. Roshan Zamir	Pr. Scientist	Dy. Chief Scientist	01.12.2021
2.	Dr. Iqbal Saeed	Sr. Scientist	Pr. Scientist	01.12.2021
3.	Dr. Syed Tariq Shah	Sr. Scientist	Pr. Scientist	01.12.2021
4.	Mr. Khurshid Ahmad	Jr. Scientist	Sr. Scientist	01.12.2021
5.	Mr. Fazli Rabbi	Sr. Scientific Assistant	Pr. Scientific Assistant	28.05.2021
6.	Mr. Essa Khan	Sr. Scientific Assistant	Pr. Scientific Assistant	28.05.2021
7.	Mr. Muhammad Tariq	Sr. Scientific Assistant	Pr. Scientific Assistant	28.05.2021
8.	Syed Manzoor Shah	Sr. Scientific Assistant	Pr. Scientific Assistant	28.05.2021
9.	Mr. M. Younas Khan	Sr. Tech	Pr. Tech	28.05.2021
10.	Mr. Abdul Haseeb Durrani	Scientific Assistant-I	Sr. Scientific Assistant	28.05.2021
11.	Mr. Asim Ullah	Tech-I	Sr. Tech	28.05.2021
12.	Muhammad Waseem	Tech-III	Tech-II	28.05.2021
13.	Syed Israr Ali Shah	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
14.	Mr. Hazrat Ali	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
15.	Mr. Wisal Khan	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
16.	Mr. Naveed Khan	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
17.	Mr. Muhammad Naveed	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
18.	Mr. Sajjad Khan	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
19.	Mr. Farhat Ullah	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
20.	Mr. Muhammad Asif	Scientific Assistant-IV	Scientific Assistant-III	28.05.2021
21.	Mr. Sharafat Khan	General Attendant-I	General Attendant	28.05.2021

Transfers / Postings:

S. No.	Name	From	To	On
1.	Dr. M. Hamayoon Khan, SS	NIA, Tandojam	NIFA, Peshawar	08.02.2021
2.	Mr. Abdul Hadi Khattak	NIFA, Peshawar	IRNUM, Peshawar	19.03.2021
3.	Mr. Yasir Muhib, Sr. Acct. Officer	IRNUM, Peshawar	NIFA, Peshawar	24.03.2021
4.	Mr. Muhammad Aftab Security Solider	NIFA, Peshawar	CPC, D.G. Khan	02.04.2021
5.	Mr. Gul Marjan, Security Solider	PIEAS, Islamabad	NIFA, Peshawar	26.05.2021
6.	Mr. Ajmali Khan	REO, Peshawar	NIFA, Peshawar	09.06.2021
7.	Mr. Muhammad Saeed, Sec. Solider	NIFA, Peshawar	REO, Peshawar	01.07.2021
8.	Lnk. Muhammad Sadaqat, Sep	NIFA, Peshawar	REO, Peshawar	01.07.2021
9.	Lnk. Badshah, Sep	NIFA, Peshawar	REO, Peshawar	01.07.2021
10.	Mr. Anwar Ali, Naib Sub	NIFA, Peshawar	REO, Peshawar	01.07.2021
11.	Mr. Fazle Subhan, Hav.	NIFA, Peshawar	REO, Peshawar	01.07.2021
12.	Mr. Gul Marjan, Sep	NIFA, Peshawar	REO, Peshawar	01.07.2021
13.	Mr. Naseer Ahmad, Hav	NIFA, Peshawar	REO, Peshawar	01.07.2021
14.	Mr. Muhammad Rafiq, Sep	NIFA, Peshawar	REO, Peshawar	01.07.2021
15.	Nk. Muhammad Taufil, Sec. Solider	NIFA, Peshawar	ACS, Islamabad	01.07.2021
16.	Nk. Shahid Mahmood, Sec. Solider	NIFA, Peshawar	KCP-I, Jauharabad	01.07.2021
17.	Mr. Tariq Hayat Khan, Sep	NIFA, Peshawar	ISF, Jauharabad Peshawar	01.07.2021
18.	Mr. Karim Nawaz Khan, Hav.	NIFA, Peshawar	STP, Chashma	01.07.2021
19.	Mr. Muhammad Nazir, Sep	NIFA, Peshawar	CROF, Karachi	01.07.2021
20.	Mr. Hasham Ghani, Jr. Asstt. (Admin)	PAEC HQs.	NIFA, Peshawar	09.08.2021
21.	Dr. Maria Kawnal Ali, JS	NIFA, Peshawar	INOR, Abbottabad	22.10.2021
22.	Mr. Fazal Ghafoor, Driver	NIFA, Peshawar	SINOR, Swat	05.11.2021

23.	Mr. Atta ur Rehman, Driver	SINOR, Swat	NIFA, Peshawar	06.12.2021
24.	Mr. Hasnain Ghani, Jr. Asstt. (Admin)	PAEC HQs.	NIFA, Peshawar	13.12.2021

Retirements:

S. No.	Name	Date
1.	Mr. Nabi Ullah, Foremen	01.01.2021
2.	Mr. Mehtab Shah, Sr. Tech	01.01.2021
3.	Mr. Abdus Sami, Assistant (Admin)	15.01.2021
4.	Mr. Amir Dad, Security Solider	03.04.2021
5.	Mr. Rashid ur Rehman, Security Solider	04.05.2021
6.	Mr. Sharafat Khan, Gen. Attdt.	31.10.2021

Deaths;

S. No.	Name	Date
1.	Mr. Masood Jan, Sr. Telecom Operator	13.02.2021

Appointment:

S. No.	Name	Date
1.	Mr. Muhammad Onais, SA-II	04.02.2021
2.	Mr. Anwar Ali, Gen. Attdt.	22.04.2021
3.	Mr. Taufiq Ullah, Gen. Attdt.	28.04.2021
4.	Mrs. Asia, Telecom Operator	02.06.2021
5.	Mr. Zahid Ali, Gen. Attdt.	02.06.2021
6.	Mr. Muhammad Junaid, Jr. Asstt. (Accounts)	09.06.2021
7.	Mr. Zia ul Haq, SA-IV	01.09.2021

SCIENTIFIC EVENTS/ TECHNOLOGY TRANSFER PICTORIAL VIEW

One day training Seminar on "Recent Trends in Food Safety & Bacteriocin Based Bio-Preservation" held at NIFA on January 27, 2021

Training on "Value Addition of Fruits and Vegetables" held at NIFA on February 09, 2021

One day training workshop on "Use of Compost and Compost Tea for Off-season Vegetables Production in Tunnels" held at NIFA on February 24, 2021

One day workshop on "Popularization of Insect Pests Control Technologies for Commercialization" held at ATI Peshawar on March 03, 2021

Organized "NIFA Farmers Day" held at NIFA on March 18, 2021

Seminar on "Use of Electron Beam/X-rays Technology for Value Addition of Food Products and Gemstones" held at NIFA on April 06, 2021

Training on "Development of Low Cost Zero-Energy Cooling Chambers for Field Heat Removal and Storage of Fruits and Vegetables" held at NIFA on May 26, 2021

One-Day Seminar on the Applications of Nuclear Techniques in Industry, organized by Pakistan Nuclear Society (PNS) held at NIFA, on May 26, 2021

DQA Training held at NIFA, on August 02-06, 2021

36th Postgraduate training course on the "Use of Nuclear and Other Techniques in Food & Agricultural Research" held at NIFA on October 4-15, 2021

GROUP PHOTOS

DIRECTOR OFFICE

PLANT BREEDING AND GENETICS DIVISION

FOOD AND NUTRITION DIVISION

SOIL AND ENVIRONMENTAL SCIENCES DIVISION

PLANT PROTECTION DIVISION

ACCOUNTS

ADMINISTRATION

TECHNICAL SERVICES DIVISION

FARM STAFF

SANITARY STAFF

Nuclear Institute for Food and Agriculture

PESHAWAR

ISO 9001:2015 Certified

Scientific Events Calendar 2022

January

18-01-2022

Training on development of low cost zero energy cooling chambers for field heat removal and storage of fruits and vegetables.

Organizer: Dr. Zahid Mehmood, PS
Mr. Ali Raza, SS
Venue: District haripur
Cell: 0333-5033898

February

22-02-2022

Integrated nutrient management for off-season vegetable production in Tunnels.

Organizer: Dr. Amir Raza, PS
Mr. Parvez Khan, PS
Venue: NIFA, Peshawar
Cell: 0304-0501455
0333-9386824
E-mail: amir.boku@gmail.com
parvez_08@yahoo.com

March

08-03-2022

NIFA Farmers Day

Organizer: Dr. Farooq-i- Azam, PS
Dr. Roshan Zamir, PS
Venue: NIFA, Peshawar
Cell: 0300-9006616
0301-8580109
E-mail: fazamcaas@gmail.com
roshanzamirhort@gmail.com

May

24-05-2022

One Day workshop on the qualitative analysis of fats/oils and its impact on food safety

Organizer: Mr. Ali Raza, SS
Dr. Zahid Mehmood, PS
Venue: NIFA, Peshawar
Cell: 0333-8365080
0333-5033898
E-mail: razi.bwn@gmail.com

June

14-06-2022

One day Training on Value Addition and Food Preservation

Organizer: Mr. Zubair Shah, PE
Mr. Asim Irshad, JS
Venue: NIFA, Peshawar
Cell: 03339201652
03347053090
E-mail: mzshah2001@gmail.com
aaxim.ch@gmail.com

July

05-07-2022

One day Awareness Seminar on use of Electron beam/ X-ray technology for value addition of food products and gem stones

Organizer: Mr. Alamgeer Khan, SS
Mr. Asim Irshad, JS
Venue: NIFA, Peshawar
Cell: 03469322294
03347053090
E-mail: alamgeer_khan86@yahoo.com
aaxim.ch@gmail.com

September

14-09-2022

One day workshop on "Management Strategies for Insect Pests of Medical Importance"

Organizer: Dr. Inamullah Khan
Dr. Gul Zamin Khan
Venue: NIFA, Peshawar
Cell: 0334-9059180, 0331-3811979
E-mail: Inamullah_nifa@yahoo.com
gulzaminkhan@yahoo.com

October

17-28, 2022

37th Postgraduate Training Course on the use of Nuclear and other Techniques in Food & Agricultural Research

Organizer: Dr. Gul Zamin Khan, PS
Mr. Muhammad Irfan, JS
Venue: NIFA, Peshawar
Cell: 0331-3811979,0336-64493394
E-mail: gulzaminkhan@yahoo.com
mirfan_ramdani@yahoo.com

November

08-11-2022

Hands on Training for microbial and compositional analysis of food and water samples

Organizer: Dr. Talat Mahmood, SS
Dr. Zahid Mehmood, PS
Venue: NIFA, Peshawar
Cell: 03009852130, 03335033898
E-mail: drtalat@nifa.org.pk
zahidnifa@gmail.com

December

15-12-2022

Popularization of mushroom cultivation as cottage industry for economic uplifting of farmers/ low income community

Organizer: Dr. Muhammad Ibrahim, PS
Mr. Aurangzeb, PSA
Venue: NIFA, Peshawar
Cell: 0334-9180642, 0333-5950937
E-mail: ibra786pk@yahoo.co.uk
zebkhan_75@yahoo.com

Contact Information

Dr. Gul Sanat Shah
DCS/Director
Mail: P.O.Box 446, Peshawar, 2500
E-mail: mails@nifa.org.pk
Ph: 091-2964058 Fax: 091-2964059

Dr. Syed Azam Shah
Principal Scientist / Incharge Outreach Cell
Ph:091-2964060-62 Ext: 273
Cell: 0334-5337825
E-mail: azamsbpn3@gmail.com

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